Breed Predispositions to Disease in Dogs and Cats

Third Edition

Alex Gough · Alison Thomas · Dan O'Neill

WILEY Blackwell

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This edition first published 2018

Edition History
John Wiley & Sons (1e, 2004)
John Wiley & Sons (2e, 2010)

Registered Offices
John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, USA
John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial Office
9600 Garsington Road, Oxford, OX4 2DQ, UK

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Wiley also publishes its books in a variety of electronic formats and by print-on-demand. Some content that appears in standard print versions of this book may not be available in other formats.

Library of Congress Cataloging-in-Publication Data

Names: Gough, Alex, author. | Thomas, Alison, 1964– author. | O'Neill, Dan (Dan G.), author.
Title: Breed predispositions to disease in dogs and cats / Alex Gough, Alison Thomas, Dan O'Neill.
Description: Third edition. | Hoboken, NJ : Wiley, [2018] | Includes bibliographical references. |
Identifiers: LCCN 2017043483 (print) | LCCN 2017055418 (ebook) | ISBN 9781119225553 (pdf) | ISBN 9781119225577 (epub) | ISBN 9781119225546 (pbk.)
Subjects: LCSH: Dogs–Diseases. | Cats–Diseases. | MESH: Dog Diseases–genetics | Cat Diseases–genetics | Genetic Predisposition to Disease | Pedigree
Classification: LCC SF991 (ebook) | LCC SF991 .G67 2018 (print) | NLM SF 991 | DDC 636.7/089607–dc23
LC record available at https://lccn.loc.gov/2017043483

Cover Design: Wiley
Cover Image: (Center right) Labrador retriever © Alison Thomas; (Top left) Cat: Seal point Ragdoll, (Bottom left) Dog: French Bulldog © Dan O'Neill

Set in 9/11pt Minion by SPi Global, Pondicherry, India

10 9 8 7 6 5 4 3 2 1

Alex Gough

To loved ones, friends and colleagues, and of course to my wife Naomi and daughter Abigail for bearing with me through another huge project.

Alison Thomas

To all the wonderful colleagues I have had the pleasure of working with over the years. Most of all to my partner Richard, and children Tom and Harry, for making my life so much fun.

Dan O'Neill

To my wife, best friend and inspiration, Joanne. And to my three children and lights of my life, Alistair, Megan and Clodagh. Thank you each for being you.

This book is also dedicated to all those vets suffering from mental illness, and particularly to those who have lost their lives due to this common condition affecting our profession.

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Head of Medicine Referrals, Bath Veterinary Referrals
Alex graduated from Cambridge University Vet School in 1996 and achieved RCVS certificates in Small Animal Medicine and Veterinary Cardiology, as well as a human Postgraduate Certificate in Neuroimaging for Research from Edinburgh University. He worked in mixed, mainly small animal practice for six years, then in referral practice, seeing referrals in medicine, cardiology and neurology, with a particular interest in medical neurology. He is the author of *Differential Diagnosis in Small Animal Medicine* (2007), has written a column summarizing the latest research for the *Veterinary Times* since 2003 as well as chapters on neurology and clinical genetics in two BSAVA manuals, and sits on the advisory clinical board of a large veterinary group. In his spare time, he writes historical fiction novels and plays guitar.

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Alison graduated from Liverpool University in 1987 and has spent most of her career working in charity small animal practice. After two years in private practice in Aylesbury, she moved to Asia, spending two years in private practice in Singapore, followed by seven years at the SPCA in Hong Kong. Since 1998 she has worked at Blue Cross in Victoria, London, becoming Senior Veterinary Surgeon in 2007 and joining the newly formed Clinical Leadership Team of Blue Cross in 2016. She gained the RCVS Certificate in Small Animal Medicine in 2001, and was awarded Advanced Practitioner Status in Small Animal Medicine in 2017. In her spare time she enjoys hiking, travelling and reading.

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After graduating from Dublin Vet School in 1987, Dan worked in industry and general practice for 22 years, latterly running his own companion animal practice in Petts Wood, Kent, for 12 years. During these years, he was awarded additional qualifications in pharmacology, general practice, dermatology, feline practice and business management. In 2009 he undertook an MSc supported by BBSRC and then a PhD supported by the RSPCA in veterinary epidemiology at the RVC to develop the VetCompass programme of primary-care veterinary clinical research. After postdoctoral posts supported by Dogs Trust and Kennel Club Charitable Trust, Dan was appointed as Senior Lecturer in Companion Animal Epidemiology at the RVC in 2017. As well as teaching and publishing, Dan focuses on expanding VetCompass internationally, with particular emphasis on breed-related health. In his spare time, he is a keen ITF taekwondo enthusiast and currently holds a 2nd Dan black belt.

Foreword

For anyone interested in the health and welfare of dogs and cats, there are few topics that engender such emotional energy, diverse opinion and heated debate as the potential negative impacts of selective breeding on canine and feline disease occurrence, and the optimal ways to manage and/or eliminate such impacts. But energy, opinion and debate can only bring true positive change when they are based on good evidence. In this respect, the third edition of *Breed Predispositions to Disease in Dogs and Cats* is hugely timely. The book comes not only at a time of increasing awareness of the impacts that breed characteristics may have on health, but also when there is growing appreciation of the glaring underuse of objective data to support traditional perceptions and opinions which have become accepted as 'fact' in breeding folklore and veterinary science. This book aims to remove the roles of speculation, opinion and anecdote from the discussion on breed health issues and instead to refocus and underpin these discussions based on solid evidence-based principles.

There is no doubt that the Bateson Report on pedigree dog health and its far-reaching recommendations (Bateson, 2010), the creation of the Royal College of Veterinary Surgeons' RCVS Knowledge initiative to promote the generation and application of veterinary clinical evidence (RCVS Knowledge, 2017) and a general increase in commitment to evidence based veterinary medicine over the past decade have resulted in a greater appreciation of the need for reliable evidence on the health impacts of breed characteristics in dogs and cats. Fortunately, this awareness of the need for valid evidence has coincided with the development of exciting new tools which allow us to collect and interpret large volumes of relevant data from primary and referral veterinary practices and to analyse these in robust and less biased ways. As a result, for the first time, we are increasingly able to provide some reliable real-world context to the likely impact of breed characteristics on animal health and welfare. The development and international adoption of standardized systems of nomenclature such as the VeNom initiative (VeNom Coding Group, 2017) and ground-breaking research tools such as the Royal Veterinary College's VetCompass Programme (VetCompass, 2017) allow researchers to explore vast amounts of clinical data from first-opinion and referral veterinary practices. These developments have transformed how we can investigate companion animal diseases and their impact on animals, their owners and their breeders. The era of 'Big Data' for companion animals and its impact on animal health and welfare is now truly upon us.

Realization of the powers from developments such as these means that this new edition of Breed Predispositions to Disease in Dogs and Cats really does herald a new and more valid perspective in our understanding of the types of disorders and their likely impact on different dog and cat breeds. The new edition has been completely rewritten using 'evidence-based veterinary medicine' criteria that are applied to international data and consequently provides an accurate reference resource on disease predispositions that is relevant to breeds from all corners of the world. The information is comprehensive and detailed but presented in a readily understandable and searchable format. Prevalence, odds and risk ratio values, as well as study design details, are provided so that the more motivated reader can go beyond an awareness that a predisposition has been reported and start to examine the context and strength of the reported associations. This book truly is a cornucopia of breed health information.

This third edition will become an invaluable and constant resource for students, vets, breeders, owners, scientists and indeed anyone interested in companion animal welfare. We are privileged to live at a pivotal tipping point in the generation and application of evidence for better decision-making in companion animal health. This book will play a key role in centralizing our current knowledge into a single resource, and is thereby a torch-bearer that will finally enable us to move beyond endless circular discussion to positive action that will benefit the welfare of our cats and dogs.

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Preface

It is widely accepted that almost all dog and cat breeds have specific diseases to which they are particularly prone (i.e. predisposed). Indeed, many textbooks and published research papers include lists of breed predispositions as a standard feature when describing specific disease conditions. To extend this focus, the first edition of *Breed Predispositions to Disease in Dogs and Cats*, published in 2004, aimed to provide a single reference resource for breed predispositions that would better illuminate our understanding of breed health (Gough & Thomas, 2004). The concept for the first edition was born during discussions between the two original authors (Alex Gough and Alison Thomas) while preparing for their RCVS Certificate in Small Animal Medicine exams in 2001. This book was the first of its kind to focus purely on breed-specific predispositions and was widely welcomed by academics, veterinarians, breeders and owners. That original edition was compiled mainly from secondary sources of evidence such as textbooks, reviews and conference proceedings and did not provide detailed reference citations for all the breed–disease combinations reported. The second edition, published in 2010, redressed many of these shortcomings and was updated with more recent publications while also ensuring that every cited disease had at least one supporting reference. However, much of the disease information still came from secondary sources such as textbooks, review articles and conference proceedings. The implication of this was that the second edition was substantially reliant on expert opinion. At that time, almost a decade ago, this approach may have been acceptable, but as we progress into the modern age of evidence-based veterinary medicine (EBVM), expert opinion is now generally considered to be weak evidence, and reliance should instead be placed on the results of original research (Holmes & Ramey, 2007).

In consequence, preparations began for a third edition that would have a strong emphasis on improved academic rigour, better compliance with the modern principles of EBVM and a sound epidemiological infrastructure. To meet these lofty aspirations, Alex and Alison enlisted Dr Dan O'Neill to join as a third co-author, to ensure high epidemiological standards and also to reduce the individual workload for each author. Dan is an epidemiologist working on the VetCompass Programme at the Royal Veterinary College (VetCompass, 2017), but with that rare academic attribute of essentially still being a general veterinary practitioner. We are confident that this third edition has achieved our academic goals – but we must also sadly report that we failed in our aspiration to reduce the workload. Indeed, it was quite the reverse, as the new perspectives introduced by Dan entailed a complete rewrite. Ah well, you can't win them all – but we do hope that you enjoy the end result of our combined labours.

For this new edition, we have consulted and referenced primary sources of evidence almost exclusively (i.e. the original published papers that reported the primary research) and have restricted inclusion to just those diseases where primary research identified sufficient evidence for the existence of a breed predisposition. As might be expected, this new approach led to some challenges and several discussions between the authors on the optimal threshold of evidence for disease inclusion. During our rewrite, we became painfully aware of just how little evidence actually exists for much of what we may 'believe' to be true about companion animal health. When we examined the literature closely, many of the predispositions commonly reported as 'knowns' in textbooks and introductions to peer-reviewed publications had very little, if any, reliable supporting evidence. This realization reinforced our determination that the new edition should follow rigorous evidence-based principles, but it also meant that the new book would entail a total rewrite, with substantial work required to freshly identify those diseases with and without a solid evidence base. We found ourselves painfully deleting many conditions that had been included in the previous book based on expert opinion but which lacked adequate evidence. 'Believing in a predisposition' and 'having evidence for a predisposition' are not always the same thing. The positive side of our new EBVM approach, however, was a refreshing discovery that our new detailed trawl of the primary literature led us to identify many new breed–disease combinations that had not made it into the previous two editions. This may have been because the predisposition was first reported after the second edition was published or because our previous reliance on expert opinion had failed to uncover the association.

Our new search methods and inclusion criteria are described more fully in the *Methods* section. We hope that these changes support a more robust and defensible evidential and scientific body of information in this third edition, which also includes additional supporting information for breed predispositions where possible. Such additional information may describe the population studied in the original papers – such as geographical location, referral or general practice population (many academic papers are based on referral populations, and their results do not necessarily generalize well to the populations of patients commonly seen in general practice) – while the date of the referenced papers may assist with a perspective on the temporal relevance of the results. Information is also provided on the comparator populations used in the studies (e.g. crossbreds or all study dogs) and the numerical results, which show the strength of the reported predisposition (e.g. odds ratio or prevalence). Taken together, these new segments of information should help the reader to piece together the likelihood of the reported predispositions being real and relevant in relation to his or her own personal animals and interests. In the first and second editions, the research was divided between the authors by body system. For this third edition, we have instead divided the research alphabetically by breed. Consequently, some differences in writing style and emphasis may be apparent between the authors' sections. However, by sticking to pre-agreed methods, we hope to have maintained a satisfactory level of consistency across the work. We have also updated the genetics section as well as adding new explanatory sections on methods, longevity and epidemiology. We hope that these will give the interested reader some useful background on these topics as well as suggestions on where to find further information as required.

Companion animals are often bred according to the whims and needs of mankind rather than following the harsh survival rules of natural selection, and therefore breed-related disease has become an important anthropogenic welfare issue. In consequence, it behoves everyone with an interest in companion animals to strive to reduce these animal welfare costs. A critical first step in this process is the need to define which breed–disease combinations (i.e. predispositions) have strong supporting evidence. We hope that the third edition of our book meets this need and provides a solid evidence base from which other companion animal stakeholders can develop effective strategies to improve animal welfare. Breeders and breeding organizations can use this book to identify priorities when considering the genetic health of their breeds. The show community, both those showing and those judging, may use this book to refine their opinions on optimal conformations and temperaments within individual breeds. The strong evidence-based approach of the book can help veterinary students and veterinarians with diagnosis and when advising prospective and current owners on breed-specific disease proclivities. Owners may find the book useful when deciding on breed selection or considering on how best to care for their current or prospective dog or cat. Ultimately, this book aims to enhance the welfare of current and future generations of cats and dogs by increasing our awareness of those diseases which commonly affect individual breeds and which may therefore be prevented or diagnosed earlier. Good evidence on breed predispositions empowers us all to combat disease occurrence and should lead to improvements in the lives of our dogs and cats.

We have thoroughly enjoyed writing this book: it became a labour of love for the three of us and consumed our lives for over a year, but we are very proud of the final product. There will obviously be some parts that we will re-read later and decide we could have done better, and we welcome the reader letting us know about these. There will also be some opportunities that were missed in this edition, and we will be glad to receive suggestions. However, we hope you will forgive these shortcomings for now and simply accept this third edition for what it is: an evidence-based blueprint for the current state of knowledge on breed predispositions to disease in dogs and cats. We hope you enjoy reading this book.

Alex Gough, Alison Thomas and Dan O'Neill

Abbreviations

95% CI	95% confidence interval
AKC	American Kennel Club
ANA	antinuclear antibodies
aPTT	activated partial thromboplastin time
AV	atrioventricular
CI	confidence interval
CYAR	cat years at risk
DYAR	dog years at risk
E. coli	*Escherichia coli*
EBVM	evidence-based veterinary medicine
ECG	electrocardiography
GSD	German Shepherd Dog
Ig	immunoglobulin, including isotypes IgA, IgG and IgM
IR	incidence rate
IRR	incidence rate ratio
KC	Kennel Club
MHC	major histocompatibility complex
MRI	magnetic resonance imaging
OR	odds ratio
PCR	polymerase chain reaction
PR	prevalence ratio
PT	prothrombin time
RR	relative risk, *or* risk ratio
SBT	Staffordshire Bull Terrier
T_4	thyroxine
TRH	thyrotropin-releasing hormone
TSH	thyroid-stimulating hormone
VMDB	Veterinary Medical Database
WHWT	West Highland White Terrier

Introduction

BASIC AND CLINICAL GENETICS

Inherited diseases and breed predisposition

It has long been recognized that many traits, desirable and undesirable, can be passed along family lines. Darwin noted in 1868 that there is a 'unanimity of … belief by veterinaries of all nations in the transmission of various morbid tendencies'. Inherited diseases in dogs and cats can be categorized as those associated with adherence to breed standards and those unrelated to breed standards. The brachycephalic head shape is particularly associated with a number of diseases such as brachycephalic obstructive airway syndrome, dystocia and corneal ulceration (Packer *et al.*, 2015; O'Neill *et al.*, 2017b, 2017c). Diseases not directly related to breed standards include many intraocular diseases, haematological and immune-mediated diseases, and endocrine diseases (although the creation of small gene pools for a breed because of adherence to breed standards may have contributed to the prevalence of these diseases). For ease of use, the accounts in this book have been arranged by body system rather than in relation to breed standards.

It should be noted that while most conditions with breed predispositions are likely to be truly hereditary, this is not always the case. (Note that in our text, we use *hereditary*, *genetic* and *inherited* as synonyms.) Some conditions may arise because of the use to which the animal is commonly put, such as racing injuries in greyhounds, or to their behaviour, such as the searching behaviour of spaniels making them prone to grass awn (grass seed) foreign bodies. Nevertheless, even diseases such as these will have a genetic component, for example in influencing the behaviour of the spaniel, or giving the greyhound the athletic ability that means it is used for racing, and therefore can still be considered to have some inheritabilty.

Domestication and the canine and feline genome

Dogs are thought to be descended from a common ancestor with wolves, with estimates for the timing of the divergence ranging from 15 000 to 100 000 years ago. Domestication may have occurred more than once, and there may have

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been further interbreeding with wolves subsequently. At least two bottlenecks have occurred in canine genetic history, one when they diverged from wolves, and another more recently when modern dog breeds were created. Nevertheless, the dog has an enormous variation in phenotype, as shown by characteristics such as size, colour, coat type and behaviour.

It has been shown that there is more variation in functional genes in domestic dogs than in wolves (Cruz *et al.*, 2008), and alterations in functional genes are often deleterious to welfare. Population bottlenecks and selective breeding may have exacerbated this, and natural selection against these deleterious conditions is less likely in domestic animals than in their wild counterparts. Domestic dogs may therefore be more prone to inherited diseases than wolves.

Dogs were originally bred to fulfil many different purposes, such as hunting, fighting, guarding, herding and companionship. Sighthound type hunting dogs have been noted in archaeological records dating back 4000 years, and in Ancient Roman times, Columella described the division of dog breeds into working and hunting types. However, most modern dog breeds originate in the last 150 years, with the development of dog breeding as a hobby of the middle- and upper-class Victorian.

In a study (Parker *et al.*, 2007) that examined the DNA of a large number of dogs representing 161 breeds, the authors were able to divide the breeds into 'clades', that is, breeds with common ancestors. This paper shows how complex the genetic history of the dog is, but certain interesting points stand out. One is that single mutations can cause recognizable changes across multiple breeds within a clade. This has the consequence that dogs in a single clade may be prone to similar inherited diseases. Since most dog breeds are young in evolutionary terms, there has been little time for new mutations to occur, and so most disease-causing genetic mutations are thought to have occurred before the breeds were founded. It is also notable that related breeds came out of certain times and geographical locations. For example, dog fighting was popular in Ireland in the 1800s, and many mastiffs and bull terrier crosses from this location and period later developed into recognized breeds. The introduction of dogs into North America by European settlers and later Asian migrations largely replaced the indigenous domesticated canine population which had been introduced by the first American settlers over 10 000 years previously. However, this study showed that breeds related to animals brought by European settlers likely had some interbreeding with the more ancient American breeds, and so American breeds of European origin retain some of the genetic material of the previous indigenous breeds.

Phenotypic variation (e.g. conformation and behaviour) is much smaller in cats than in dogs. Cats are thought to have been domesticated later than dogs, but are probably of less direct use to humans as working animals than dogs, since they are harder to train. Deliberate breeding was therefore more limited, and domesticated cats show as much genetic diversity as the wildcat.

The canine and feline genomes have both been sequenced, and the body of research into the genome and into genetic diseases in these species is rapidly growing.

Basic genetics

All mammalian life is based on the genetic code stored within the nucleus of a cell. This genetic code is stored in a long molecule called *deoxyribonucleic acid* (DNA). Each DNA molecule is composed of a string of units, called bases. There are four different bases, and they attract each other in pairs – *guanine* to *cytosine* and *adenine* to *thymine*. When attached together, they form the famous *double helix*. The order in which these bases (or base pairs, since they always match together) occur along the molecule provides the code for the synthesis of proteins. Proteins are then responsible for most of the functions of the body, from the structure of tissues, to the biological catalysts called enzymes, to the hormones which regulate the body's metabolic processes.

A length of DNA which codes for a particular protein is called a *gene*. Long strings of genes, interspersed with areas of DNA which do not code for proteins, make up *chromosomes*. Each nucleus of a mammalian cell contains a set number of chromosomes, except the sex cells (*gametes*) – sperm and ovum. For dogs this number is 78, and for cats it is 38.

When a somatic (body) cell divides, the chromosomes shorten and thicken within the nucleus, so they become visible under a microscope. They then replicate, and one copy of each chromosome separates into a new nucleus before the cell splits. This process is called *mitosis*.

However, in the production of the gametes (the process of *meiosis*), the chromosomes line themselves up in the middle of the cell with a companion. This companion is always the same, and two chromosomes that associate together are called *homologous pairs*. These homologous pairs separate, so the gametes have half the number of chromosomes as normal cells. This means that when a sperm and ovum combine at fertilization, the newly formed cell (the *zygote*) has the correct number of chromosomes.

Homologous pairs code for related genes, but are not identical. The two genes, one on each chromosome, interact in different ways. Sometimes one gene is *dominant* to the other, the less dominant gene being termed *recessive*, and the expression of the gene, that is, the protein that is produced, will be determined by the dominant gene. In other cases both genes will play a role in the production of the protein, a situation called *co-dominance*.

The exception to the homologous pairs are two chromosomes called the sex chromosomes (all the other chromosomes are called the *autosomes*). These chromosomes determine the sex of an animal. In most mammals, including dogs and cats (and humans), a female's somatic cells contain two X chromosomes while the male's somatic cells contain an X and a Y. At meiosis, the ova acquire a single X chromosome from the mother, whereas the sperm inherit either an X or a Y from the father. This has significance for the inheritance of conditions carried on the X chromosome, and means that some inherited diseases can be more prevalent in one sex than another.

Although any one animal will carry only up to two versions of a gene, many more can exist within a population because of mutation and natural selection. These different versions of the gene are called *alleles*.

In conditions and characteristics that are inherited in a simple way, that is, the conditions are autosomal dominant or recessive, a system of genetics devised by the monk Gregor Mendel (hence Mendelian genetics) can be used to predict the likely offspring of two parents, if the parents' genetic make-up is known. For example, the gene that codes for Labrador coat colours is dominant for black and recessive for brown. A Labrador with two alleles for black colour (call the allele B) is described as BB and hence the coat will be black. If it has one allele for black and one for brown (call the allele b), it will be described as Bb but the coat colour will still be black since this colour is dominant. However, if the dog possesses two alleles for brown (bb), it will be brown. The genetic make-up is called the *genotype*, whereas the physical expression of the genes is called the *phenotype*.

The situation is slightly more complex when looking at matings, and a matrix can be used to aid prediction of offspring types. Take the example of a BB black male crossed with a bb brown female. The BB male will produce sperm each carrying a single B gene, and the female will produce ova each carrying a single b gene. These are then recombined at random to produce offspring. The matrix would therefore look like this:

		Male	
		B	B
Female	b	Bb	Bb
	b	Bb	Bb

This means that all the offspring would be Bb. They all carry the b gene for brown coat, but because this allele is recessive, the coat colour is black. An animal with two identical alleles (e.g. BB or bb) is called a *homozygote*, while an animal with two different alleles (e.g. Bb) is called a *heterozygote*. If a black Bb female were then crossed with a black Bb male a different pattern would emerge:

		Male	
		B	b
Female	B	BB	Bb
	b	Bb	bb

On average three of the offspring would be black: one a homozygote (BB) and two heterozygotes (Bb). The fourth would be a homozygote for brown coat colour (bb), and, since this b allele is not now being suppressed by the dominant B allele, the brown coat colour phenotype is expressed.

In fact, since the fertilization process is random, a litter of four pups may not be born in the exact 1:2:1 ratio, but if this were repeated enough times, the proportions of pups of the various genotypes would approximate to this.

Generally, the alleles separate randomly from each other. If a parent has two genetic conditions, just because one condition is expressed in an

offspring, that does not mean that the other will be. However, some alleles that are closely positioned on a chromosome tend to be passed on together. Thus, two traits controlled by different genes may often be found together in the same individual, and the presence of one of these traits may act as a marker for the other. This process is known as linkage.

When one allele is not dominant over another co-dominance exists. For example, certain flowers that have alleles for red flowers (R) and white flowers (W) will be coloured red if homozygous for red (RR), white if homozygous for white (WW) but pink if heterozygous (RW).

Some genes, even if dominant, do not always produce a physical effect in the host. For example, the condition polycystic kidney disease in cats is inherited as an autosomal dominant trait, but not all cats with the genes have cysts in their kidneys. This situation is called *incomplete penetrance*. Penetrance is the proportion of individuals with a particular genotype that demonstrate the characteristics normally expected with that genotype.

Some characteristics are carried on the X chromosome, and this can lead to the phenomenon of *sex linkage*. For example, Golden Retrievers are predisposed to a condition called X-linked muscular dystrophy. The allele for muscular dystrophy (call it M) is carried on the X chromosome, as is the allele for a normal dog not suffering from the condition (call it N). M is recessive to N. Therefore a female carrying a single affected X chromosome (genetic make-up X^MX^N) would not show the effects of the disease. If this female were mated with a normal male (X^NY), then the matrix for their offspring would be as follows:

		Male	
		X^N	Y
Female	X^M	X^MX^N	X^MY
	X^N	X^NX^N	X^NY

All of the females born to this cross will be clinically unaffected by the disease, but 50% of the females will be carriers of the disease. These will not show the disease, since they have a normal gene on the other X chromosome which suppresses the abnormal, recessive gene. However, the males only possess a single X chromosome, so the 50% of males born X^MY will show the disease (since they do not possess another X chromosome with a normal gene). The 50% of males born X^NY will not show the disease and will not carry it.

Because of this process, sex-linked diseases usually affect only males, and males cannot normally be asymptomatic carriers. Females are often carriers, but the only way they can express the disease is if their mother was a carrier and their father was affected. This situation is rare in nature, especially for uncommon genes, but can occur in domestic animals due to inbreeding.

Some disease inheritances are more complex still, because more than one gene may determine the expression of a disease, or the interaction of genes and environment can determine the outcome in an individual. For example, more than one gene is considered to be responsible for hip dysplasia but the dog's nutrition, exercise and other factors can also influence the severity of the disease.

Finally, some diseases are not inherited through the DNA of the cell nucleus at all, but through the DNA present within the *mitochondria* (which are intracellular organelles responsible for energy production). Mitochondria are entirely inherited from the mother, hence characteristics and diseases caused by mitochondrial DNA can only be passed down from the mother. Although conditions caused by mitochondrial DNA are rare, some canine myopathies are thought to be inherited this way.

In summary, an autosomal dominant trait is transmitted from generation to generation without skipping. Each affected offspring has at least one affected parent, unless the disease has arisen because of mutation. If the disease is lethal, then it will be very rare. An autosomal recessive disease may skip generations. If the two parents are affected, then all the offspring are affected. With an X-linked dominant condition, affected males mated to normal females transmit the gene to their daughters, who are all affected, but not their sons. Affected females then pass the condition on to approximately half of their sons and half of their daughters. In the overall population, the incidence in females tends to be twice that of males. With an X-linked recessive disease, the condition may skip generations. The incidence is more common in males. Affected males do not transmit the disease when mated to a normal female, but all female offspring will be carriers. Females showing the disease who are mated with normal males will pass the condition on to all their sons, and all their daughters will be carriers.

Clinical genetics

As noted above, genetic diseases may be more frequently encountered in domestic animals than in most wild populations. The process of domestication involves selecting animals for desirable traits from a human point of view. Initially, these traits would have been practical: speed in a horse, fertility and milk production in a cow, herding instincts in a sheepdog and so on. Over time, for animals such as dogs and cats that came to be kept for their companionship and aesthetic appeal, selection pressures switched towards features that made the animals fit in well to the human environment or made them look 'cute' – for example, miniaturization or achondroplasia – but which may have reduced adaptation to survive in the wild. As breeding practices were refined and the science of genetics was developed, inbreeding was used to create breeds that bred true with respect to certain desired characteristics (i.e. offspring greatly resembled their parents).

Unfortunately, inbreeding reduces the genetic variation within a breed, and tends to accentuate the expression of diseases that are due to recessive genes. Population bottlenecks occur through the importation of a small number of founder animals to a new country or because of regenerations of previously extinct breeds, and they are complicated by the *popular sire effect* whereby desirable individuals such as a show champion are overused (particularly males, which can produce many more offspring than a female). Most of the characterized genetic diseases of the dog are inherited as autosomal recessive traits. This may be because of inbreeding, but it is also due to the difficulty in identifying and eliminating recessive traits in breeding programmes.

It should be noted that inbreeding of itself does not cause genetic disease, and some degree of inbreeding can be of benefit for the concentration of desirable genes. In fact, some inbred strains of mice and rats are entirely homozygous and yet are quite healthy (Beck *et al.*, 2000). Inbreeding promotes homozygosity, and thus deleterious recessive genes are exposed by increasing the probability of their expression. However, by exposing these genes, it is possible to eliminate them by further selective breeding.

Data are currently sparse regarding the prevalence of disease caused by the spontaneous appearance of new mutations. It seems likely that most of the genotypic variability of the domestic dog was present in its common ancestor with the wolf. However, it has been suggested that the Canidae family have elevated genome-wide basal slippage rates, meaning an increased rate of creation of new mutations due to errors in replication, compared to humans and cats (Shearin & Ostrander 2010). In most of those limited cases studied, the mutation seems to be uniform within a breed. This suggests that a *founder effect* applies, that is, a single initial mutation was propagated throughout the breed. In some cases, closely related breeds may have the same mutation causing a disease – for example, phosphofructokinase deficiency in English Springers and American Cocker Spaniels (and presumably Sprockers) – suggesting that a common ancestor was responsible for the original mutation. Some diseases, however, have more than one mutation in the same gene (*allelic heterogeneity*) or mutations in different genes which can lead to the same outcome. For example, oculoskeletal dysplasia is caused by mutations of different genes in the Labrador and the Samoyed, while multifocal retinopathy is caused by two different mutations of the same gene (Guziewicz *et al.*, 2007; Goldstein *et al.*, 2010).

When determining whether a disease is heritable, certain typical characteristics increase suspicion of a genetic predisposition. Often the first thing to suggest that a disease is inherited is that the disease occurs with a higher frequency in a group of related animals than in the general population. This can help distinguish an inherited disease from a breed predisposition (although it can be argued that in most cases breed predispositions are related to genetics in some sense, and a breed predisposition is suggestive of a genetic cause). For example, St Bernards are predisposed to osteosarcomas (Egenvall *et al.*, 2007), but it is possible this is merely a reflection of their large size, the faster growth rate leading to more mistakes being made in DNA replication, leading to cancer. However, analysis of pedigrees shows that there is a familial clustering pattern to cases of the disease, which suggests a specific gene or group of genes being responsible.

A hereditary defect often involves the same anatomic site in a group of related animals. This is often seen in congenital heart disease in dogs. Also, a hereditary disease is often seen to increase

in frequency with inbreeding. Hereditary diseases often have an early onset, and those that do not often have a consistent age of onset. Hereditary diseases usually affect a few individuals within a litter, as opposed to intoxications and infectious diseases, which frequently affect higher proportions. Some genetic diseases will cause abortion or resorption, and these are often difficult to recognize clinically. Similarly, some hereditary diseases will cause a failure to thrive, the 'fading kitten (or puppy) syndrome', and again it can be hard to determine the cause in these cases.

There is an extremely wide range of severity of hereditary diseases, from the relatively benign to the invariably fatal. Diagnosis of a hereditary disease is usually based on history, clinical signs, history of disease in related individuals, test matings, specific imaging or clinicopathological tests for diseases and genetic testing.

Test matings are often suggested in order to identify autosomal recessive diseases, but this does have problems. With late-onset defects, the results of the mating will be known too late to be useful in selecting which individuals to use for breeding. Test matings can be more useful for early-onset diseases, but the ethics of keeping a known affected animal purely for test purposes, and what to do with affected offspring, can be problematic. Furthermore, the results of test matings may be unreliable. For example, in the case of a recessive disease in which the N allele is normal and n is abnormal, a mating of a suspected carrier (N?) to a known carrier (Nn) which produced six normal puppies would give only an 82.2% certainty that the N? was not a carrier (NN). However, a single abnormal pup would confirm carrier status.

The results of random matings, if performed often enough and with respect to a sufficiently prevalent gene, can provide useful information without the need to maintain a carrier or affected animal, and with less likelihood of breeding unwanted affected individuals.

Specific tests for diseases include ultrasonography and histopathology for polycystic kidney disease, MRI for syringomyelia, and von Willebrand factor assay for von Willebrand's disease. Some laboratories will test samples using enzyme and immunological assays to detect diseases, and the results may indicate whether an individual is a homozygote or heterozygote. An example of this is testing for haemophilia B. A defect in an affected protein's size, function or amount allows the identification of carriers of a disease in some cases, although there may be an overlap with normal values. Also, compensatory rises in other proteins, such as an isoenzyme related to pyruvate kinase in pyruvate kinase deficiency, may reduce the accuracy of this sort of test.

Causal molecular defects have been identified for some inherited diseases. Examples identified on the X chromosome include haemophilia B, severe combined X-linked immunodeficiency and hereditary nephropathy. Some autosomal recessive traits for which the mutation has been identified include copper toxicosis in Bedlington Terriers, progressive retinal atrophy in Irish Setters, von Willebrand's disease in Scottish Terriers and pyruvate kinase deficiency in Basenjis.

Many specific DNA tests are now commercially available to identify genetic diseases, and the number of tests is increasing rapidly, to include tests for such diverse diseases as degenerative myelopathy, von Willebrand's disease, copper toxicosis and anal furunculosis.

Specific DNA test results for diseases should be interpreted with caution, and what may seem a clear-cut result may often be misleading. For example, a positive genetic test result for degenerative myelopathy means the individual is at some risk for developing the disease. However, it does not mean that developing the disease is inevitable, nor does it mean that a clinically affected individual does not have another cause of its clinical signs, such as disc disease or neoplasia. Another pitfall is that there may be more than one type of mutation responsible for a disease, particularly between breeds. For example, the mutation causing muscular dystrophy in the Cavalier King Charles Spaniel is different from the one causing muscular dystrophy in the Golden Retriever.

DNA tests are either linkage-based or mutation-based. Linkage-based tests look for a marker gene that is physically near the gene of interest. Mutation-based tests look for the specific mutation causing a disease. Linkage tests may be inaccurate in a small number of cases where chromosomal recombination has occurred in the region between the marker and the mutation.

DNA testing shows great promise for the identification and elimination of genetic diseases

in dogs and cats. The inherited diseases can be identified before an animal is bred, and affected animals can either be removed from the breeding pool or, in the case of recessive traits, bred only to normal individuals, to preserve desirable characteristics. This allows the genetic diversity of breeds to be retained while inherited diseases are eliminated.

The limitations of DNA testing, such as the limited availability of tests, and the fact that its utility is largely restricted to single-gene diseases, mean that there is still a vital role for screening programmes to eliminate inherited diseases. Screening programmes currently in operation in the UK include the British Veterinary Association/Kennel Club programmes for hip and elbow dysplasia and eye diseases, and the International Cat Care scheme for polycystic kidney disease.

EPIDEMIOLOGY

The first and second editions of this book applied relatively loose evidence-based approaches to report on predispositions to diseases in dogs and cats. These evidence-based methods were not explicitly defined and were heavily reliant on expert opinion from textbooks, review articles and conference proceedings. Expert opinion is sometimes called 'eminence-based' veterinary medicine; it represents the personal view of recognized experts or self-appointed commentators without explicit external critical appraisal applied to its quality as evidence. Expert opinion is commonly promulgated as 'evidence' in veterinary medicine, particularly at conferences, in editorials and during undergraduate teaching. However, it is widely considered to be weak evidence at best, unless underpinned by a solid and stated evidential platform (Holmes, 2007). This is because many cognitive biases are inevitably inherent within the belief systems of any individual expert, which also explains why experts so often vehemently disagree on specific issues.

This third edition of *Breed Predispositions to Disease in Dogs and Cats* aims to be more explicit about how the epidemiological results for each breed–disease combination were chosen for inclusion. The book also aimed to cite those references that related to the highest available quality of study designs for each disease. Most of the references in this new book describe original research that has been published in high-quality peer-reviewed journals. To support our new emphasis on reporting quantitative results from primary research, we have penned this introduction to epidemiology, to explain the epidemiologic metrics (e.g. prevalence, odds) that are reported throughout the book. Further information on this fascinating science of epidemiology is available in several useful texts (Thrusfield, 2007; Dohoo *et al.*, 2009; Pfeiffer, 2010).

Epidemiology is the study of disease levels in populations and of factors that determine the occurrence of these diseases. Veterinary epidemiology is a structured scientific approach towards collecting, integrating, analysing and interpreting data on health and demographics at a population level. Epidemiology aims to describe quantitatively the population under investigation. For example, we can define the proportion of German Shepherd Dogs among a known population of dogs [demography] or the proportion of these German Shepherd Dogs with aggression [prevalence] or whether male German Shepherd Dogs have a higher risk of aggression than females [risk factor analysis] (O'Neill *et al.*, 2017a). By identifying key relationships in biological systems, we can develop options for prevention or better diagnosis of future disease cases. New epidemiological evidence is interpreted within the wider body of basic scientific knowledge to contribute towards understanding and solving problems. For example, if we know that Pugs are predisposed to corneal ulceration, then we can recommend that owners are diligent with ocular care and more alert to eye problems in this breed, and that veterinarians are more vigilant during ophthalmological examinations, especially to assess for keratoconjunctivitis sicca (dry eye) which predisposes to corneal ulceration (O'Neill *et al.*, 2016a, 2017b). This evidence-based approach is very different to the traditional anecdotal approach where opinion (no matter how expert) and personal experience are the dominant forces. In the new epidemiological paradigm, data reign supreme.

At its most basic level, there are two main types of epidemiology: descriptive and analytic. Descriptive epidemiology describes the world that is defined by the data under examination in order to understand its demographic, disease or risk-factor features. In the context of the current book, descriptive epidemiology is used to report the frequency of the occurrence of disease within specific breeds. One measure of disease occurrence

is prevalence, which is commonly reported as the proportion or percentage of animals in a group that are affected by the disease at any one point in time (*point prevalence*) or during any specified period (*period prevalence*). So, for example, a statement that the 'St Bernard had 19.4% prevalence for elbow dysplasia in the UK' means that 19.4% of the St Bernard dogs in that study group of dogs in the UK had a diagnosis of elbow dysplasia during that particular study. Prevalence does not draw any distinction between long-standing cases that pre-existed the study period and new cases that were first diagnosed during the study period: these all count equally towards the prevalence total. Cases that are newly diagnosed during a specified period are called *incident cases*. These are reported as either the *incidence risk* (the proportion of animals that were not affected at the start of the study and that are newly diagnosed during the study period) or the *incidence rate* (number of new cases diagnosed divided by the sum of the length of time at risk for each animal in the study overall). Incidence rate is a useful measure to assess the rapidity with which animals develop disease over time.

Measures that describe deaths associated with specific diseases are called mortality. These are very useful pieces of data that offer information on the severity and impact of the condition. The *mortality rate* is derived similarly to the incidence rate and reports the number of deaths during a specific period diagnosed divided by the sum of the length of time at risk of death for each animal in the study overall. *Case fatality* describes the probability of death in affected animals. This is generally reported as a proportion (from 0.0 to 1.0) or percentage (0% to 100%) that describes the number of deaths divided by the total number of animals diseased.

Whereas descriptive epidemiology describes patterns of disease and can report absolute values for disease (e.g. prevalence tells us what percentage of a group of animals have a disease of interest), analytic epidemiology explores risk factors for diseases. *Risk factors* are attributes of an animal that affect its probability of developing a specific disease. For example, important risk factors for patellar luxation in dogs include bodyweight, breed, age, sex and neutering (O'Neill *et al.*, 2016b). In the context of this book, breed is the most important attribute that we explore as a risk factor for disease. A key feature of analytic epidemiology is that it requires a comparison group. If we aim to identify whether some category within a risk factor increases the probability of disease, we need to compare this probability to some other category and then report the relative results. For example, in relation to sex as a risk factor, we might choose to compare disease levels in males versus females to assess whether being male is associated with increased probability of a disease such as epilepsy (Kearsley-Fleet *et al.*, 2013). These comparative results can be reported using metrics such as *risk ratio* or *relative risk* (RR), *odds ratio* (OR) or *incidence risk/rate ratio* (IRR). The reader will see these terms used throughout this book. These metrics report the relative value for the risk-factor category of interest compared with the baseline (comparator) category. These ratios can be broadly interpreted in a equivalent way: a value above 1.0 suggests an increased probability of disease whereas a value below 1.0 suggests that the category is protective and may be associated with reduced probability of disease.

When exploring breed as a risk factor for disease, it is very important to select a logical comparator group to assist meaningful inference from the results. Options for the breed comparator group include 'all dogs in the study', 'all remaining dogs in the study', 'all crossbred dogs', or even another specified 'single breed'. Swapping the comparator category from a group with a low risk of disease to a group with a high risk of disease can cause an odds ratio to change from above 1.0 to below 1.0 and give an illusion of reversal of risk. From this, it is clear that we must interpret results with great care. As Mark Twain aptly observed, 'There are three kinds of lies: lies, damned lies, and statistics.'

A *census* is an epidemiological study that examines every animal in a population and can give an exact (true) value for the overall population, provided that all other aspects of the study design are perfect. However, owing to financial and logistical constraints, most epidemiological studies rely on just subsets (*samples*) of the overall population and are therefore restricted to reporting values that can then be extrapolated from the sample to the overall population. Statistical methods allow studies to report the exact value for the sample and then also to provide a spread of lower and higher values between which the study is 95% confident the true value in the wider general population lies.

This spread is called the 95% confidence interval (often abbreviated to 95% CI) and defines the statistical uncertainty associated with the reported measure of disease occurrence. The *power of a study* to confidently report precise results increases as the study sample size increases. This means that larger and possibly more reliable studies can report narrower spreads for the 95% CI; in other words, they have greater *precision*. When interpreting results, it is very important to examine not just the central exact value for the sample but also the width of the 95% CI that describes the inference for the wider population. A wide spread for the 95% CI suggests that the study was low-powered (i.e. a small sample size) and that precise conclusions may be difficult or unsafe to accept (Poole, 2001). The 95% CI for a prevalence value can be interpreted loosely as the range of values within which we are 95% confident that the true prevalence in the wider target population exists. For an odds ratio or risk ratio, if the lower limit of the 95% CI is above 1.0, then we can be highly confident ($p < 0.05$) of an increased odds/risk compared with the comparator group.

The *p-value* is another tool that helps to infer the strength of evidence for statistical results. Ideally, all analytic test results should report an associated p-value. The p-value defines the probability (from 0.0 to 1.0) of obtaining a result equal to or more extreme than what was observed, generally assuming that there is no true difference between the groups under comparison. A very low p-value describes a very low probability that the current result would have been found if there truly was no difference between the groups, and therefore we interpret this as suggesting that the groups are likely to truly differ. Previously, a simplistic approach was taken to the interpretation of the p-value, whereby any value less than 0.05 was taken as being 'statistically significant' and many older papers just reported whether p-values were above or below this cut-off. While many sources continue to use this heuristic, it is preferable to report the actual p-value for fuller interpretation by the reader in conjunction with other aspects of the result such as the size of the effect, the width of the confidence interval and the nature of the comparator groups chosen (Jeffery, 2015).

Causality (causation) deals with interpretation of possible causal relationships between a risk factor and a disease. A true causal relationship (i.e. the risk factor can be stated as an absolute cause of the disease) is often very difficult to establish, even in the face of large volumes of supporting evidence. Most diseases have a complicated web of genetic, epigenetic, environmental and temporal factors that interact to promote disease occurrence. Even then, there may be random elements in play that determine which individuals from an apparently similar group get diseased. The relative effects and directions of causal factors can be problematic to unravel and quantify. For this reason, it is generally wise to avoid ascribing causality to risk factors, but instead to report just what the evidence usually suggests, which is an association. For example, rather than saying that 'being a Yorkshire Terrier causes patellar luxation', it is safer to say that 'there is an association between being a Yorkshire Terrier and having patellar luxation' (McGwin, 2010; O'Neill *et al.*, 2016b).

Many of the diseases investigated in the early days of epidemiological analyses had relatively simple and direct causal pathways. Exposure to a risk factor such as canine distemper virus regularly resulted in a very clear disease outcome called distemper. In such cases, analyses that only took account of a single risk factor (variable) were often adequate to answer the research question about probable causality. Such analyses are called *univariable* and explore associations between just one risk factor and a disease outcome. Nowadays, however, most of these 'simple' questions have already been answered and we are left with the more complex questions where multiple causal factors may be implicated in disease: the web of causation. To answer these multifactorial questions, we need more complex statistics called *multivariable* analyses that account for several variables in a single analysis. Thankfully, modern computing power now enables most researchers to carry out multivariable analysis easily and the cautious reader should seek out multivariable results rather than just to accept the more simplistic and possibly misleading findings from univariable analyses.

Confounding is a critically important concept when trying to understand the web of factors associated with disease occurrence. Confounding (meaning 'mixing up' or 'confusing') occurs when the effects of the risk factor of interest (e.g. breed) are mixed up with some other associated factor that is also associated with the disease outcome. Pet insurance is a good example of possible confounding. It is now well established that insured

pets are more likely to have disease diagnosed than uninsured pets, especially for those diseases that are more expensive or complicated to diagnose. It is also the case that certain dog breeds are more likely to be insured than others because of breed-related owner attitudes or differential pricing of policies by insurers, among other reasons. Consequently, a simple (univariable) analysis that directly reports the odds of diagnosis of a specific disease between two breeds of dog that have differing levels of pet insurance may appear to show the more insured breed as apparently more diseased. However, a multivariable analysis that also takes insurance into account can remove the effects of the differential uptake of insurance across the breeds and give a truer comparison of inherent predisposition between the breeds. Confounders, both known and unknown, should always be considered when planning studies, and especially when interpreting the results from any study.

Epidemiological studies are population-based analyses. This means that they are essentially reporting the cases (the *numerator*) that are identified from some underlying group of animals (the *denominator*). We often place inordinate focus on the numerator animals, because these are the ones with the disease of interest, but we ignore the denominator population at our own peril. It is critical to learn as much as possible about the denominator population so that we can extrapolate study results safely to wider or different populations. We especially need to know where these denominator animals lived (e.g. the UK or the USA), the dates for the study (e.g. 1990 or 2010), and some basic demography on these animals (e.g. ages, breeds, insurance). These key pieces of information are needed to assess the representativeness of the sample animals for the target population within that study. Additionally, this information allows comparison with our own population of interest so that we can evaluate the generalizability of the results, for example, in the same breed but in a different country and 10 years after the original study. The astute epidemiologist recognizes that time and location/setting are associated with many other 'hidden' changes such as economics or DNA testing that may affect the propensity for true or apparent disease diagnosis/occurrence.

Epidemiological studies rarely examine true disease status (i.e. whether an animal is truly diseased or not in the real world) but instead generally apply some belief or knowledge about the disease status. Hence, the same individual animal at the same time point may have differing disease status recorded depending upon how the data are collected. For example, a puppy with a diagnosis of congestive heart failure from a primary-care veterinary practice may be recorded as a congenital ventricular septal defect case by a referral specialist but may also be recorded as having no cardiac disease by an insurance database if the heart disease preceded the inception of the insurance policy or if the policy did not cover congenital diseases. Meanwhile, the owner of this same animal may record the disease as coughing or collapsing. The fact that none of these disease status reports is incorrect in its own context highlights the importance of carefully stating the case definition for the disease of interest and exploring how the disease data were derived. In this book, we try to help the reader by describing where possible how the data were collected – for example, from an owner survey, from an insurance database, or from referral or primary-care veterinary data.

In summary, epidemiology is the best method yet devised to understand the demography and health of dogs and cats. It can unlock secrets of disease that are otherwise impossible to discover. It can tell us which breeds are predisposed to which diseases. But with great power comes great responsibility. It behoves the user of epidemiology to understand the basics of this science so that we do not abuse or misuse its power.

LONGEVITY: UNDERSTANDING AND INTERPRETING THE DATA

Longevity (lifespan) and mortality (causes of death) statistics offer tantalizing prospects for unique insights into health and welfare variation in domestic dogs. However, interpretation of published statistics is fraught with pitfalls for the unwary, who may rush to draw conclusions without deeper consideration about such data drawn from various sources. Longevity (lifespan) is hugely uncertain for any individual animal and can be heavily influenced by unexpected disease, environmental effects or accidents. However, estimating average longevities for general populations of animals (e.g. a specific breed) can

be much more accurate, especially for comparison across breeds within restricted geographical and temporal limits taken from the same dataset.

We considered adding data on longevity for each breed into this edition to provide another perspective on comparative breed health that might act as a proxy value for the summative effects of all diseases within each breed. After all, surely the average duration that a breed lives should be an excellent and trustworthy measure of the health of that breed. But could it really be so simple? Following prolonged consideration, we rejected the option of adding longevity because of current limitations on the availability of reliable comparative population-based data, and because there are many caveats to the use of such data that often go unrecognized or ignored. However, to provide some information on breed longevity, and to highlight some of the pitfalls to the safe interpretation of these data, Table 1 shows some longevity results from the VetCompass Programme in the UK that illustrate apparently wide lifespan variation across breeds. Many other reports have shown similar results (Michell, 1999; Proschowsky *et al.*, 2003b; Adams *et al.*, 2010; Fleming *et al.*, 2011).

Reviewing the data shown in Table 1, the reader may feel very comfortable to accept these longevity values across a range of breeds as incontrovertible evidence that can rank breeds based on the summative effects of their general health, robustness and proclivity to disease. There are several other sources of good published evidence on longevity in dogs and cats that appear to tell a similar story (Proschowsky *et al.*, 2003a, 2003b; Fleming *et al.*, 2011; O'Neill *et al.*, 2013a). However, a good conceptual grasp of longevity is needed before we can safely move from our current position of data access to a position of data understanding and thence to a desired position of new beliefs (Proschowsky *et al.*, 2003a, 2003b; Fleming *et al.*, 2011; O'Neill *et al.*, 2013a). 'Having data' and 'understanding data' are not always synonymous.

Firstly, it is worth emphasizing that longevity in dogs is influenced by many factors other than just breed effects. The domestic dog (*Canis lupus familiaris*) exhibits unparalleled morphological diversity, from the 1 kg Chihuahua to the 85 kg Mastiff (Alderton & Morgan, 1993; Neff & Rine, 2006). There is now substantial evidence that average longevity reduces as breeds increase in average body size (Patronek *et al.*, 1997; Michell, 1999; Galis *et al.*, 2007; Greer *et al.*, 2007; Adams *et al.*, 2010; O'Neill *et al.*, 2013a). Lifespan reduction in larger dogs has been attributed to a range of genetic differences and pathological conditions induced by artificial selection and accelerated growth (Galis *et al.*, 2007; Urfer *et al.*, 2007; Fleming *et al.*, 2011; Salvin *et al.*, 2012; Kraus *et al.*, 2013). Consequently, perhaps we should restrict comparison to breeds of similar bodyweight if we wish to compare reliably true breed-related health as opposed to longevity effects that are related to bodysize irrespective of breed. In other words, is it fair to directly compare the lifespans of the Cairn Terrier and the Great Dane from Table 1 and to assume that we can draw safe conclusions about their relative health from these values alone, or are we really just seeing differences that come mainly from comparing small and large breeds?

Euthanasia is another phenomenon in companion animals that needs to be considered when evaluating longevity as an indicator of health. Most humans undergo unassisted (so-called 'natural') deaths, but the converse is generally true for domestic pet species in developed countries. Reported euthanasia rates for dogs vary from 52% to 86% (Gobar, 1998; Michell, 1999; O'Neill *et al.*, 2013a), while 86% of deaths of UK cats involve euthanasia (O'Neill *et al.*, 2015a). By definition, euthanasia means that these animals have died prematurely before reaching the end of their so-called natural lifespan. The average ages at euthanasia may therefore be a highly reliable indicator of the inflection point at which quality of life dips below an acceptable threshold, and therefore may be a better measure of lifetime health than the maximum achievable lifespan up to a 'natural' death (McCutcheon & Fleming, 2001/2002). However, high euthanasia rates in dogs and cats also mean that longevity is influenced heavily by the opinions and decision-making patterns of owners, which may take welfare and suffering into account but may be additionally influenced by economic, performance and social factors. Varying decision-making on the acceptability and timing of euthanasia across breeds, diseases, countries and time could therefore impact differentially on subsequent longevity results. For example, owners may perceive the need for euthanasia differently between larger and smaller breeds for issues such as canine aggression, incontinence, mobility or even surgery, because larger breeds may cost more to treat, pose more risk to owners or offer shorter potential future lives than smaller breeds.

Table 1
Longevity for common dog breeds attending primary veterinary practices in England ranked by median age at death. The interquartile range (IQR), range and number of study dogs are also shown ($n = 5095$) (O'Neill *et al.*, 2013a).

Breed	Median (years)	IQR	Range	No. of dogs
Miniature Poodle	14.2	11.1–15.6	2.0–19.4	20
Bearded Collie	13.7	12.2–14.3	4.0–17.0	25
Border Collie	13.5	11.5–15.0	0.1–19.1	184
Miniature Dachshund	13.5	9.2–14.3	2.0–19.5	25
West Highland White Terrier	13.5	10.4–14.9	0.2–21.0	128
Cairn Terrier	13.4	10.6–15.4	0.2–21.6	27
Jack Russell Terrier	13.4	9.3–15.7	0.0–24.0	298
Shih Tzu	13.3	9.2–15.6	0.0–18.6	79
English Springer Spaniel	13.3	10.4–14.8	0.3–19.4	111
Dalmatian	13.3	11.5–14.0	0.9–17.2	27
Crossbreed	13.1	10.1–15.0	0.0–22.0	1120
Yorkshire Terrier	13.0	10.0–15.1	0.01–20.6	217
Lhasa Apso	13.0	7.7–15.3	0.0–16.7	32
Bichon Frise	12.7	9.5–14.8	0.1–18.5	56
Weimaraner	12.6	11.1–13.5	6.5–17.0	36
Labrador Retriever	12.5	10.6–14.0	0.0–18.0	418
Golden Retriever	12.5	11.0–14.1	0.1–17.6	114
Shetland Sheepdog	12.5	11.7–13.8	8.5–14.6	20
Rough Collie	12.0	9.4–13.8	1.0–17.1	28
Border Terrier	12.0	8.9–13.1	1.2–21.2	31
King Charles Spaniel	12.0	10.0–14.2	0.0–15.3	26
Scottish Terrier	12.0	9.1–12.7	0.3–15.9	21
Cocker Spaniel	11.5	7.5–13.7	0.0–18.0	145
Bull Terrier	11.2	7.3–13.0	1.4–16.3	36
German Shepherd Dog	11.0	9.2–12.9	0.0–18.0	312
Greyhound	10.8	8.1–12.0	2.5–16.3	88
Staffordshire Bull Terrier	10.7	4.7–14.0	0.0–18.1	300
Boxer	10.0	7.7–11.6	0.0–16.5	91
Cavalier King Charles Spaniel	9.9	8.1–12.3	0.0–17.2	124
Dobermann	9.2	6.2–11.0	2.1–13.0	37
Bulldog	8.4	3.2–11.3	0.4–15.2	26
Rottweiler	8.0	5.5–10.2	0.0–16.6	105
Chihuahua	7.1	1.0–11.9	0.0–19.9	36
Mastiff	7.1	2.0–9.0	0.0–13.8	35
Great Dane	6.0	4.0–9.0	0.0–11.0	23
Dogue de Bordeaux	5.5	3.3–6.1	0.0–8.8	21

In the current context of dog and cat breeds, longevity defines the average lifespan for each breed. These longevity values are generally identified using death data from large populations such as referral or primary-care veterinary records, pet insurance data or owner/breeder surveys (Proschowsky *et al.*, 2003b; Bonnett *et al.*, 2005; Adams *et al.*, 2010; Fleming *et al.*, 2011; O'Neill *et al.*, 2013a, 2015a). A steady state of breed popularity over time is a key assumption when using these data for comparison between breeds, but this assumption is rarely true. If the relative proportion of all puppies born each year is constant over a prolonged period for each breed, then the ages at death for each breed should be a reliable indicator of average breed longevity. However, breeds often rise and fall markedly in popularity over time, resulting in waves of young and old individuals for these breeds that complicate the interpretation of subsequent death data. For example, the popularity of Pugs in the UK has increased sharply in recent years, rising from less than 1% of all puppies born before 2008 to 2.8% of puppies born in

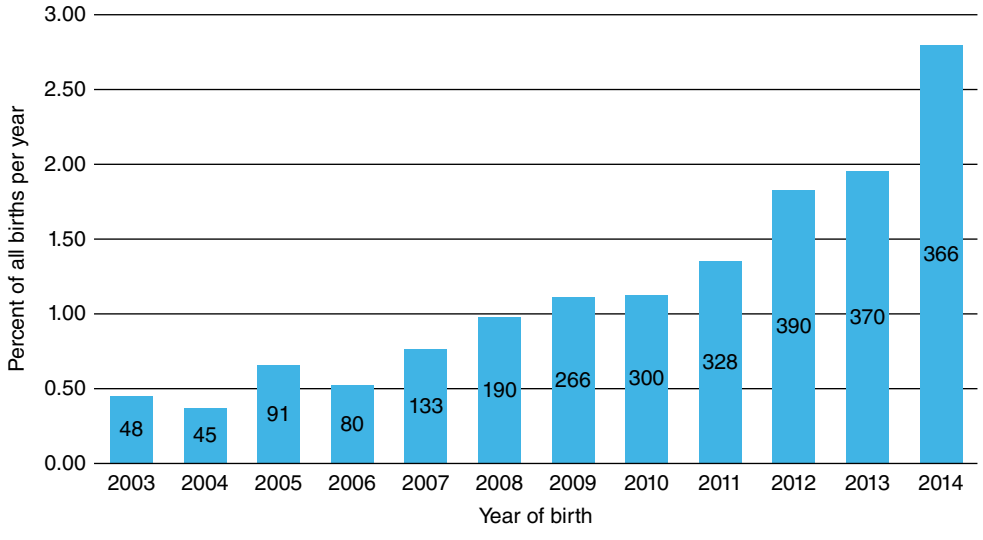

Figure 1
Annual proportional birth rates (2003–2014) for Pugs among all dogs ($n = 263\,456$) attending VetCompass primary-care veterinary clinics in England. The annual birth count of Pugs is shown in each bar (O'Neill *et al.*, 2016a).

2013 (Figure 1). Given that a high proportion of the Pugs that existed in 2014 were therefore young, it follows that younger Pugs have a greater probability of inclusion in mortality statistics compared with breeds that have not recently increased in population counts. Consequently, results from mortality data during 2014 that report the average longevity of Pugs will bias the true age at death for the Pug downwards and give misleading results showing that the breed dies younger than it truly does. The converse effect applies for breeds that are in numerical decline, which have relatively higher proportions of older dogs available to die during any one year. This effect is known as cohort bias, and it renders direct comparisons between average breed longevities highly problematic (Urfer, 2008).

In addition to breed popularity, several other factors that vary across breeds can also influence breed longevity results and complicate comparisons that aim to use longevity as a measure of breed health. Levels of neutering uptake can vary between countries. For example, some Scandinavian countries have historically restricted neutering in dogs to direct health-related purposes, whereas the procedure is routinely promoted in other countries such as the UK for population control and health prophylaxis, with the outcome that much higher proportions of UK dogs are neutered (Anfinsen *et al.*, 2011; O'Neill *et al.*, 2014b). Likewise, pet insurance uptake in dogs varies widely: 0.3–3.0% in America, 4% in Canada, 34.0–40.3% in the UK, 68.4% in Sweden (O'Neill *et al.*, 2014a). Both neutering and pet insurance status are differentially associated with the health status, diagnostic rates and lifespans of dogs, and therefore variable uptake across breeds can influence the longevities achieved by these breeds, independently of inherent breed health characteristics (Egenvall *et al.*, 1998; Hart *et al.*, 2016; O'Neill *et al.*, 2016c; Belanger *et al.*, 2017).

This *Longevity* section started with an unchallenged thesis that longevity, if it could be reliably interpreted, could be a useful metric to evaluate and compare breed health and welfare. But, as we have seen, this is perhaps too simple a perspective, for many reasons. For example, can we even believe that longevity and welfare are linearly related, and that welfare continues to score higher as longevity increases to its maximum? It is not necessarily true that a long life is an indicator of high animal welfare, and perhaps therefore the focus of welfare studies should be more on the quality of the overall life lived, rather than on the quantity. In human medicine, scientists are now turning their attention to the concept of healthspan

(healthy longevity) and towards quantifying both the length and the proportion of lifespan that qualifies as healthspan (Waters, 2011). This is yet another example of how a simple comparative analysis of breed longevity could direct the unwary towards unsafe conclusions.

METHODS

This third edition of *Breed Predispositions to Disease in Dogs and Cats* has substantially bolstered the scientific methods used in the two earlier editions in order to place stronger emphasis on compliance with modern principles of evidence-based veterinary medicine (EBVM) (Holmes, 2007). In line with this progression, this new *Methods* section explains the processes followed during the literature searching and reporting in the current edition, while the *Epidemiology* section (above) describes the epidemiological approaches used.

Information on breed predispositions is available from a wide variety of sources. *Primary sources* of information describe original studies and show the information that was first published. For instance, for a scientific study that describes the common diseases of dogs in England, the primary source is the paper originally published by the scientists who performed the research, 'Prevalence of disorders recorded in dogs attending primary-care veterinary practices in England' (O'Neill *et al.*, 2014b). *Secondary sources* are documents such as websites, the press, books, editorials and review articles that may include information taken from primary sources. In relation to the paper describing the common diseases of dogs in England, a secondary source might be a newspaper article entitled 'Pedigree dogs "as healthy as mongrels", say vets' (Copping, 2014). Such sources often add further discussion or interpretation that extends or does not necessarily reflect the true intent of the original primary research, that may cherry-pick certain aspects of the original research, or that may not be completely accurate. While secondary sources can make for interesting general reading, they may not always tell an accurate story, or the full story, or an unbiased story. Consequently, it is wise to validate secondary reports by following the trail back to the original primary research before accepting the veracity of any conclusions.

Human medicine moved towards applying more rigorous standards for defining information sources that were 'good evidence' in the 1980s, and the Cochrane Collaboration aimed to provide clinicians with valid publications and guidelines to assist improved decision-making in public health from 1993 (Cochrane, 2017). Later, in the 1990s, evidence-based medicine (EBM) was recognized in human medicine as a distinct discipline that should be founded on the best available clinically relevant research (Sackett *et al.*, 1996). Since then, evidence-based veterinary medicine (EBVM) has become increasingly accepted in the veterinary field and is similarly reliant on understanding and using the most reliable sources of evidence when making decisions or developing beliefs (Cockcroft & Holmes, 2003).

A critical aspect of EBVM is to identify the most reliable sources of evidence from the ever-increasing deluge of information that is available in the modern era of electronic publication and data dissemination. The hierarchy of evidence quality is stylized as a pyramid that narrows progressively from the wider volume of lower reliability material at the base to a smaller volume of higher reliability material at the tip (Figure 2). The higher quality evidence towards the top of the pyramid tends to be individual or amalgamated analyses based on well-designed original pieces of research (studies) that have been through the peer-review process. These high-quality studies are designed to reduce selection or information biases, to be large enough to reduce random error, and to have appropriate statistical analytic methods (Vandeweerd *et al.*, 2012). Although there is some debate about whether the study design or the quality of the execution are more important for validating the reliability of the results, it is generally accepted that the pyramid of evidence is a useful model for the quality of evidence (Rosner, 2012). This EBVM aspiration was at the forefront of our minds when we designed the research and reporting methods for the current edition. Where possible, we aimed to reference only original peer-reviewed scientific publications and to avoid the inclusion of conference proceedings, review articles, editorials, websites or veterinary textbooks.

The research and writing process that we used was as follows. Each of the three authors was allocated a random subset of breeds for which

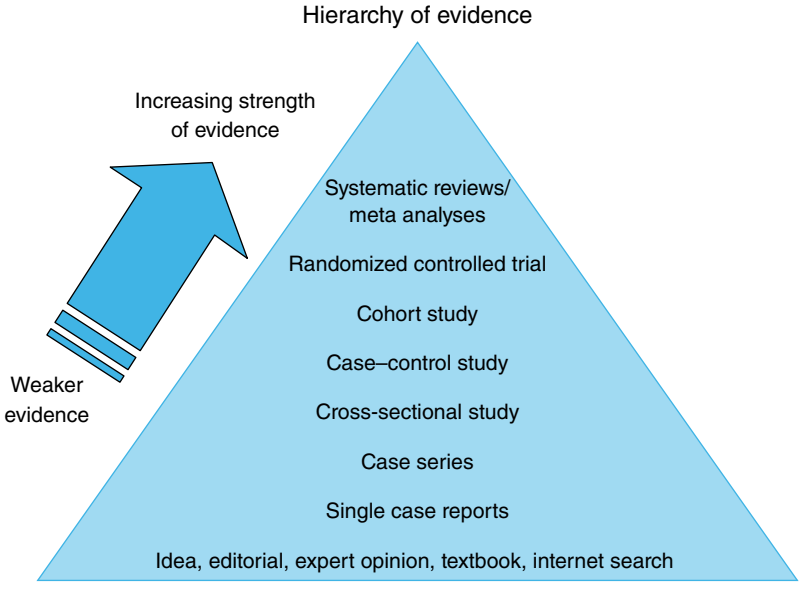

Figure 2
Hierarchy of evidence quality.

we aimed to identify all disease predispositions with sufficient supporting evidence. A breed was considered predisposed to a disease if some available evidence reported an increased incidence, prevalence or risk compared with an appropriate comparator group, preferably within a peer-reviewed primary publication. Specifically, where an odds ratio, a risk ratio or an incidence ratio was the reported metric of comparison, this ratio value would be greater than 1.0 and be supported by a p-value of < 0.05 or by a 95% confidence interval that spanned values entirely greater than 1.0.

Each author followed the same general literature search strategies to ensure that the probability of disease discovery was similar across the breeds. The literature search covered a spectrum of electronic bibliographic databases including *CAB Direct*, *Google Scholar*, *IVIS* (International Veterinary Information Service), *PubMed*, *Science Direct*, *Veterinary Information Network* and *Web of Knowledge*. The precise search strategies included various keyword search combinations from relevant categories, including [BREED NAME], [DISEASE NAME], INHERIT*, HERED*, CONGEN*, GENETIC* and PREDISPOS*.

Relevant findings were merged from multiple searches for each breed. Analytic studies reporting the results of comparative studies that reported increased incidence or prevalence in the breed of interest compared with some other meaningful comparator group (e.g. crossbreds) were prioritized. Where this level of evidence was not available, high-quality descriptive studies were accepted. We also accepted results from genetic studies that identified the mutations for specific diseases or evidence of inheritance within the specified breeds in combination with some evidence of increased incidence or prevalence. Case reports, studies conducted on laboratory research animals, and literature not published in the English language were generally excluded. The constraints of working within the available literature meant that a variety of comparator groups were accepted; these included 'all study dogs', 'all remaining study dogs', 'all crossbred dogs', or single or a combination of other breeds. If an author was in doubt about a source, then all three authors independently reviewed the original article to reach a majority consensus. From the final list of accepted publications, available information was extracted that described (1) the predisposed breed and disease, (2) the strength of the predisposition and the comparator group, (3) the geographic location, (4) the authors and date of the original publication, and (5) any other information of potential relevance such as inheritance and

signalment (e.g. sex or age) associations. These metadata were summarized and reproduced in this book.

For breed predispositions with several supporting publications, we applied some criteria to decide which publications to include in the book. Reports that were larger, more recent and had stronger study designs according to the pyramid of evidence (Figure 2), or those papers that provided evidence on the genetic mechanisms, were favoured for inclusion. Preference was also given to references based on studies with larger underlying denominator populations or those that were deemed more representative of the wider populations. Priority was additionally given to studies based on multivariable statistical analyses rather than univariable results. Multivariable statistical methods take account of multiple risk factors when reporting the breed effects and therefore account for confounding effects from other factors such as insurance status, age and neutering in order to provide less biased inference (O'Neill *et al.*, 2013b).

The lists of breeds included in the current edition have been extended from those presented in previous editions. The current edition includes predispositions to over 650 diseases across 204 breeds of dog and 45 breeds of cat. In line with moves towards international standardization of veterinary language, the breed names and synonyms used in this edition were based on the breed lists available within the VeNom coding system (VeNom Coding Group, 2017) along with additional breed terms identified from the VetCompass Programme database (VetCompass, 2017). This third edition defined breed and purebred as any dog types that were achieved through the process of selective breeding and that would breed true. *Breeding true* was taken to mean that when any two individuals from the same breed are mated, their progeny show consistent, replicable and predictable characteristics typical of the parents. *Pedigreed* animals were defined as that subset of individual breeds with known parentage for several generations. The terms *crossbred* and *mixed breed* were taken as synonyms to describe any dog types that were not a purebred, regardless of whether their parentage was known or not.

In this edition, we have aimed to include only information on disease predisposition. A contrarian approach that we contemplated as a useful adjunct towards improved understanding of breed health was to also include evidence for diseases against which specific breeds are protected (i.e. they are less likely to get this disease than a comparator group of animals). Ultimately, however, we did not tackle this task in the current text because there is little information published on disease protection within breeds, but it may be included in a future edition.

Usage of the term 'inherited' was downplayed in the current edition, because it is now recognized that the majority of diseases in dogs and cats have both inherited and environmental components to their causality. For example, information on the inheritance of hip dysplasia in dogs has been widely published, and so hip dysplasia is widely considered as an inherited disorder (Lewis *et al.*, 2011b; Wilson *et al.*, 2013). However, age and sex are also known to be associated with hip dysplasia (Witsberger *et al.*, 2008). The current edition therefore uses the term *breed predisposition* to cover the combined effects from all factors (including genetic, epigenetic, environmental and owner-related) associated with increased probability of disease in a given breed.

It is also worth noting that the current edition is restricted to breeds and their diseases with published supporting evidence. It is clear that breed-based research is not carried out at random but may be biased towards common or popular breeds, human translational research, working breeds, laboratory breeds or perceptions of priority topics where funding for research may be more readily available. This means that, while this edition may accurately identify the evidenced predispositions within breeds, this does not necessarily mean that these are the only or even a representative selection of the true predispositions for each breed. As always, absence of evidence is not evidence of absence.

PART I

DOG BREEDS

AFFENPINSCHER

Dermatological conditions

Canine follicular dysplasia (seasonal flank alopecia)

- Reported in a small case series
- In this breed, low plasma levels of sex hormones were not considered the cause of the condition

(Waldman, 1995)

AFGHAN HOUND

Cardiovascular conditions

Heart block

- This breed reported to be predisposed to high-grade second-degree or third-degree heart block in a US case series
- Heavier, older and sexually intact female dogs over-represented

(Schrope & Kelch, 2006)

Musculoskeletal conditions

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- OR 1.9 compared to mixed breeds

(LaFond *et al.*, 2002)

Neurological conditions

Afghan myelopathy

- Reported in two case series
- Considered to be inherited in an autosomal recessive fashion
- Onset in young adolescents

(Averill & Bronson, 1977; Cummings & de Lahunta, 1978)

Ocular conditions

Cataract

- Prevalence of primary cataract 2.36%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)
- Prevalence declined over the years 1964–2003
- Highest prevalence at age 1–2 years in this breed

(Gelatt & MacKay, 2005)

Corneal oedema (due to infection or vaccination with canine adenovirus type 1)

- Increased susceptibility (less commonly seen with the development of canine adenovirus type 2 vaccines)
- Afghans showed a more profound clinical response than Beagles experimentally

(Curtis & Barnett, 1981)

Breed Predispositions to Disease in Dogs and Cats, Third Edition. Alex Gough, Alison Thomas and Dan O'Neill.

Respiratory conditions

Chylothorax

- Usually idiopathic
- Afghan hounds comprised 37.5% of dogs with idiopathic chylothorax and 26.5% of all dogs with chylothorax
- No sex predisposition noted

(Fossum *et al.*, 1986)

Laryngeal paralysis–polyneuropathy syndrome

- Afghans reported to be predisposed
- May be inherited by an autosomal dominant mode

(Burbidge, 1995)

Lung lobe torsion

- Afghans reported to be over-represented compared to hospital population, with 4/22 cases

(Johnson & Feeney, 1984; Neath *et al.*, 2000)

AFRICAN BOERBOEL

Musculoskeletal conditions

Elbow dysplasia

- Common in this breed in South Africa
- >38% incidence
- Males predisposed

(Kirberger & Stander, 2007)

Neurological conditions

Cervical spondylomyelopathy (cervical vertebral malformation, wobbler syndrome)

- Seen in first 2 years of life in this breed
- Reported in a South African case series

(Gray *et al.*, 2003)

AIREDALE TERRIER

Cardiovascular conditions

Dilated cardiomyopathy (DCM)

- Increased prevalence with age
- Approximately twice as common in males as in females
- Thought to be familial or genetic

(Tidholm & Jonsson, 1997)

Electrocardiographic abnormalities

- All 42 dogs of this breed investigated in a screening survey had ECG abnormalities
- Abnormalities included mean electrical axis deviations, low-voltage QRS complexes and first-degree AV block

(Amberger *et al.*, 1996)

Dermatological conditions

Grass awn migration

- Increased prevalence in this breed compared to hospital population
- Common in the summer months

(Brennan & Ihrke, 1983)

Canine follicular dysplasia (seasonal flank alopecia)

- Neutered females predisposed
- A marked predilection in this breed implies a genetic basis for this group of diseases
- Hair loss begins at 2–4 years of age and occurs mainly on the flank

(Miller & Dunstan, 1993)

Endocrine conditions

Hypothyroidism

- Breed at increased risk ($p < 0.01$)
- Genetic component suspected
- May occur at a younger age in breeds at risk (2–3 years)
- Ratio of affected males:females higher in at-risk breeds compared to non-high-risk breeds

(Milne & Hayes, 1981; Larsson, 1986)

Haematological/immunological conditions

Haemophilia B

- Severe factor IX deficiency in this breed
- Familial in this breed

(Brooks, 1999)

von Willebrand's disease (vWD)

- Type I seen in this breed

(Brooks, 1999)

Musculoskeletal conditions

Congenital umbilical hernia

- This breed reported to be significantly over-represented
- Females reported to be at excess risk

(Hayes, 1974a)

Hip dysplasia

- OR 3.9 compared to mixed breeds
- Neutered male dogs predisposed

(LaFond *et al.*, 2002)

Neoplastic conditions

Bladder and urethral tumours

- Airedales significantly over-represented compared to a hospital population
- Male:female ratio 1.95:1, but this was not statistically significant ($p > 0.05$)

(Norris *et al.*, 1992)

Nasal cavity tumours
- Breed at increased risk in a US teaching hospital case series
- Relative risk (RR) 4.6 (95% CI 2.24–9.25)
- Median age 9 years
- Males over-represented in most studies

(Hayes *et al.*, 1982)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)
- Breed at moderately increased risk in a Finnish population

(Niskanen & Thrusfield, 1998)

AKBASH

See *Turkish Shepherd Dog*

AKITA INU

See *Japanese Akita Inu*

ALASKAN HUSKY

Endocrine conditions

Hypothyroidism (lymphocytic thyroiditis)
- Breed with a higher prevalence of thyroid hormone autoantibodies (THAA)
- In a cohort study of 287 948 serum samples from dogs in the USA with clinical signs of hypothyroidism, Huskies had an OR of 1.45 ($p = 0.001$) of being affected compared to dogs of all other breeds
- Across the study, females were over-represented, and the highest prevalence was in dogs 2–4 years old

(Nachreiner *et al.*, 2002)

Neurological conditions

Lysosomal storage disease – GM_1 gangliosidosis
- Autosomal recessive inheritance; mutation identified
- Symptoms include proportional dwarfism and neurological deficits (ataxia and dysmetria) from 5–7 months of age

(Kreutzer *et al.*, 2005)

Mitochondrial encephalopathy
- Inherited, mutation identified
- Genetic defect at the level of the thiamine transporter

(Vernau *et al.*, 2015)

ALASKAN KLEE KAI

Haematological/immunological conditions

Factor VII deficiency
- 6/18 client-owned dogs of this breed had this deficiency in an American study
- Inherited condition

(Kaae *et al.*, 2007)

ALASKAN MALAMUTE

Endocrine conditions

Hypothyroidism
- More than 30% of Malamutes had a low T_4 in a sample of 2033 dogs of various breeds, compared to 10% for Dachshunds and Schnauzers
- Median TSH concentration significantly lower in this breed in a series of 693 dogs from 7 different breeds
- American populations studied

(Blake & Lapinski, 1980; Hegstad-Davies *et al.*, 2015)

Gastrointestinal conditions

Pancreatitis
- This breed reported to be predisposed in a Hungarian series of 80 cases

(Pápa *et al.*, 2011)

Haematological/immunological conditions

Stomatocytosis
- Reported in a few cases of Malamutes with chondrodysplasia in a Canadian study
- May be associated with anaemia

(Fletch & Pinkerton, 1972)

Musculoskeletal conditions

Alaskan Malamute chondrodysplasia
- Autosomal recessive inheritance with complete penetrance and variable expression
- American population studied

(Sande *et al.*, 1982; Bingel *et al.*, 1985)

Cranial cruciate ligament (CCL) disease
- Prevalence in this breed 3.25% (OR 1.29, 95% CI 1.10–1.50; $p = 0.018$)
- Population studied was from 27 teaching hospitals in the USA
- Neutered female dogs predisposed

(Witsberger *et al.*, 2008)

Hip dysplasia
- 7.8% prevalence (OR 2.33, 95% CI 2.10–2.58; $p < 0.001$)
- Population studied was from 27 teaching hospitals in the USA
- Neutered male dogs predisposed

(Witsberger *et al.*, 2008)

Neoplastic conditions

Tracheal and laryngeal tumours
- 5/26 dogs in a series and literature review were Alaskan Malamutes
- 10 of the 26 cases in the study were a Spanish population, the rest were a worldwide literature review

(Ramírez *et al.*, 2015)

Sebaceous gland tumours
- Breed at risk of sebaceous adenoma and epithelioma in case series
- American population

(Scott & Anderson, 1990)

Neurological conditions

Idiopathic polyneuropathy in Alaskan Malamutes
- Affects mature young adults
- Previously considered eliminated by breeding programmes, but more cases have arisen recently in the USA and northern Europe
- Autosomal recessive inheritance due to a single gene mutation

(Braund *et al.*, 1997; Bruun *et al.*, 2013)

Ocular conditions

Cone degeneration (hemeralopia or day blindness)
- Autosomal recessive inheritance
- Different underlying mutations reported in American versus Australian populations

(Seddon *et al.*, 2006; Sidjanin *et al.*, 2002)

ALSATIAN

See *German Shepherd Dog*

AMERICAN BULLDOG

See *Bulldog – American*

AMERICAN COCKER SPANIEL

See *Cocker Spaniel*

AMERICAN ESKIMO

See *Eskimo Dog*

AMERICAN PIT BULL TERRIER

Gastrointestinal conditions

Parvovirus enteritis

See under *Infectious conditions*

Infectious conditions

Babesiosis
- High incidence reported in this breed in a number of countries, including USA, Australia and Romania
- In Romania, significantly associated with fighting-dog breeds, especially American Pit Bulls

(Birkenheuer *et al.*, 2005; Jefferies *et al.*, 2007; Imre *et al.*, 2013)

Parvovirus enteritis
- Breed at increased risk in cases series
- Age 6 weeks to 6 months at higher risk

(Houston *et al.*, 1996)

Ocular conditions

Retinal dysplasia
- Reported in one purpose-bred colony from a single affected founder dog in Brazil
- Authors extrapolate that this condition is inherited in this breed
- Autosomal dominant inheritance

(Rodarte-Almeida *et al.*, 2016)

Renal and urinary conditions

Urolithiasis – cystine
- Breed at significantly increased risk in case series

(Case *et al.*, 1992)

AMERICAN STAFFORDSHIRE TERRIER

Behavioural conditions

Aggression

- A genetic basis for aggression has been described
- American Staffordshire Terrier was reported with high aggressivity in Italy
- 5/16 cases which involved repeated biting or shaking of the victim were this breed (all male dogs)

(Notari & Goodwin, 2007; Zapata *et al.*, 2016; Wright, 1985)

Cardiovascular conditions

Arrhythmia

- American Staffordshire Terrier had the highest prevalence (28.6%) of supraventricular arrhythmias among referred cardiology cases in Poland

(Noszczyk-Nowak *et al.*, 2017)

Congenital heart disease

- Includes a range of congenital heart disorders
- OR 4.2 compared with all referral dogs in Italy

(Oliveira *et al.*, 2011)

Dermatological conditions

Atopic dermatitis (atopy)

- In this breed, symptoms started between 1 and 2 years of age more often than at other ages
- Incidence rate (IR) 7.6 per 1000 DYAR (95% CI 4.2–11.0)
- Hungarian and Swedish populations studied
- This breed frequently has adverse reactions to food

(Nødtvedt *et al.*, 2006; Tarpataki *et al.*, 2006)

Demodicosis

- An inheritance pathway has been described
- This breed had the highest odds of juvenile-onset generalized demodicosis: OR 35.6 (95% CI 4.6–277.0) compared with an overall US first-opinion population

(It *et al.*, 2010; Plant *et al.*, 2011)

Endocrine conditions

Hypothyroidism

- Females and younger dogs are predisposed to having serum thyroid hormone autoantibodies (THAA) that are associated with hypothyroidism
- American Staffordshire Terrier had OR 1.78 ($p = 0.001$) for THAA compared with all other breeds

(Nachreiner *et al.*, 2002)

Infectious conditions

Babesiosis

- Purebreds and dogs living in rural areas predisposed, especially in the autumn and spring
- American Staffordshire Terrier was significantly over-represented, with a prevalence of 33.3% among dogs in Poland showing typical symptoms of babesiosis

(Adaszek *et al.*, 2011)

Musculoskeletal conditions

Cranial cruciate ligament (CCL) disease

- Estimated heritability of 0.48 and is a highly polygenic complex trait
- Neutered and older individuals are predisposed
- OR 1.62 (95% CI 1.42–1.82) compared with an overall referral population in the USA
- American Staffordshire Terrier had 6.5% prevalence, compared with 1.58% overall in referred dogs in the Czech Republic

(Nečas *et al.*, 2000; Witsberger *et al.*, 2008; Baker *et al.*, 2017)

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- OR 2.0 compared to mixed breeds

(LaFond *et al.*, 2002)

Neoplastic conditions

Canine cutaneous histiocytoma

- OR 2.60 (95% CI 1.45–4.68) compared with crossbreeds in the USA

(Goldschmidt & Mcmanus, 2000; Fulmer & Mauldin, 2007)

Lymphoma

- German population
- Two comparison populations: own clinic ($n = 52$ 142) and insured population ($n = 123$ 423)
- Odds ratios 3.3 and 4.6 respectively for the two populations

(Ernst *et al.*, 2016)

Mast cell tumour (MCT)

- Mean age at presentation between 7.5 and 9 years, but can occur at any age
- OR 8.57 (95% CI 5.14–8.13) compared with crossbreeds in Austria

- American Staffordshire Terrier had the third-highest breed RR (7.33) compared with all breeds in laboratory records in the USA
- OR 2.07 (95% CI 1.44–2.99) compared with crossbreeds in the USA

(Goldschmidt & Mcmanus, 2000; Villamil *et al.*, 2011; Leidinger *et al.*, 2014; Mochizuki *et al.*, 2016)

Neurological conditions

Cerebellar degeneration

- Autosomal recessive inheritance suspected
- Prevalence of 1 in 400 estimated in an American population
- Onset 18 months to 9 years
- Described in American Staffordshire Terriers from several countries, and characterized using MRI in Germany

(Olby *et al.*, 2004; Henke *et al.*, 2008)

Severe subacute necrotizing encephalopathy (Leigh-like syndrome)

- Reported in a case series of 17 dogs from seven closely related litters
- Age of onset 6–8 weeks
- Suspected to be inherited

(Collins *et al.*, 2013)

Ocular conditions

Retinal degeneration

- Causative mutations identified in American Staffordshire Terrier in the USA: *PDE6B* deletion mutation and *IQCB1* insertional mutation

(Goldstein *et al.*, 2013)

Renal and urinary conditions

Hyperuricosuria

- American Staffordshire Terrier had 3.17% prevalence of carriers for the mutation in the USA

(Karmi *et al.*, 2010a)

Reproductive conditions

Prostate disorders

- Survey of 72 300 male dogs in a French population
- Prostate disorders included: benign prostatic hyperplasia (45.9%), prostatitis (38.5%), abscesses (7.7%), cysts (5.0%), neoplasia (2.6%)
- OR in this breed 3.8 (95% CI 2.5–5.8)

(Polisca *et al.*, 2016)

ANATOLIAN SHEPHERD DOG

Behavioural conditions

Tail-chasing

- This breed over-represented in a Turkish population

(Yalcin, 2010)

Musculoskeletal conditions

Carpal laxity syndrome

- Turkish population
- 9/43 dogs in a case series were this breed
- 6–8 weeks usual age of onset

(Cetinkava *et al.*, 2007)

AUSTRALIAN CATTLE DOG

Behavioural conditions

Aggression

- 9/33 dog attacks on postal delivery officers in Queensland where breed was reported were Australian Cattle Dogs
- This breed showed increased aggression to strangers in Australia compared to seven other common breeds

(Podberscek & Blackshaw, 1991; Duffy *et al.*, 2008)

Gastrointestinal conditions

Congenital portosystemic shunt

- 13/62 dogs were this breed in an Australian case series
- Large intrahepatic shunts often involve the right liver lobe in this breed (OR 5.6 right vs. left)

(Tisdall *et al.*, 1994; Hunt, 2004; Krotscheck *et al.*, 2007)

Musculoskeletal conditions

Patellar luxation

- This breed reported to be over-represented in a Korean case series of 134 dogs

(Alam *et al.*, 2007)

Neoplastic conditions

Mast cell tumour (MCT)

- Breed at increased risk in an Australian case series of 70 mast cell tumours

(Baker-Gabb *et al.*, 2003)

Neurological conditions

Congenital deafness

- 10.8% prevalence in 899 dogs tested
- Australian population

- Females predisposed, with an OR of 1.7 (95% CI 1.0–2.8)
- Autosomal recessive inheritance with incomplete penetrance
- Heritability of 0.21

(Strain, 2004; Sommerlad *et al.*, 2012)

Hereditary polioencephalomyelopathy of the Australian Cattle dog

- Affects young dogs
- Thought to be due to an inherited biochemical defect

(Brenner *et al.*, 1997)

Neuronal ceroid lipofuscinosis

- Suspected to be autosomal recessive inheritance
- Reported in case reports and a case series forming a US genetic study

(Kolicheski *et al.*, 2016)

Ocular conditions

Cataract

- Suspected to be inherited
- Prevalence of primary cataract 2.32%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005)

Glaucoma – primary

- 1.51% prevalence in this breed in a North American population 1994–2002
- Males predisposed in this breed

(Gelatt & MacKay, 2004a)

Glaucoma – secondary

- More diagnoses than expected in this breed compared to an American hospital population

(Johnsen *et al.*, 2006)

Renal and urinary conditions

Urolithiasis – cystine

- Almost all cases reported were male
- Significantly increased risk of cystine calculus formation in an American population

(Case *et al.*, 1992)

AUSTRALIAN KELPIE

Musculoskeletal conditions

Perineal herniation

- Intact male dogs predisposed
- Mean age of onset: 9.4 years
- This breed reported to be over-represented in an Australian population

(Bellenger, 1980)

Neurological conditions

Cerebellar degeneration

- Autosomal recessive inheritance
- Signs seen at 6–12 weeks
- A 3 Mb region on CFA 3 containing 29 genes identified as the location for the cerebellar abiotrophy mutation in Australian Kelpie in Australia

(Fletcher *et al.*, 2010; Shearman *et al.*, 2011)

Physiological conditions

Pain perception and fear memory resilience

- Selective sweep spanning three megabases on chromosome 3 identified in Australian Working Kelpie
- May be associated with the *HOMER1* gene
- Selection allows Australian Working Kelpies to work effectively in harsh environmental conditions

(Arnott *et al.*, 2015)

AUSTRALIAN SHEPHERD DOG

Dermatological conditions

Sterile nodular panniculitis

- This breed significantly over-represented in a series of 39 dogs in an American population

(Contreary *et al.*, 2015)

Drug reactions

Ivermectin and milbemycin

- Associated with the mutant *MDR1* allele
- 16.6% of dogs of this breed tested had the mutation in an American study from volunteer breeders and owners
- Mutation occurred with a frequency of 46% in this breed in a UK population

(Neff *et al.*, 2004; Mealey *et al.*, 2005; Tappin *et al.*, 2012)

Endocrine conditions

Hyperadrenocorticism (Cushing's syndrome)

- Reported to be common in this breed in a case series of 153 dogs in an American population

(Wood *et al.*, 2007)

Haematological/immunological conditions

Haemophilia A
- Moderate factor VIII deficiency in this breed
- Familial in this breed

(Brooks, 1999)

Selective malabsorption of cobalamin (vitamin B_{12})
- Genetic mutation identified

(He *et al.*, 2005)

Musculoskeletal conditions

Avascular necrosis of the femoral head (Legg–Calvé–Perthes disease)
- Uncommon condition
- OR 1.91 in one study (compared to mixed breeds)

(LaFond *et al.*, 2002)

Neoplastic conditions

Pituitary tumour resulting in hyperadrenocorticism
See under *Endocrine conditions*

Neurological conditions

Epilepsy
- 50 epileptic Australian Shepherds with epilepsy compared to 50 non-epileptic Australian Shepherds in a German population
- 56% had poor seizure control
- Non-merle coat phenotype was associated with poorer seizure control
- Genetic basis suspected

(Weissl *et al.*, 2012)

Ocular conditions

Cataract
- Autosomal dominant inheritance suspected
- Prevalence of primary cataract 1.71%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Mellersh *et al.*, 2006; Gelatt & MacKay, 2005)

Chronic superficial keratitis (pannus)
- Breed at risk in case series, suspected to be inherited
- Age of onset: 4–7 years
- Prevalence and severity increase at higher altitude

(Chavkin *et al.*, 1994)

Collie eye anomaly
- Congenital condition, suspected to be inherited

(Munyard *et al.*, 2007)

Multiple ocular defects
- Autosomal recessive inheritance with incomplete penetrance
- Defects seem to be associated with merles with predominantly white coats
- Defects may include microphthalmia, microcornea, cataract, persistent pupillary membranes, equatorial staphylomas, colobomas and retinal dysplasia

(Gelatt *et al.*, 1981)

Persistent hyaloid remnants
- Congenital, suspected to be inherited
- 13/223 dogs of this breed in a case series were affected by this condition

(Munyard *et al.*, 2007)

Renal and urinary conditions

Urolithiasis – cystine
- Almost all cases reported were male
- Significantly increased risk of cystine calculus formation in an American population

(Case *et al.*, 1992)

AUSTRALIAN SILKY TERRIER

Dermatological conditions

Atopic dermatitis (atopy)
- OR 6.8 (95% CI 2.1–22.2) compared with an overall referral population in Australia

(Jaeger *et al.*, 2010)

Gastrointestinal conditions

Congenital portosystemic shunt
- Usually presents in young dogs
- Referred Australian Silky Terriers (8.5% incidence) had an OR of 9.3 (95% CI 5.5–15.6) compared with an overall Australian referral population

(Hunt, 2004)

Sialocoele
- Australian Silky Terrier was over-represented ($p < 0.01$), comprising 6.6% of cases compared with 1.8% of a referral population in Australia

(Bellenger & Simpson, 1992)

Musculoskeletal conditions

Patellar luxation
- Mainly medial luxation observed, often bilateral

- OR 16.0 (95% CI 3.5–73.7) compared to crossbreeds in the USA, and over-represented in Korea

(LaFond *et al.*, 2002; Alam *et al.*, 2007)

Ocular conditions

Cataract

- 28% of cataracts reported as breed-related in France
- Prevalence of primary cataract 10.29%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)
- Silky Terrier had 22.76% prevalence, compared with 4.04% for crossbreeds in a US referral study

(Gelatt & MacKay, 2005; Bellumori *et al.*, 2013; Donzel *et al.*, 2016)

Toxicity

Cane toad toxicity

- Smaller breeds, and especially terriers, predisposed
- Australian Silky Terrier was the second most affected dog, comprising 14.4% of a referral caseload in Australia

(Reeves, 2004)

AUSTRALIAN TERRIER

Endocrine conditions

Diabetes mellitus

- Swedish population
- Incidence rate (IR) was 183 per 10 000 DYAR (mixed-breed IR 15)

(Fall *et al.*, 2007)

Musculoskeletal conditions

Patellar luxation

- OR 8.0 (compared to mixed breeds) in a US population

(LaFond *et al.*, 2002)

Ocular conditions

Cataract

- Prevalence of primary cataract 4.10%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005)

BASENJI

Gastrointestinal conditions

Immunoproliferative enteropathy (of Basenjis)

- Familial, likely inherited
- Usually presents before 3 years

(Ochoa *et al.*, 1984; MacLachlan et al., 1988)

Haematological/immunological conditions

Pyruvate kinase deficiency

- Inherited as an autosomal recessive trait
- Prevalence of 20 carriers for the disease out of 186 dogs tested in an Australian population in 1978

(Hogg *et al.*, 1978; Whitney & Lothrop, 1995)

Musculoskeletal conditions

Pyruvate kinase deficiency

See under *Haematological/immunological conditions*

Ocular conditions

Persistent pupillary membranes

- Suspected to be genetic
- 75/105 Basenjis affected in one Australian study

(James, 1991; Mason, 1976)

Physiological conditions

Reduced thyroxine levels

- Basenjis have lower T_4 reference range than mixed-breed dogs
- Australian population studied

(Seavers *et al.*, 2008)

Renal and urinary conditions

Fanconi syndrome

- Familial, autosomal recessive inheritance suspected
- 10% Basenjis in the USA affected in one study
- 37% 'probably carriers' and 6% 'probably affected' in a Czech and German population
- Females outnumbered males 3:1

(Bovee *et al.*, 1978; Noonan & Kay, 1990; Načeradská, 2009)

Urolithiasis – cystine

- Almost all cases reported were male
- Significantly increased risk of cystine calculus formation in an American population

(Case *et al.*, 1992)

BASSET HOUND

Dermatological conditions

Malassezia dermatitis

- This breed significantly over-represented in American and UK case series
- Predisposition in this breed to overcolonization with yeast thought to be due to a primary keratinization defect and/or the presence of deep skin folds

(Bond *et al.*, 1996; Mauldin *et al.*, 1997; Guillot *et al.*, 2003)

Primary seborrhoea

- Probably inherited as an autosomal recessive trait
- Signs first appear at an early age and get worse
- In this breed, otitis, greasy seborrhoea and dermatitis are seen, often in the body folds

(Bond *et al.*, 1998)

Skin tumours

See under *Neoplastic conditions* (*Trichoepithelioma*)

Gastrointestinal conditions

Gastric dilatation/volvulus (bloat, GDV)

- Breed ranked seventh-highest at risk in a case series
- Increased weight generally increased risk, but Basset belonged to the lowest weight class of all the purebred dogs in this study

(Glickman *et al.*, 1994)

Mycobacterium avium complex infection

See under *Infectious conditions*

Haematological/immunological conditions

Hereditary thrombopathy

- Also known as Basset Hound thrombopathia
- Familial, autosomal recessive inheritance
- Reported in Canadian and American case series
- Signal transduction defect in this breed

(Patterson *et al.*, 1989; Brooks, 1999)

Severe combined immunodeficiency

- Inherited as an X-linked recessive trait
- Thymic hypoplasia and lymphopenia seen

(Perryman, 2004)

Infectious conditions

Malassezia dermatitis

See under *Dermatological conditions*

Mycobacterium avium complex infection

- Reported in a small American case series
- Possibly due to an inherited defect in cell-mediated immunity

(Carpenter *et al.*, 1988)

Musculoskeletal conditions

Elbow dysplasia

- Ununited anconeal process (OR 2.7 compared to mixed breeds) and fragmented coronoid process (OR 19.5) seen in this breed
- In Basset Hounds, ununited anconeal process is secondary to non-traumatic premature closure of the distal ulnar growth plate
- Also reported to be at increased risk in an American case series of 284 dogs with this condition

(Hayes *et al.*, 1979; LaFond *et al.*, 2002)

Inguinal/scrotal herniation

- Significantly increased risk in an American case series

(Hayes, 1974a)

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- OR 3.5 compared to mixed breeds

(LaFond *et al.*, 2002)

Patellar luxation

- OR 2.0 compared to mixed breeds

(LaFond *et al.*, 2002)

Neoplastic conditions

Nasal cavity tumours

- Breed at increased risk in a US teaching hospital case series
- RR 3.3 (95% CI 1.89–5.83)
- Median age 9 years
- Males over-represented in most studies

(Hayes *et al.*, 1982)

Trichoepithelioma

- Breed at risk in an American case series

(Scott & Anderson, 1991)

Neurological conditions

Cervical spondylomyelopathy (cervical vertebral malformation, wobbler syndrome)

- 12/224 cases were Bassets in a British series

(Lewis, 1989)

Intervertebral disc disease (IVDD)

- 10/229 dogs were Bassets in an American study
- This breed typically has its first episode of this disease at a greater age than other breeds
- Ratio of back length to height at withers is positively associated with increased risk

(Mayhew *et al.*, 2004; Packer *et al.*, 2013)

Lafora's disease

- Reported in this breed in several case reports and a German histological study
- Hereditary and progressive

(Kaiser *et al.*, 1991)

Ocular conditions

Glaucoma – primary

- Inheritance suspected
- Prevalence increases with age (mean age of onset 6.3 years)
- Females predisposed in one study
- 11.36% prevalence in this breed in an American study
- Pectinate ligament dysplasia had a prevalence of 38.4% in a UK study
- Autosomal recessive inheritance
- A genetic study of 223 UK Bassets found a mutation frequency of 0.081, with a predicted frequency of affected dogs in the population of 0.007

(Gelatt & MacKay, 2004a; Dees *et al.*, 2014; Oliver *et al.*, 2015, 2016a)

Lens luxation – secondary

- Significant predisposition in this breed, in a Swiss population

(Betschart *et al.*, 2014)

Physiological conditions

Osteochondrodysplasia

- Accepted as breed standard
- Histopathologically confirmed that this breed is chondrodysplastic

(Martinez *et al.*, 2007)

Renal and urinary conditions

Urolithiasis – cystine

- Breed at risk in case series in American, Irish and New Zealand populations
- Young dogs affected (2–5 years)
- Almost all cases are male

(Brown *et al.*, 1977; Jones *et al.*, 1998, 2001)

BEAGLE

Note: Because of the Beagle's extensive use in research settings, a large number of conditions are described in the breed that are not described in detail in other breeds. However, these may not represent true breed predispositions. It may be because the beagle is the only breed in which a condition has been studied in detail, the study being carried out to assist in human medical research. The conditions listed below are likely to represent true breed predispositions in the Beagle.

Behavioural conditions

Aggression

- Reported to be one of the breeds most likely to direct aggression towards owners

(Duffy *et al.*, 2008)

Withdrawal

- Beagles more likely to withdraw from stimuli compared to three other breeds

(Plutchik, 1971)

Cardiovascular conditions

Mitral valve disease

- 25.3% of healthy Beagles in a series with an age range 1.4–11.7 years had a murmur consistent with mitral valve disease, confirmed by colour-flow Doppler

(Vörös *et al.*, 2015)

Dermatological conditions

Familial vasculopathy

- Early onset of signs (4–10 months)
- No sex predilection noted

(Scott-Moncrieff *et al.*, 1992)

Skin tumours

See under *Neoplastic conditions* (*Palpebral neoplasia*)

Endocrine conditions

Diabetes mellitus

- Swedish population
- Incidence rate (IR) 24 cases per 10 000 DYAR, compared with 15 for mixed breeds

(Fall *et al.*, 2007)

Hyperadrenocorticism (Cushing's syndrome)

- Reported to be common in this breed in a case series of 153 dogs in an American population

(Wood *et al.*, 2007)

Hypoadrenocorticism (Addison's disease)
- Breed reported to commonly affected in one Brazilian case series

(Romão, 2011)

Hypothyroidism
- Reported in American and Czech Beagle colonies
- 8% incidence in Czech colony

(Fritz *et al.*, 1970; Vajner *et al.*, 1997)

Thyroid neoplasia
- Breed at increased risk in Swiss and US case series

(Harari *et al.*, 1986; Wenger *et al.*, 2005)

Gastrointestinal conditions

Selective malabsorption of cobalamin (vitamin B_{12})
- Autosomal recessive inheritance suspected
- Genetic mutation described in a US series

(Fyfe *et al.*, 1991)

Haematological/immunological conditions

Factor VII deficiency
- Inherited as an autosomal dominant trait
- Reported in multiple Beagle colonies in USA and UK

(Spurling *et al.*, 1972, 1974; Brooks, 1999)

Haemophilia A
- Severe factor VIII deficiency in this breed
- Familial in this breed

(Brooks, 1999)

Meningitis and polyarteritis
See under *Neurological conditions*

Non-spherocytic haemolytic anaemia
- Inherited condition
- Causes increased osmotic fragility of red cells

(Maggio-Price *et al.*, 1988; Pekow *et al.*, 1992)

Pyruvate kinase deficiency
- In a US case series of 39 anaemic and 29 non-anaemic Beagles, 35% were PK-deficient

(Inal Gultekin *et al.*, 2012a)

Neoplastic conditions

Extraskeletal soft-tissue osteosarcomas
- Breed reported to be at increased risk in a case series
- No sex predilection
- Older animals predisposed

(Langenbach *et al.*, 1998)

Palpebral neoplasia
- Increased risk compared to mixed-breed dogs
- Median age 9.6 years

(Roberts *et al.*, 1986)

Perianal (hepatoid) gland adenomas
- Breed at risk in US case series
- Average age was 10.5 years
- RR 2.4 (95% CI 1.73–3.73) in males and 1.9 (not statistically significant) in females (VMDB)

(Hayes & Wilson, 1977)

Pituitary tumour resulting in hyperadrenocorticism
See under *Endocrine conditions*

Thyroid neoplasia
See under *Endocrine conditions*

Urinary tract neoplasia
- Beagles significantly over-represented ($p < 0.05$) in a Canadian study, compared to hospital population, and in a Japanese study

(Norris *et al.*, 1992; Aoki *et al.*, 2012)

Neurological conditions

Idiopathic epilepsy
- Reported in a colony of Beagles and an American case series

(Bielfelt *et al.*, 1971; Ekenstedt *et al.*, 2011)

Intervertebral disc disease (IVDD)
- 29.4% were Beagles in a US retrospective case series of cervical intervertebral discs
- 43.9% of herniated cervical discs in this breed were at C2–C3
- 11/229 dogs with thoracolumbar intervertebral disc disease were Beagles

(Mayhew *et al.*, 2004; Hakozaki *et al.*, 2015)

Meningitis and polyarteritis
- Also known as Beagle pain syndrome, steroid-responsive meningitis
- OR 11.51 (95% CI 2.56–51.72; $p = 0.01$) compared to selected controls in a UK population
- Suspected to be genetic

(Rose *et al.*, 2014)

Ocular conditions

Cataract

- 24/1314 Beagles in a 1974 case study had punctate anterior opacities
- In a Korean population, 7.5% of beagles had cataracts

(Hirth *et al.*, 1974; BongKyeong *et al.*, 2001)

Corneal dystrophy

- Inheritance suspected
- One report found that 15% of Beagles examined were affected
- Progressive but rarely affects vision

(Roth *et al.*, 1981)

Glaucoma – primary, open angle

- Autosomal recessive inheritance
- Beagles at higher risk than mixed-breed dogs in an American population

(Slater & Erb, 1986)

Ocular neoplasia

See under *Neoplastic conditions* (*Palpebral neoplasia*)

Prolapse of the gland of the nictitating membrane ('cherry eye')

- Breed at increased risk
- 10/71 cases were Beagles in a Brazilian case series
- Usually presents in the first 1–2 years of life

(Merlini *et al.*, 2014)

Tapetal degeneration

- Autosomal recessive inheritance
- Reported in US laboratory dogs

(Burns *et al.*, 1988)

Renal and urinary conditions

Renal amyloidosis

- Breed at increased risk in American case series
- Most cases > 6 years at diagnosis
- Females predisposed in one study

(DiBartola *et al.*, 1989)

Renal dysplasia

- May result in unilateral agenesis
- High prevalence reported in some families of Beagles

(Robbins, 1965; Bruder *et al.*, 2010)

Urinary tract neoplasia

See under *Neoplastic conditions*

Urolithiasis

- Breed at significantly increased risk ($p < 0.05$) in a case series

(Brown *et al.*, 1977)

BEARDED COLLIE

Dermatological conditions

Pemphigus foliaceus

- Increased risk compared to the hospital population and the dermatology caseload
- Mean age of onset 4.2 years

(Ihrke *et al.*, 1985)

Endocrine conditions

Hypoadrenocorticism (Addison's disease)

- 9.4% of an American population of 635 Bearded Collies were affected
- Heritability estimated to be 0.76
- Breed at increased risk in Swedish population (RR 7.43, 95% CI 5.11–10.5; $p < 2.2 \times 10^{16}$)
- Females at increased risk in Swedish population (RR 1.85, 95% CI 1.55–2.22; $p < 0.001$)
- Prevalence in this breed in Swedish population of 0.322% (95% CI 0.088–0.825%)

(Oberbauer *et al.*, 2002; Hanson *et al.*, 2016)

Musculoskeletal conditions

Hip dysplasia

- Neutered male dogs predisposed in an American population
- OR 3.1 (95% CI 1.1–8.7) compared to mixed breeds

(Lafond *et al.*, 2002)

Ocular conditions

Cataract

- Prevalence of primary cataract 1.94%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005)

Lens luxation – secondary

- Significant predisposition in this breed in a Swiss population

(Betschart *et al.*, 2014)

BEAUCERON

Neoplastic conditions

Mast cell tumour (MCT)

- Significantly increased risk for this breed in an Austrian population

(Leidinger *et al.*, 2014)

Squamous cell carcinoma – digit

- Over-represented in a French population
- Mean age 10.2 years
- No sex predisposition

(Belluco *et al.*, 2013)

BEDLINGTON TERRIER

Gastrointestinal conditions

Chronic hepatitis (copper storage hepatopathy, copper toxicosis)

- Inherited as an autosomal recessive trait
- Clinical onset seen in young to middle-aged dogs
- High prevalence worldwide
- 68/90 dogs of this breed affected in a 1979 American study

(Twedt *et al.*, 1979; Johnson *et al.*, 1980; Hultgren *et al.*, 1986)

Ocular conditions

Cataract

- Prevalence of primary cataract 8.49%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005)

Congenital alacrima (congenital keratoconjunctivitis sicca)

- Significantly over-represented in an American study ($p = 0.04$)

(Westermeyer *et al.*, 2009)

BELGIAN SHEPHERD DOG (INCLUDING GROENENDAEL, LAEKENOIS, TERVUREN, AND MALINOIS)

Behavioural conditions

Aggression

- This breed reported to have higher odds of inter-dog dominance aggression

(Rugbjerg *et al.*, 2003)

Dermatological conditions

Vitiligo

- Presumed to be hereditary
- Antimelanocyte antibodies found in all 17 affected Belgian Tervurens tested and none of the 11 normal Belgian Tervurens tested in one study

(Mahaffey *et al.*, 1978)

Gastrointestinal conditions

Gastric carcinoma

See under *Neoplastic conditions*

Neoplastic conditions

Gastric carcinoma

- 8/11 dogs in one case series were of this breed
- Male dogs more commonly affected in case series
- Mean age of occurrence: 8–10 years

(Fonda *et al.*, 1989; Scanziani *et al.*, 1991)

Neurological conditions

Idiopathic epilepsy

- Common in the Danish population of this breed
- Late onset in this breed increases prevalence, owing to dogs already being used for breeding by the time they first show signs
- In a Finnish survey, 9.6% of Belgian Shepherds had had a seizure. These were all Groenendael and Tervuren variants, and none Malinois or Laekenois

(Teikari, 1996; Berendt *et al.*, 2008)

Ocular conditions

Chronic superficial keratitis (pannus)

- Breed at risk in case series, suspected to be inherited
- Age of onset: 4–7 years
- Prevalence and severity increase at higher altitude

(Chavkin *et al.*, 1994)

Physiological conditions

Leucopenia

- 6/9 healthy Belgian Tervurens sampled had white blood cell counts in the range $2.4–5.4 \times 10^9$/l

(Greenfield *et al.*, 1999)

BERGER BLANC SUISSE

See *White Swiss Shepherd Dog*

BERNESE MOUNTAIN DOG

Dermatological conditions

Skin tumours

See under *Neoplastic conditions*

Leptospirosis

- This breed significantly over-represented in a German study

(Geisen *et al.*, 2008)

Gastrointestinal conditions

Gastric or mesenteric dilatation/volvulus

- 1.8% mortality rate from these conditions in this breed in a Swiss population

(Klopfenstein *et al.*, 2016)

Hepatocerebellar degeneration

See under *Neurological conditions*

Oesophageal foreign bodies

- This breed over-represented in a Swiss hospital population

(Gianella *et al.*, 2009)

Haematological/immunological conditions

Factor I deficiency

- Autosomal inheritance

(Brooks, 1999)

Factor VII deficiency

- Autosomal inheritance

(Brooks, 1999)

Infectious conditions

Borreliosis (Lyme disease)

- Seroprevalence of 58% in this breed, compared to 15% in control dogs in a Swiss study ($p < 0.001$)

(Gerber *et al.*, 2007)

Musculoskeletal conditions

Elbow dysplasia

- Ununited anconeal process (OR 50.5, 95% CI 25.9–98.6 compared to mixed breeds) and fragmented coronoid process (OR 140.1, 95% CI 62.2–301.4) seen in this breed
- Fragmented coronoid process thought to be inherited

(Ubbink *et al.*, 1999; LaFond *et al.*, 2002; Temwichitr *et al.*, 2010)

Hip dysplasia

- Neutered male dogs predisposed
- OR 7.2 (95% CI 4.2–12.3) in one study (compared to mixed breeds)
- Decreasing prevalence seen in this breed in a French study

(LaFond *et al.*, 2002; Genevois *et al.*, 2008)

Osteochondrosis – shoulder

- Males predisposed
- Age of onset usually 4–7 months, but can be older
- OR 47.1 (95% CI 26.4–84.0) compared to mixed breeds

(Rudd *et al.*, 1990; LaFond *et al.*, 2002)

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- OR 2.8 (95% CI 1.5–6.0) compared to mixed breeds

(LaFond *et al.*, 2002)

Neoplastic conditions

Histiocytic sarcoma complex – disseminated histiocytoma

- Polygenic mode of inheritance
- Affects older dogs (7–8 years)
- More common in males
- In a Danish population, 13/812 dogs of this breed were diagnosed with this condition, and 11 of these were related
- OR 17.92 in a Japanese population

(Moore & Rosin, 1986; Padgett *et al.*, 1995; Nielsen *et al.*, 2010; Shiokawa *et al.*, 2013)

Lymphoma

- German population
- Two comparison populations: own clinic ($n = 52$ 142) and insured population ($n = 123$ 423)
- Odds ratios 2.4 and 2.0 respectively for the two populations

(Ernst *et al.*, 2016)

Mast cell tumour (MCT)

- This breed reported to be over-represented in a German population and an Austrian population

(Kessler *et al.*, 1997; Leidinger *et al.*, 2014)

Systemic histiocytosis

- Benign, technically non-neoplastic condition
- Polygenic inheritance suspected
- Mainly affects young to middle-aged males

(Moore, 1984; Padgett *et al.*, 1995)

Neurological conditions

Alexander disease

- Out of a total of 11 reports of this disease in dogs, 5 were Bernese Mountain Dogs and 1 was a Bernese cross

(Weissenböck *et al.*, 1996; Wrzosek *et al.*, 2015)

Cervical spondylomyelopathy (cervical vertebral malformation, wobbler syndrome)

- Reported in a US case series of 7 Bernese

(Eagleson *et al.*, 2009)

Degenerative myelopathy

- *SOD1*:c.118A has a frequency of 38% in this breed
- The *SOD1*:c.52 T allele appears to be restricted to this breed, with a frequency of 3.5%

(Zeng *et al.*, 2014)

Hepatocerebellar degeneration

- Reported in three related litters from two kennels in the USA
- Age of onset 4–6 weeks
- Autosomal recessive inheritance

(Carmichael *et al.*, 1996)

Idiopathic epilepsy

- Polygenic mode of inheritance in this breed

(Kathmann *et al.*, 1999)

Ocular conditions

Progressive retinal atrophy (PRA)

- Familial, inheritance suspected
- Early-onset retinopathy has been described in this breed in France

(Chaudieu & Molon-Noblot, 2004)

Physiological conditions

Prolonged activated partial thromboplastin time (aPTT)

- Higher levels of lupus anticoagulants and anticardiolipin in this breed

(Nielsen *et al.*, 2011)

Renal and urinary conditions

Familial renal disease (membranoproliferative glomerulonephritis and interstitial nephritis)

- Autosomal recessive with expression affected by a second sex-linked locus
- Affected dogs present at 2–5 years with renal failure and marked proteinuria
- Most of the dogs in one study had a high titre to *Borrelia burgdorferi*, suggesting that this organism may have had a role in the development of the condition (see also *Infectious conditions*)
- Incidence of renal disease in this breed was 51 cases per 10 000 DYAR (95% CI 41–61), compared with a mean incidence for all breeds of 15.8 per 10 000 DYAR, in a Swiss population

(Minkus *et al.*, 1994; Reusch *et al.*, 1994; Pelander *et al.*, 2015)

Urolithiasis – struvite

- This breed reported to be at statistically increased risk of struvite in a Hungarian population

(Bende *et al.*, 2015)

Reproductive conditions

Prostate disease

- Over-represented in a French population (OR 2.5, 95% CI 1.3–4.7)

(Polisca *et al.*, 2016)

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- Breed at increased risk in Swedish case series

(Egenvall *et al.*, 2001)

Respiratory conditions

Histiocytic sarcoma complex – disseminated histiocytoma

See under *Neoplastic conditions*

BICHON FRISE

Dermatological conditions

Atopic dermatitis (atopy)

- Increased risk in an Australian hospital population (OR 3.3, 95% CI 1.81–5.87)
- Males may be predisposed in this breed ($p = 0.05$)

(Mazrier *et al.*, 2016)

Sarcoptic mange

- Reported to be at risk in a Chinese population
- Prevalence 3.19% (95% CI 0–6.75%) compared to average prevalence of pet dogs of 1.18% (95% CI 0.85–1.52%)

(YiZhou *et al.*, 2014)

Endocrine conditions

Diabetes mellitus

- Incidence rate (IR) 17 per 10 000 DYAR in a Swedish population (mixed-breed IR was 15)

(Fall *et al.*, 2007)

Hyperadrenocorticism

- OR 6.5 (95% CI 3.5–12.1; $p < 0.001$) in a UK general practice population
- Dogs aged 12 years and above had an OR of 5.7 (95% CI 3.7–8.7; $p < 0.001$) of hyperadrenocorticism compared with dogs aged 6–8.9 years

(O'Neill *et al.*, 2016d)

Gastrointestinal conditions

Congenital portosystemic shunt

- Breed significantly over-represented in an Australian case series
- More common in females than males in this breed (12:2; $p < 0.001$)
- Usually extrahepatic

(Hunt, 2004)

Haematological/immunological conditions

Immune-mediated haemolytic anaemia (IMHA)

- Usually affects young adult and middle-aged animals
- May be more common in bitches
- May be seasonal variations
- OR 5.3 (95% CI 1.2–22.5; $p = 0.024$) compared to hospital population in a US study

(Miller *et al.*, 2004)

Musculoskeletal conditions

Cranial cruciate ligament (CCL) disease

- This breed over-represented (11/55) in a case series of dogs < 15 kg presenting for cranial cruciate ligament surgery (US population)

(Campbell *et al.*, 2016)

Patellar luxation

- OR 4.8 (95% CI 2.5–9.3) compared to mixed breeds in an American population

(LaFond *et al.*, 2002)

Ocular conditions

Cataract

- Autosomal recessive inheritance suspected
- High prevalence in this breed: 11.45% in a US population, compared to 1.61% in mixed-breed dogs, in a retrospective report based on VMDB data, 1964–2003
- Age of onset 2–8 years

(Gelatt & MacKay, 2005; Adkins & Hendrix, 2005; Wallace *et al.*, 2005)

Renal and urinary conditions

Urolithiasis – calcium oxalate

- Breed at increased risk in large Canadian case series

(Lulich *et al.*, 1999; Houston *et al.*, 2004)

Urolithiasis – cystine

- Almost all cases reported were male
- Significantly increased risk of cystine calculus formation in an American population

(Case *et al.*, 1982)

Urolithiasis – struvite

- Breed at increased risk in large Canadian case series
- Females predisposed (16:1 in one large study)

(Houston *et al.*, 2004)

Respiratory conditions

Primary ciliary dyskinesia

- Inherited defect
- Several case series affecting related dogs in this breed

(Maddux *et al.*, 1991; Vaden *et al.*, 1991; Jamne *et al.*, 1998)

BLOODHOUND

Gastrointestinal conditions

Gastric dilatation/volvulus (bloat, GDV)

- Breed at increased risk in case series
- 30.5% of deaths in this breed were from this condition in one study
- Prevalence ratio (PR) of 13.2 (95% CI 9.4–18.6; $p < 0.0001$) GDV deaths compared to 23 breeds with three or more deaths due to GDV

(Evans & Adams, 2010b)

Musculoskeletal conditions

Hip dysplasia

- Neutered male dogs predisposed
- OR 4.5 (95% CI 2.0–9.9) compared to mixed breeds

(LaFond *et al.*, 2002)

Neurological conditions

Degenerative myelopathy

- High frequency of mutation for this disease reported in a Belgian population

(Beckers *et al.*, 2016)

BOLOGNESE

Renal and urinary conditions

Urolithiasis – purine

- Reported to be at increased risk in a Hungarian population

(Bende *et al.*, 2015)

BOLONKA ZWETNA

Ocular conditions

Lens luxation – secondary

- Significantly increased incidence in a German population in this breed

(Betschart *et al.*, 2014)

BORDER COLLIE

Cardiovascular conditions

Patent ductus arteriosus

- Breed association noted in one Australian study

(Aherne & Beijerink, 2013)

Drug reactions

Vincristine-associated myelosuppression

- 3/5 dogs of this breed with the *ABCB1* wild-type gene developed vincristine-associated myelosuppression, compared to 0/21 dogs without this genotype (Border Collies and other breeds) – this was significantly different

(Lind *et al.*, 2013)

Endocrine conditions

Diabetes mellitus

- Incidence rate (IR) 36 per 10 000 DYAR in a Swedish population, compared with a mixed-breed IR of 15

(Fall *et al.*, 2007)

Gastrointestinal conditions

Congenital portosystemic shunt

- Breed at risk in case series
- Clinical signs usually seen in young dogs < 1 year

(Hunt, 2004)

Gastrointestinal foreign bodies

- Breed at increased risk in case series

(Hayes, 2009)

Inflammatory bowel disease

- Significantly increased risk in a UK population
- OR 1.99 (95% CI 1.17–3.41; $p = 0.012$)

(Kathrani *et al.*, 2011)

Selective malabsorption of cobalamin (vitamin B_{12})

- Autosomal recessive inheritance suspected
- Median age 11.5 months

(Battersby *et al.*, 2005; Lutz *et al.*, 2013)

Haematological/immunological conditions

Selective malabsorption of cobalamin (vitamin B_{12})

See under *Gastrointestinal conditions*

Trapped neutrophil syndrome

- Autosomal recessive inheritance suspected
- Reported in numerous countries
- Carrier frequency 11.1% in a Japanese study

(Allan *et al.*, 1996; Sharman & Wilton, 2007; Mizukami *et al.*, 2013)

Infectious conditions

Cryptococcosis

- Breed at increased risk in an Australian case series
- Usually seen in dogs < 4 years
- Living outdoors and exposure to bird droppings are risk factors

(O'Brien *et al.*, 2004)

Musculoskeletal conditions

Achilles tendon rupture

- 7/45 dogs in a UK study with this condition were Border Collies or Border Collie crosses

(Corr *et al.*, 2010)

Central tarsal bone fracture

- Reported in case series of 6 UK border collies
- May have the radiographic appearance of a luxation

(Guilliard, 2007)

Gastrocnemius musculotendinopathy

- 8/9 dogs with this condition were Border Collies in a Swiss case series
- May be related to biomechanical forces or motion pattern

(Stahl *et al.*, 2010)

Hip dysplasia
- Neutered male dogs predisposed
- OR 2.1 compared to mixed breeds (95% CI 1.4–3.1)

(LaFond *et al.*, 2002)

Osteochondrosis – shoulder
- Males predisposed
- Age of onset usually 4–7 months, but can be older
- OR 15.0 compared to mixed breeds (95% CI 9.6–23.3)
- Increased risk of shoulder osteoarthritis in this breed

(LaFond *et al.*, 2002; Maddox *et al.*, 2013)

Trauma from agility work
- This breed at increased risk of injury compared to its exposure

(Levy *et al.*, 2009)

Neoplastic conditions

Lingual haemangiosarcoma
- Reported to be at increased risk in a large case series

(Dennis *et al.*, 2006)

Testicular neoplasia
See under *Reproductive conditions*

Neurological conditions

Acute non-compressive nucleus pulposus extrusion
- Border collies over-represented in a UK case series

(Fenn *et al.*, 2016)

Adult-onset deafness
- Onset between 3 and 7 years
- Autosomal dominant pattern of inheritance suspected
- 4/6 dogs aged 12 years or older were deaf in one or both ears

(Schmutz, 2014)

Border Collie collapse
- Reported in a US case series of 165 Border Collies
- Median age of onset 2 years
- Genetic basis suspected

(Taylor *et al.*, 2016a, 2016b)

Congenital deafness
- Prevalence of 2.8% estimated in a UK population of this breed in one UK study
- In another UK study, 2.0% were unilaterally deaf and 0.4% bilaterally deaf
- Higher rates of merle coat pigmentation, blue iris pigment, and excess white on the head compared to Border Collies with normal hearing ($p < 0.001$ for all of these)
- Suspected to be inherited

(Platt *et al.*, 2006; De Risio *et al.*, 2011)

Epilepsy
- Often juvenile onset in this breed
- Reduced mean survival time compared to other breeds ($p = 0.01$)
- 13/136 dogs with juvenile-onset epilepsy were this breed in a UK population
- 11/13 Border Collies experienced cluster seizures in this study
- In a German study of Border Collies with idiopathic epilepsy, 49% had a severe course of the disease, and drug resistance was found in 71% of dogs treated with two or more antiepileptic drugs
- Mutations in the *ABCB1* gene were associated with antiepileptic drug resistance in this breed

(Hulsmeyer *et al.*, 2010; Alves *et al.*, 2011; Arrol *et al.*, 2012)

Neuronal ceroid lipofuscinosis
- Autosomal recessive inheritance
- Signs seen at 1–2 years
- Gene responsible identified in a Australian study
- Carrier frequency estimated at 8.1% in a Japanese study

(Melville *et al.*, 2005; Mizukami *et al.*, 2011)

Steroid-responsive meningitis–arteritis (SRMA)
- At increased risk in a UK study: multivariable analysis showed OR 6.91 (95% CI 2.20–21.66; $p = 0.001$)
- All cases < 2 years of age at presentation

(Rose *et al.*, 2014)

Ocular conditions

Chronic superficial keratitis (pannus)
- Breed at risk in case series, suspected to be inherited
- Age of onset: 4–7 years
- Prevalence and severity increase at higher altitude

(Chavkin *et al.*, 1994)

Collie eye anomaly
- Congenital disorder; autosomal recessive inheritance suspected
- 6% prevalence in this breed in a 1982 UK survey

(Bedford, 1982a)

Lens luxation – primary
- Simple autosomal recessive inheritance suggested
- Age of onset: 3–5 years (mean 4.7 years)

(Foster *et al.*, 1986)

Neuronal ceroid lipofuscinosis
See under *Neurological conditions*

Progressive retinal atrophy (PRA)
- X-linked, generalized and central forms of PRA have been identified in this breed
- 33/161 dogs had retinal lesions in a French study
- Frequency decreased from 20% in 2001 to 8% in 2012 in a French study
- 91/326 dogs of this breed in a Norwegian study were affected by multifocal retinal degeneration

(Chaudieu, 2001; Vilboux *et al.*, 2008; Kjær *et al.*, 2010; Chaudieu *et al.*, 2014)

Physiological conditions
Methylmalonic aciduria
- Found as an incidental finding in healthy eucobalaminaemic Border Collies and Border Collies with clinical signs of cobalamin deficiency

(Lutz *et al.*, 2012)

Reproductive conditions
Testicular neoplasia
- Breed at increased risk of Sertoli cell tumour in case series
- Common tumour in male dog
- Median age 9.5 years

(Weaver, 1983)

BORDER TERRIER

Dermatological conditions
Generalized sebaceous gland hyperplasia
- Possible genetic predisposition

(Dedola *et al.*, 2010)

Neurological conditions
Canine epileptoid cramping syndrome
- First episode usually occurs before 3 years of age

(Black *et al.*, 2014)

Epilepsy
- OR 2.70 (95% CI 1.57–4.62; $p < 0.001$) in a UK general practice population
- As these cases were not from a referral population, some of the cases seen may represent a misdiagnosis of canine epileptoid cramping syndrome
- Also reported in a German survey of breeders and owners, where incidence was estimated at 13.1%

(Kloene *et al.*, 2008; Kearsley-Fleet *et al.*, 2013)

Ocular conditions
Corneal ulceration (ulcerative keratitis)
- OR 2.21 (95% CI 1.18–4.14; $p = 0.014$) compared to crossbreeds in a UK general practice population

(O'Neill *et al.*, 2017b)

Renal and urinary conditions
Ectopic ureter
- Significantly increased risk in this breed in a UK population

(Holt *et al.*, 2000)

Reproductive conditions
Dystocia
- Odds ratio in a UK first-opinion practice study of 4.2 (95% CI 2.0–8.5; $p < 0.001$)

(O'Neill *et al.*, 2017c)

BORZOI

Gastrointestinal conditions
Gastric dilatation/volvulus (bloat, GDV)
- Breed at increased risk

(Burrows & Ignaszewski, 1990)

Neurological conditions
Cervical spondylomyelopathy (cervical vertebral malformation, wobbler syndrome)
- Reported to be inherited as an autosomal recessive trait in a small group of related Borzois

(Jaggy *et al.*, 1988)

Ocular conditions

Inherited focal retinal degeneration
- Inherited as a simple autosomal trait
- Reported in a French population

(Chaudieu, 1995)

Lens luxation – secondary
- Significant predisposition in this breed
- Swiss population

(Betschart *et al.*, 2014)

Multifocal chorioretinitis (Borzoi chorioretinopathy)
- Inheritance suspected, but not by simple autosomal or sex-linked pattern
- Reported in dogs aged 7 months to 7 years
- Some reports suggest a male predisposition

(Storey *et al.*, 2005)

BOSTON TERRIER

Dermatological conditions

Atopic dermatitis (atopy)
- OR 2.0 compared to an American hospital population
- Age of onset usually 4–6 years

(Scott, 1981)

Calcinosis circumscripta
- This breed is predisposed to lesions on the cheek and at the base of the pinna

(Scott & Buerger, 1988)

Localized parakeratotic hyperkeratosis
- Reported in a US case series of 16 dogs of this breed

(Lee *et al.*, 2016)

Endocrine conditions

Hyperadrenocorticism (Cushing's syndrome)
- Reported to be common in this breed in a case series of 153 dogs in an American population

(Wood *et al.*, 2007)

Gastrointestinal conditions

Atresia ani
- This breed showed an increased incidence of this rare disease in an American population
- Females predisposed

(Vianna & Tobias, 2005)

Musculoskeletal conditions

Patellar luxation
- Common condition
- OR 4.2 (95% CI 2.9–6.0) compared to mixed breeds

(LaFond *et al.*, 2002)

Perineal herniation
- Intact males predisposed

(Hosgood *et al.*, 1995)

Neoplastic conditions

Chemodectomas (aortic body and carotid body)
- Breed at significantly increased risk
- Older male dogs predisposed
- 5/16 cases in a recent US study were of this breed

(Hayes & Sass, 1988; Mai *et al.*, 2015)

Mammary neoplasia
- Increased incidence in this breed in a US population

(MacVean *et al.*, 1978)

Mast cell tumour (MCT)
- Relative risk (RR) > 8 in a 1969 US study

(Peters, 1969)

Pituitary tumour resulting in hyperadrenocorticism
See under *Endocrine conditions*

Primary brain tumour
See under *Neurological conditions*

Neurological conditions

Primary brain tumour
- 8/41 post-mortem examinations of this breed had this condition ($p = 0.0001$)
- Increased risk of glial neoplasms in this breed (astrocytomas and oligodendrogliomas)

(Song *et al.*, 2013)

Ocular conditions

Cataract
- Autosomal recessive inheritance suspected
- Significantly increased odds ratio for the condition in this breed
- Prevalence of primary cataract 11.11%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

- Early- and late-onset inherited cataracts in this breed are thought to be genetically distinct conditions

(Adkins & Hendrix, 2005; Gelatt & MacKay, 2005; Mellersh *et al.*, 2006, 2007)

Glaucoma – primary

- Suspected to be inherited
- 2.88% prevalence in this breed in a North American population

(Gelatt & MacKay, 2004a)

Glaucoma – secondary

- This breed at increased risk compared to a US hospital population
- Increased risk of glaucoma and other complications after phacoemulsification for cataract removal in this breed. Odds ratio of 290.44 of postoperative blindness in this breed compared to mixed breeds (95% CI 4.77–17.673; $p = 0.007$)
- 10.5% of cases in this breed eviscerated or enucleated after cataract surgery

(Lannek & Miller, 2001; Johnsen *et al.*, 2006; Klein *et al.*, 2011; Scott *et al.*, 2013)

Lens luxation – secondary

- Significant predisposition in this breed
- Swiss population

(Betschart *et al.*, 2014)

Traumatic proptosis

- One of the most commonly affected breeds in a Brazilian population

(Brandão *et al.*, 2005)

Uveal cysts

- Breed at increased risk
- Mean age 6.8 years in one study

(Corcoran & Koch, 1993)

Renal and urinary conditions

Hypospadias

- Congenital defect with a higher incidence in this breed, suggesting a possible genetic basis
- Predominantly affects male dogs

(Hayes & Wilson, 1986)

Reproductive conditions

Dystocia

- Breed predisposition to obstructive dystocia due to dorsoventrally flattened maternal pelvic canal and large fetuses with large heads
- 92.3% of this breed required caesarean sections
- OR 17.1 (95% CI 7.8–37.6; $p < 0.001$) in a UK first-opinion series

(Eneroth *et al.*, 1999; Evans & Adams, 2010a; Martins-Bessa *et al.*, 2015; O'Neill *et al.*, 2017c)

Hypospadias

See under *Renal and urinary conditions*

Respiratory conditions

Brachycephalic obstructive airway syndrome (BOAS)

- Most commonly present with clinical signs aged 1–4 years
- 9% of cases were this breed in one US study

(Riecks *et al.*, 2007; Fasanella *et al.*, 2010)

Tracheal hypoplasia

- This breed represented 15% of cases in an American case series
- Age at diagnosis from 2 days to 12 years

(Coyne & Fingland, 1992)

BOUVIER DES FLANDRES

Gastrointestinal conditions

Muscular dystrophy of pharyngeal and oesophageal muscles causing dysphagia

- Hereditary

(Peeters *et al.*, 1991; Peeters & Ubbink, 1994)

Musculoskeletal conditions

Elbow dysplasia

- Fragmented coronoid process: OR 19.5 (95% CI 8.1–46.9) compared to mixed breeds

(LaFond *et al.*, 2002)

Hip dysplasia

- Neutered male dogs predisposed
- OR 4.1 (95% CI 2.8–6.1) compared to mixed breeds

(LaFond *et al.*, 2002)

Muscular dystrophy

See under *Gastrointestinal conditions*

Osteochondrosis – shoulder

- Males predisposed
- Age of onset usually 4–7 months, but can be older
- OR 12.1 (95% CI 5.8–25.4) compared to mixed breeds

(LaFond *et al.*, 2002)

Neoplastic conditions

Gastric carcinoma

- Males predisposed
- Median age 10 years
- Proportional mortality ratio 36.5 in a Norwegian population

(Seim-Wikse *et al.*, 2013)

Prostatic carcinoma

- OR 8.44 (95% CI 4.38–16.1)
- Older dogs affected
- Some studies suggest an increased risk in castrated dogs

(Teske *et al.*, 2002)

Ocular conditions

Glaucoma – primary

- Inheritance suspected
- Goniodysgenesis common

(van der Linde-Sipman, 1987)

Reproductive conditions

Prostatic carcinoma

See under *Neoplastic conditions*

Respiratory conditions

Laryngeal paralysis–polyneuropathy syndrome

- Age of onset 4–6 months
- Neurogenic and hereditary in this breed

(Venker-van Haagen *et al.*, 1978)

BOXER

Behavioural conditions

Aggression

- Increased risk of being involved in human and animal attacks in a German study
- In an Australian study, Boxers were only reported to attack animals

(Blackshaw, 1991; Unshelm *et al.*, 1993)

Cardiovascular conditions

Aortic stenosis – subaortic stenosis (SAS)

- High prevalence of murmurs consistent with aortic stenosis in this breed in various populations, for example 77% in a Norwegian and Swedish population
- Male predisposition

(Heiene *et al.*, 2000; Chetboul *et al.*, 2006b; Bussadori *et al.*, 2009)

Arrhythmogenic right ventricular cardiomyopathy

- Familial and thought to be inherited
- Prognosis better for younger dogs without syncope
- All cases in the UK thought to come from a small number of Boxers imported from the USA

(Basso *et al.*, 2004; Caro-Vadillo *et al.*, 2013; Cattanach *et al.*, 2015)

Atrial septal defect

- 31.9% of cases were this breed in a French cardiology population
- OR 15.28 (95% CI 10.24–22.84; $p < 0.05$) compared to hospital population
- No sex predisposition
- Mean age of diagnosis 4.1 years

(Chetboul *et al.*, 2006a, 2006b)

Dilated cardiomyopathy (DCM)

- At least one gene has been identified that is associated with the DCM phenotype in this breed
- This breed may exhibit the 'fatty infiltration–degenerative' type, or the 'attenuated wavy fibre' type of DCM

(Tidholm & Jonnson, 1997; Meurs *et al.*, 2013)

Mitral valve dysplasia

- Recognized as common in this breed in a French population

(Chetboul *et al.*, 2006b)

Pulmonic stenosis

- Congenital
- 3.3% prevalence in this breed in a Swiss study

(Matic, 1988; Chetboul *et al.*, 2006b; Höpfner *et al.*, 2010)

Dermatological conditions

Atopic dermatitis (atopy)

- Above average risk for this condition in this breed in a Swedish population
- OR 1.9 (95% CI 1.06–2.67) compared to Australian hospital population

(Nødtvedt *et al.*, 2006; Mazrier *et al.*, 2016)

Calcinosis circumscripta

- No sex predisposition
- This breed is predisposed to lesions on the cheek and at the base of the pinna
- Commonly reported breed in a US population

(Scott & Buerger, 1988; Doerr *et al.*, 2013)

Canine follicular dysplasia (seasonal flank alopecia)
- Presumed genetic basis
- Seen concurrently with interface dermatitis in one case series in a US population
- Alopecia starts at 2–4 years of age and is restricted to the flank in this breed

(Miller & Dunstan, 1993; Rachid *et al.*, 2003)

Canine leproid granuloma
See under *Infectious conditions*

Demodicosis
- Predisposed in an Argentine population

(Barrientos *et al.*, 2013)

Idiopathic sterile granuloma and pyogranuloma
- This breed over-represented in one US study

(Panich *et al.*, 1991)

Otitis externa
- Breed over-represented in a Polish study

(Sapierzyński, 2009)

Skin tumours
See under *Neoplastic conditions*

Endocrine conditions

Hyperadrenocorticism (Cushing's syndrome)
- Breed at increased risk in case series
- Median age 10 years

(Ling *et al.*, 1979)

Hypothyroidism
- Breed at increased risk
- May occur at a younger age in breeds at risk (2–3 years)
- Females and neutered males at increased risk

(Nesbitt *et al.*, 1980)

Thyroid neoplasia
- Breed at increased risk in a Swiss study

(Wenger *et al.*, 2005)

Gastrointestinal conditions

Cleft palate
- Congenital
- Probable autosomal recessive inheritance
- Prevalence of 2.3% in a Dutch population

(Nielen *et al.*, 2001)

Folate – low serum level
- Reported to be significantly at risk in a UK clinical pathology laboratory study

(Dandrieux *et al.*, 2013)

Gastric dilatation/volvulus (bloat, GDV)
- 5.4% of cases in a Brazilian post-mortem population were Boxers

(Castro *et al.*, 2013)

Gingival and oropharyngeal neoplasia
See under *Neoplastic conditions*

Inflammatory bowel disease
- Increased risk reported in UK population (OR 1.70, 95% CI 1.04–2.76; $p = 0.0328$)

(Kathrani *et al.*, 2011)

Pancreatitis
- Breed at risk of chronic pancreatitis in case series of post-mortem dogs
- Relative risk 3.0 (95% CI 2.4–3.8)

(Watson *et al.*, 2007)

Splenic disease
- Boxers significantly over-represented in an Australian histopathological case series ($p = 0.0148$) compared to Australian National Kennel Council population data

(Christensen *et al.*, 2009)

Ulcerative colitis (histiocytic ulcerative colitis)
- Occurs predominantly in this breed

(Churcher & Watson, 1997; German *et al.*, 2000a)

Haematological/immunological conditions

Eccentrocytosis
- Boxers reported to be over-represented in an Italian case series

(Caldin *et al.*, 2005)

Factor I deficiency
- Autosomal inheritance

(Brooks, 1999)

Factor II deficiency
- Autosomal inheritance

(Brooks, 1999)

Haemophilia A
- Severe factor VIII deficiency in this breed
- Familial in this breed

(Brooks, 1999)

Inflammatory myopathy
- This breed over-represented in a US case series

(Evans *et al.*, 2004)

Infectious conditions

Babesiosis

- This breed over-represented in a Brazilian population

(Ungar de Sá *et al.*, 2007)

Canine leproid granuloma

- Boxers most commonly affected in a Brazilian population

(Conceição *et al.*, 2011)

Cryptococcosis

- Breed at increased risk in an Australian case series
- Usually seen in dogs < 4 years
- Living outdoors and exposure to bird droppings are risk factors

(O'Brien *et al.*, 2004)

Leishmaniasis

- Breed significantly over-represented in a Spanish population

(Miranda *et al.*, 2008)

Protothecosis

- 7/17 cases in an Australian population were Boxers or Boxer crosses

(Stenner *et al.*, 2007)

Musculoskeletal conditions

Cranial cruciate ligament (CCL) disease

- Neutered individuals are predisposed
- Older animals are predisposed
- OR in this breed 2.14 (95% CI 2.00–2.30; $p < 0.01$)
- In a UK referral population, 9% with this condition were Boxers

(Witsberger *et al.*, 2008; Guthrie *et al.*, 2012)

Hip dysplasia

- Heritability of 0.24 in an Italian population

(Sturaro *et al.*, 2006)

Metaphyseal osteopathy (hypertrophic osteodystrophy)

- Affects dogs aged 2–6 months
- Males possibly predisposed
- OR in this breed 18.4 (95% CI 7.1–47.5)

(LaFond *et al.*, 2002)

Osteochondrosis – lumbosacral

- This breed heavily represented in a UK study
- Mean age at diagnosis 6.3 years

(Hanna, 2001)

Osteochondrosis – shoulder

- Males predisposed
- Age of onset usually 4–7 months, but can be older
- OR 2.2 (95% CI 1.1–4.5) compared to mixed breeds

(LaFond *et al.*, 2002)

Osteochondrosis – stifle

- Males predisposed
- Age of onset usually 5–12 months, but may be earlier
- OR 56.3 (95% CI 24.8–127.8) compared to mixed breeds

(LaFond *et al.*, 2002)

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- OR 1.8 (95% CI 1.4–2.3) compared to mixed breeds

(LaFond *et al.*, 2002)

Perineal herniation

- Intact males predisposed

(Robertson, 1984)

Radial carpal bone fracture

- 11/15 dogs were Boxers in a UK case series

(Li *et al.*, 2000)

Spondylosis deformans

- Usually clinically insignificant
- 84% of boxers had spondylosis lesions in one Italian study

(Canier *et al.*, 2004)

Neoplastic conditions

Canine cutaneous histiocytoma

- Breed at increased risk in Australian case series (9/80 cases were this breed)

(Er & Sutton, 1989)

Chemodectomas (aortic body and carotid body)

- Breed at significantly increased risk
- Older male dogs predisposed

(Hayes & Sass, 1988)

Chondrosarcoma (skeletal)

- 24% of cases in an American case series were Boxers

(Brodey *et al.*, 1974)

Fibroadnexal hamartoma
- Increased risk in a Brazilian population
- Average age of onset 6.3 years
- No sex predisposition

(Loures & Conceição, 2009)

Gingival and oropharyngeal neoplasia
- Breed at increased risk in case series
- Particularly prone to epuli

(Dorn & Priester, 1976; Delverdier *et al.*, 1991)

Haemangioendothelioma
- Significant predisposition in this breed in a German post-mortem study

(Giesel *et al.*, 1986)

Lymphoma
- Breed at increased risk
- Most cases are seen in middle-aged dogs (mean 6–7 years)
- OR 3.26 (95% CI 1.57–6.76; $p = 0.002$) in a UK population, compared to other breeds

(Edwards *et al.*, 2003; Lurie *et al.*, 2004)

Mammary neoplasia
- Lifetime prevalence of 0.38 in a Norwegian survey
- Incidence rate (IR) of 35.47 malignant tumours per 1000 bitches per year in a Norwegian population

(Moe, 2001; Dahl *et al.*, 2002)

Mast cell tumour (MCT)
- 12/53 dogs with mast cell tumours were Boxers in an Australian case series
- Boxers presented significantly younger than other breeds
- OR 10.7 (95% CI 3.7–30.4) in a UK study

(Baker-Gabb *et al.*, 2003; Warland & Dobson, 2013; Shoop *et al.*, 2015)

Osteosarcoma
- Breed at risk in a US case series
- Males over-represented
- Seen in older dogs

(Misdrop & Hart, 1979)

Pituitary tumour resulting in hyperadrenocorticism
See under *Endocrine conditions*

Primary brain tumour
See under *Neurological conditions*

Testicular neoplasia
See under *Reproductive conditions*

Thyroid neoplasia
See under *Endocrine conditions*

Transmissible venereal tumour
- Breed significantly predisposed in a Brazilian population

(Brandão *et al.*, 2002)

Vaginal/vulval neoplasia
- This breed reported to be predisposed in a Polish study

(Sapierzyński, 2007)

Vascular tumours
- Boxers were reported to be at increased risk of primary vascular neoplasia in a Norwegian population
- Annual incidence rate (IR) of primary malignant vascular tumours in this breed of 1.5 per 1000 dogs

(Moe *et al.*, 2008)

Neurological conditions

Central vestibular disease
- Reported to be more common in Boxers than in mixed-breed dogs in a Brazilian population

(Chaves *et al.*, 2014)

Degenerative myelopathy
- Reported to have a high incidence in a Belgian population
- 14/52 Boxers in a South African study were carriers and one was affected

(Zeiler *et al.*, 2013; Beckers *et al.*, 2016)

Discospondylitis
- Young/middle-aged dogs affected
- Males twice as likely to be affected as females
- Odds ratio in this breed 3.5 (95% CI 1.8–6.9) in a US study

(Burkert *et al.*, 2005)

Epilepsy
- Prevalence of 2.4% in a Dutch population
- More likely to suffer cluster seizures compared to Labradors ($p = 0.01$)

(Nielen *et al.*, 2001; Monteiro *et al.*, 2012)

Idiopathic head tremor syndrome
- 13% of cases were this breed in one multinational survey of vets

(Shell *et al.*, 2015)

Primary brain tumour
- Older dogs affected
- 16/18 dogs of this breed with brain tumours had gliomas in one study
- Boxers significantly over-represented in a US post-mortem case series ($p = .0001$, 28/212 cases)
- Boxers also over-represented in a histological case series of meningiomas

(Snyder *et al.*, 2006; Sturges *et al.*, 2008; Song *et al.*, 2013)

Progressive axonopathy
- Autosomal recessive inheritance
- Reported in a UK case series

(Griffiths *et al.*, 1985)

Steroid-responsive meningitis–arteritis (SRMA)
- Multivariable analysis of a UK population showed an OR of 4.39 (95% CI 1.14–16.98; $p = 0.032$)
- Prognosis better in this breed than in other breeds

(Behr & Cauzinille, 2006; Rose *et al.*, 2014)

Ocular conditions

Distichiasis
- Breed at increased risk

(Lawson, 1973)

Spontaneous chronic corneal epithelial defects (refractory corneal ulceration, indolent ulcers)
- Breed at increased risk
- Age of onset 7–9 years
- Odds ratio for corneal ulceration in this breed 13.84 (95% CI 10.05–19.06; $p < 0.001$) compared to crossbreeds in a UK general practice population

(Bentley, 2005; Chandler *et al.*, 2010; O'Neill *et al.*, 2017b)

Physiological conditions

Blood group
- < 20% of Boxers were DEA 1.1-positive in a South African study
- All Boxers were DEA 1.1-negative in one Portuguese and one Swiss study

(van der Merwe *et al.*, 2002; Ferreira *et al.*, 2011; Riond *et al.*, 2011)

Polyodontia
- 16/47 dogs in a German case series with supernumerary teeth were Boxers

(Kuiper *et al.*, 1982)

Renal and urinary conditions

Renal disease
- Incidence rate (IR) in a large Swedish case series of 36 cases per 10 000 DYAR (95% CI 27–44), mean age of diagnosis 5.3 years
- Juvenile nephropathy reported in a UK case series

(Chandler *et al.*, 2007; Pelander *et al.*, 2015)

Urethral sphincter mechanism incompetence
- Breed at risk in case series (65% of Boxers reported to be affected in a German study)
- Spayed females predisposed

(Blendinger *et al.*, 1995; Arnold, 1997)

Reproductive conditions

Cryptorchidism
- Congenital defect believed to be inherited as a sex-limited autosomal recessive trait
- Breed at risk in case series
- Prevalence 10.7% in a Dutch population

(Nielen *et al.*, 2001)

Dystocia
- Dystocia occurred in 27.7% of all whelpings in a Swedish population
- Caesarean sections were performed in 22.8% of all the whelpings and in 80.1% of cases of dystocia
- 60% of cases of dystocia were due to uterine inertia
- In a UK first-opinion study, OR was 2.5 (95 CI 1.3–4.8; $p = 0.006$)

(Linde Forsberg & Persson, 2007; O'Neill *et al.*, 2017c)

Testicular neoplasia
- Breed at increased risk
- Seen at earlier age than in other breeds (mean age 7.2 years in one study)
- One study suggests increased risk of Sertoli cell tumours

(Hayes & Pendergrass, 1976; Weaver, 1983)

Vaginal hyperplasia/vaginal prolapse
- This breed most often reported to be affected

(Post *et al.*, 1991)

BOYKIN SPANIEL

Cardiovascular conditions

Pulmonic stenosis

- Reported in 4 dogs with a common ancestry
- May be familial in this breed
- May be a polygenic mode of inheritance

(Jacobs *et al.*, 1990)

Haematological/immunological conditions

Haemophilia A

- Severe factor VIII deficiency in this breed
- Familial in this breed

(Brooks, 1999)

Musculoskeletal conditions

Hip dysplasia

- 40% prevalence in a North American screening population

(Tsai & Murphy, 2006)

Neurological conditions

Exercise-induced collapse

- In a North American study, 36% were heterozygous and 10% homozygous for the *DNM1* mutation causing this condition

(Minor *et al.*, 2011)

BRIARD

Neoplastic conditions

Lymphoma

- German population
- Two comparison populations: own clinic ($n = 52\,142$) and insured population ($n = 123\,423$)
- Odds ratios 5.6 and 9.5 respectively for the two populations

(Ernst *et al.*, 2016)

Squamous cell carcinoma – digit

- Over-represented in a French population
- Mean age 10.2 years
- No sex predisposition

(Belluco *et al.*, 2013)

Ocular conditions

Hereditary retinal dystrophy of Briards (congenital stationary night blindness)

- Autosomal recessive inheritance with variable expression

(Wrigstad *et al.*, 1994; Narfström, 1999a)

Retinal pigment epithelial dystrophy (RPED, central progressive retinal atrophy)

- Autosomal recessive inheritance has been suggested
- Age of onset varies
- A 1984 study showed that 31% of Briards of 18 months or older were affected
- Becoming much less prevalent following the introduction of control schemes

(Bedford, 1984, 2009; Lightfoot *et al.*, 1996)

Physiological conditions

Hypercholesterolaemia

- Possible primary abnormality in cholesterol metabolism

(Watson *et al.*, 1993)

Renal and urinary conditions

Ectopic ureter

- Significant increased risk in this breed in a UK population

(Holt *et al.*, 2000)

BRITISH BULLDOG

See *Bulldog – English*

BRITTANY SPANIEL

Dermatological conditions

Grass awn migration

- Predisposition due to behaviour
- Increased prevalence in this breed compared to hospital population

(Brennan & Ihrke, 1983)

Otitis externa

- This breed over-represented in a Greek case series

(Saridomichelakis *et al.*, 2007)

Sterile nodular panniculitis

- This breed significantly over-represented in a series of 39 dogs in an American population

(Contreary *et al.*, 2015)

Gastrointestinal conditions

Cleft palate

- Autosomal recessive inheritance
- 26.9% incidence in a breeding colony

(Richtsmeier *et al.*, 1994)

Haematological/immunological conditions

Deficiency of third component of complement
- Discovered in a colony of Brittany Spaniels with inherited spinal muscular atrophy
- Inherited as an autosomal recessive
- Inherited separately from the spinal atrophy gene

(Blum *et al.*, 1985)

Infectious conditions

Histoplasmosis
- Breed at increased risk
- Most dogs are < 2 years, males predisposed
- Mostly seen in the Americas, India and Southeast Asia

(Selby *et al.*, 1981; Clinkenbeard *et al.*, 1989)

Musculoskeletal conditions

Hip dysplasia
- Neutered male dogs predisposed
- OR 1.7 (95% CI 1.3–2.3) compared to mixed breeds

(LaFond *et al.*, 2002)

Spinal muscular atrophy

See under *Neurological conditions*

Neoplastic conditions

Thyroid neoplasia
- Breed over-represented in a French case series

(Cohn-Bendit, 1995)

Neurological conditions

Spinal muscular atrophy
- Autosomal dominant inheritance
- Age of clinical onset < 1 year

(Cork *et al.*, 1982, 1990)

Spinocerebellar degeneration (late onset)
- Signs seen at 7–13 years
- Familial
- Reported in a small American case series

(Higgins *et al.*, 1998)

Ocular conditions

Lens luxation – primary
- Reported in a French population
- *ADAMTS17* mutation responsible for this condition in some breeds not identified in cases of primary lens luxation in this breed in a UK population

(Chaudieu *et al.*, 1993; Gould *et al.*, 2011)

Sudden acquired retinal degeneration (SARD, amaurosis)
- 7/17 dogs in a French case series with this condition were Brittany Spaniels

(Goulle, 2010)

Renal and urinary conditions

Renal amyloidosis
- Breed over-represented in a French case series
- 54% of cases were aged 5–8 years

(Pagès, 1988)

BRUSSELS GRIFFON

See *Griffon Bruxellois*

BUHUND

See *Norwegian Buhund*.

BULL TERRIER

Cardiovascular conditions

Aortic stenosis – subaortic stenosis (SAS)
- Inheritance possibly autosomal dominant with modifying genes, or polygenic
- Mean age of onset for acquired disease 7.6 years
- Associated with polycystic kidney disease in this breed

(O'Leary *et al.*, 2005; O'Leary and Wilkie, 2009)

Mitral dysplasia
- Congenital
- Genetic basis suspected
- Associated with polycystic kidney disease in this breed

(Malik & Church, 1988; O'Leary *et al.*, 2005; O'Leary & Wilkie, 2009)

Dermatological conditions

Acrodermatitis
- Inherited as an autosomal recessive trait
- Low IgA levels may predispose to infection
- May be associated with zinc deficiency

(McEwan *et al.*, 2000, 2003)

Atopic dermatitis (atopy)
- Dogs between 1 and 2 years of age have highest probability of an insurance claim for atopy

- This breed had a risk factor of 21 cases per 1000 DYAR (if 1000 dogs were followed for 1 year, 21 would have an insurance claim for atopy)
- Some studies show no sex predilection, others show females predisposed
- Increased risk of adverse food reaction in this breed according to a Hungarian study

(Nødtvedt *et al.*, 2006; Tarpataki *et al.*, 2006)

Otitis externa

- 4% of cases were this breed in a Romanian case series

(Mircean *et al.*, 2008)

Haematological/immunological conditions

Acrodermatitis

See under *Dermatological conditions*

Musculoskeletal conditions

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- OR 1.6 (95% CI 1.0–2.4) compared to mixed breeds

(LaFond *et al.*, 2002)

Patellar luxation

- Mainly medial luxation observed
- Breed predisposed in a Korean case series

(Alam *et al.*, 2007)

Neoplastic conditions

Lymphoma

- Breed over-represented in an Australian case series

(Wyatt & Robertson, 1998)

Mast cell tumour (MCT)

- Breed at increased risk in an Australian case series
- May be seen at any age (from 4 months onwards), but usually seen in older animals

(Er & Sutton, 1989)

Squamous cell carcinoma

- Breed over-represented in a Mexican case series

(Silva-Hidalgo *et al.*, 2015)

Neurological conditions

Congenital deafness

- 96.29% of deaf puppies of this breed had a white coat

(Strain, 2004; De Risio *et al.*, 2016b)

Tail-chasing

- 14/32 dogs with this condition were this breed in an Australian population
- Other abnormal behaviours may also be seen in this breed, possibly due to complex partial seizures

(Blackshaw *et al.*, 1994; Dodman *et al.*, 1996; Moon-Fanelli & Dodman, 1998)

Trance-like syndrome

- Reported in a UK case series
- Possibly a compulsive disorder

(Lowrie *et al.*, 2015a)

Renal and urinary conditions

Familial renal disease (glomerular basement membrane disorder)

- Autosomal dominant inheritance
- Condition believed to be similar to Alport syndrome in humans
- Proteinuria may be an early indicator, with cases progressing to renal failure at 1–8 years of age
- Most reports of the condition come from Australia
- May be seen concurrently with polycystic kidney disease

(Hood *et al.*, 2002a; O'Leary & Atwell, 2003)

Polycystic kidney disease (PKD)

- Autosomal dominant inheritance
- Bilateral cysts (1–25 mm) found in cortex and medulla
- May be seen concurrently with hereditary nephritis (see *Familial renal disease*)
- Dogs with PKD had an increased risk of mitral valve disease and left ventricular outflow obstruction

(O'Leary *et al.*, 1999, 2002, 2005)

Respiratory conditions

Tracheal collapse

- Thought to be primary in this breed
- Reported in a UK case series

(Spaull & Friend, 2014)

BULL TERRIER – MINIATURE

See *Miniature Bull Terrier*

BULLDOG – AMERICAN

Dermatological conditions

Ichthyosis

- 32/545 dogs of this breed homozygous for the suspected mutation
- All affected dogs homozygous and their parents heterozygous
- Autosomal recessive inheritance
- US population

(Mauldin *et al.*, 2015)

Neurological conditions

Neuronal ceroid lipofuscinosis

- Autosomal recessive mode of inheritance
- Affected American Bulldogs were homozygous for the A allele of a G to A transition in the cathepsin D gene (*CTSD*)
- A allele not detected in DNA samples from 131 randomly selected dogs of 108 breeds other than American Bulldog
- A allele had a frequency of 0.28 in 123 American Bulldogs tested

(Evans *et al.*, 2005; Awano *et al.*, 2006)

Ocular conditions

Iridociliary cysts

- Reported in a case series of 7 dogs of this breed
- Brazilian and Spanish population
- Some dogs closely related, so possibly inherited

(Pereira *et al.*, 2014)

Neuronal ceroid lipofuscinosis

See under *Neurological conditions*

BULLDOG – ENGLISH (BRITISH BULLDOG)

Behavioural conditions

General behavioural traits

- In a questionnaire survey, this breed reported to jump up at people frequently, and to be active and hard to train

(Ricciarelli, 2016)

Cardiovascular conditions

Pulmonic stenosis

- May be polygenic mode of inheritance
- This breed accounted for 15.3% of cases of this condition in a Canadian referral population
- May be associated with anomalous coronary artery development in this breed

(Darke, 1989; Ramos *et al.*, 2014)

Tetralogy of Fallot

- Congenital

(Darke, 1989)

Ventricular tachycardia

- Reported in a small Italian case series
- Possibly associated with segmental arrhythmogenic right ventricular cardiomyopathy
- Arrhythmogenic right ventricular cardiomyopathy may be an emerging disease in this breed

(Santilli *et al.*, 2011, 2014)

Dermatological conditions

Atopic dermatitis (atopy)

- Breed at increased risk in an Australian case series

(Mazrier *et al.*, 2016)

Demodicosis

- Younger dogs predisposed
- Susceptibility to generalized demodicosis may be inherited
- Increased incidence in this breed reported in a Russian population

(Kuznetsova *et al.*, 2012)

Idiopathic nasodigital hyperkeratosis

- Breed possibly predisposed in an American case series

(Scott & Miller, 2012a)

Idiopathic sterile granuloma and pyogranuloma

- This breed over-represented in one US study

(Panich *et al.*, 1991)

Gastrointestinal conditions

Cleft palate

- Probable autosomal recessive inheritance

(Mulvihill *et al.*, 1980)

Hiatal hernia

- Breed predisposed in a US case series

(Lorinson & Bright, 1998)

Primary splenic torsion

- English Bulldogs accounted for 11.2% of cases in a US case series

(DeGroot *et al.*, 2016)

Haematological/immunological conditions

Haemophilia A

- Severe factor VIII deficiency in this breed
- Familial in this breed

(Brooks, 1999)

Metabolic conditions

Hypomagnesaemia

- Period of prevalence of 15% in this breed
- Risk ratio (RR) 1.8 (95% CI 1.3–2.7) compared to Boxers
- Possibly related to sleep apnoea or arterial hypertension

(Mellema & Hoareau, 2014)

Musculoskeletal conditions

Cranial cruciate ligament (CCL) disease

- Neutered individuals are predisposed
- Older animals are predisposed
- OR in this breed 2.14 (95% CI 1.99–2.37; $p < 0.001$)

(Witsberger *et al.*, 2008)

Hip dysplasia

- Torsional deformity common in this breed
- Neutered male dogs predisposed
- OR in this breed 1.27 (95% CI1.15–1.40; $p < 0.001$)

(Witsberger *et al.*, 2008; Gnudi *et al.*, 2009)

Osteochondrosis – stifle

- Males predisposed
- Age of onset usually 5–12 months, but may be earlier
- OR 44.2 (95% CI 17.4–112.6) compared to mixed breeds

(LaFond *et al.*, 2002)

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- OR 1.9 (95% CI 1.5–2.5) compared to mixed breeds

(LaFond *et al.*, 2002)

Patellar luxation

- OR 6.1 (95% CI 4.2–9.0) compared to mixed breeds

(LaFond *et al.*, 2002)

Swimmer puppy syndrome

- 8.33% of cases in a Thai population were English Bulldogs

(Nganvongpanit &Yano, 2013)

Vertebral anomalies

See under *Neurological conditions*

Neoplastic conditions

Chemodectomas (aortic body and carotid body)

- Breed at increased risk
- Older male dogs predisposed

(Hayes & Sass, 1988; Owen *et al.*, 1996)

Granulosa-theca cell ovarian tumour

- This breed reported to be predisposed in Polish and US studies

(Hayes & Young, 1978; Sapierzyński, 2007)

Lymphoma

- Breed at increased risk
- Most cases are seen in middle-aged dogs (mean 6–7 years)
- OR 4.73 (95% CI 1.42–15.83; $p = 0.012$) in a UK population, compared to other breeds

(Edwards *et al.*, 2003)

Perianal (hepatoid) gland adenomas

- Breed at risk in US case series
- Average age was 10.5 years
- Relative risk (RR) in males 4.6 (95% CI 2.11–9.89) compared to VMDB data
- Not seen in females in this breed

(Hayes & Wilson, 1977)

Neurological conditions

Discospondylitis

- Young/middle-aged dogs affected
- Males twice as likely to be affected as females
- OR in this breed 3.0 (95% CI 1.2–7.5) in a US study

(Burkert *et al.*, 2005)

Idiopathic head tremor syndrome

- 37% of cases were this breed in one multinational survey of vets

(Shell *et al.*, 2015)

Otitis media

- This breed has increased risk of having material in middle ear on MRI, compared to the total population undergoing MRI

(Owen *et al.*, 2004)

Ventriculomegaly

- This breed has larger cerebral lateral ventricles than other breeds

(Vite *et al.*, 1997; Ryan *et al.*, 2014)

Vertebral anomalies
- Congenital
- Thoracic vertebral anomalies very common in this breed

(Schlensker & Distl, 2012; Ryan *et al.*, 2017)

Ocular conditions

Corneal ulceration (ulcerative keratitis)
- OR 6.53 (95% CI 3.96–10.78; $p < 0.001$) compared to crossbreeds in a UK general practice population

(O'Neill *et al.*, 2017b)

Prolapse of the gland of the nictitating membrane ('cherry eye')
- Breed at increased risk
- Usually presents in the first 1–2 years of life

(Morgan *et al.*, 1993; Mazzucchelli *et al.*, 2012; Prémont *et al.*, 2012; Multari *et al.*, 2016)

Renal and urinary conditions

Ectopic ureter
- Significant increased risk in this breed in UK and US populations

(Hayes, 1984; Holt *et al.*, 2000)

Urethral prolapse
- Generally seen in male dogs at 4 months to 5 years of age
- Odds ratio in a US population 366.99 (95% CI 265.83–506.65) compared to all breeds

(Kirsch *et al.*, 2002; Carr *et al.*, 2014)

Urolithiasis – cystine
- Almost all cases reported were male
- Significantly increased risk of cystine calculus formation in an American population
- Also reported in a New Zealand population
- Odds of a Bulldog being affected with cystine was 154.1 times greater than for other breeds

(Case *et al.*, 1992; Bartges *et al.*, 1994; Jones *et al.*, 1998)

Urolithiasis – urate
- Breed at risk in case series
- Average age at diagnosis in one large study: males 5.5 years, females 4.6 years
- Males are predisposed
- Odds of a Bulldog being affected with urate was 43.0 times greater than for other breeds

(Houston *et al.*, 2004; Bartges *et al.*, 2014)

Reproductive conditions

Cryptorchidism
- Congenital defect believed to be inherited as a sex-limited, autosomal recessive trait
- Breed at risk in case series

(Hayes *et al.*, 1985)

Dystocia
- This breed at increased risk of both emergency and elective caesarean section in a North American case series
- Odds ratio in a UK first-opinion practice study of 5.7 (95% CI 3.1–10.5; $p < 0.001$)

(Moon *et al.*, 1998; O'Neill *et al.*, 2017c)

Urethral prolapse
See under *Renal and urinary conditions*

Vaginal hyperplasia/vaginal prolapse
- This breed one of the most often reported to be affected

(Post *et al.*, 1991)

Respiratory conditions

Brachycephalic obstructive airway syndrome (BOAS)
- Most commonly present with clinical signs aged 1–4 years
- 61% of cases were this breed in one US study
- 19% of this breed in a large UK primary-care study were suffering from upper respiratory tract disorders
- Bronchial disorders also common with this disorder

(Riecks *et al.*, 2007; De Lorenzi *et al.*, 2009; Fasanella *et al.*, 2010; O'Neill *et al.*, 2015b)

Tracheal hypoplasia
- This breed represented 55% of cases in an American case series
- Age at diagnosis from 2 days to 12 years

(Coyne & Fingland, 1992)

BULLMASTIFF

Musculoskeletal conditions

Elbow dysplasia
- Fragmented coronoid process OR 38.9 (95% CI 19.8–76.5) compared to mixed breeds

(LaFond *et al.*, 2002)

Hip dysplasia
- Neutered male dogs predisposed
- OR 3.5 (95% CI 2.2–5.6) compared to mixed breeds

(LaFond *et al.*, 2002)

Osteochondrosis – hock
- Affects dogs 5–9 months of age
- OR 85.9 (95% CI 35.8–206.4) compared to mixed breeds

(LaFond *et al.*, 2002)

Osteochondrosis – shoulder
- Males predisposed
- Age of onset usually 4–7 months, but can be older
- OR 6.7 (95% CI 2.9–15.5) compared to mixed breeds

(LaFond *et al.*, 2002)

Neoplastic conditions

Lymphoma
- Two German comparison populations – own clinic ($n = 52\ 142$) and insured population ($n = 123\ 423$)
- Odds ratio 7.8 and 5.0 respectively for the two populations
- Familial in a 1984 study, with estimated incidence of 5000 cases per 100 000 dogs
- High incidence also reported in this breed in a UK study: OR 6.76 (95% CI 2.03–22.51; $p = 0.002$)

(Onions, 1984; Edwards *et al.*, 2003; Ernst *et al.*, 2016)

Neurological conditions

Cerebellar degeneration
- Autosomal recessive inheritance suggested
- Signs seen at 4–9 weeks
- May be seen with hydrocephalus

(Johnson *et al.*, 2001)

Ocular conditions

Entropion
- Polygenic inheritance suspected
- Associated with macroblepharon

(Read & Broun, 2007)

Progressive retinal atrophy (PRA)
- Autosomal dominant inheritance suspected (may be more than one genetic form)
- Ophthalmoscopic signs at 4 months to 3 years

(Kijas *et al.*, 2003)

Renal and urinary conditions

Urolithiasis – cystine
- Breed at risk in case series
- Young dogs affected (2–5 years)
- Almost all cases are male

(Case *et al.*, 1992)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)
- Breed over-represented in a UK case series ($p < 0.0001$)

(Gibson *et al.*, 2013)

Vaginal hyperplasia/vaginal prolapse
- This breed one of the most often reported to be affected

(Post *et al.*, 1991)

CAIRN TERRIER

Cardiovascular conditions

Mitral valve disease
- Odds ratio in a UK study 2.11 (95% CI 1.34–3.32) in males

(Thrusfield *et al.*, 1985)

Dermatological conditions

Atopic dermatitis (atopy)
- Some studies show no sex predilection, others show females predisposed
- Breed predisposed in a US study
- This breed 5.7 times more frequently diagnosed than the general hospital population

(Schick & Fadok, 1986)

Endocrine conditions

Diabetes mellitus
- Swedish population
- Incidence rate (IR) 183 per 10 000 DYAR, compared with a mixed-breed IR of 15

(Catchpole *et al.*, 2005; Fall *et al.*, 2007)

Hypoadrenocorticism (Addison's disease)
- Increased risk in an insured Swedish population
- Relative risk 3.39 (95% CI 2.17–5.06)

(Hanson *et al.*, 2016)

Thyroid neoplasia

See under *Neoplastic conditions*

Gastrointestinal conditions

Chronic hepatitis
- Reported to be predisposed in a UK case series
- Mean age of diagnosis 8 years

(Bexfield *et al.*, 2012a)

Congenital portosystemic shunt
- Breed at risk in case series
- 58/6372 dogs screened in a Dutch population had portosystemic shunt
- Clinical signs usually seen in young dogs < 1 year
- Usually extrahepatic in this breed
- Inheritance autosomal, monogenic or polygenic

(van Straten *et al.*, 2005)

Microvascular portal dysplasia
- Complex inheritance in this breed
- Reported in a US case series

(Schermerhorn *et al.*, 1996; van Steenbeek *et al.*, 2012)

Musculoskeletal conditions

Avascular necrosis of the femoral head (Legg–Calvé–Perthes disease)
- OR 17.9 (95% CI 6.5–49.2) compared to mixed breeds in a US study

(LaFond *et al.*, 2002)

Craniomandibular osteopathy (lion jaw)
- This breed reported to be at high risk in a US study

(Munjar *et al.*, 1998)

Patellar luxation
- Odds ratio 1.9 (95% CI 1.1–3.2) compared to mixed breeds in a US study

(LaFond *et al.*, 2002)

Neoplastic conditions

Testicular neoplasia
See under *Reproductive conditions*

Thyroid neoplasia
- Breed significantly over-represented in a UK case series

(Sullivan *et al.*, 1987a)

Ocular conditions

Cataract
- Prevalence of primary cataract 3.89%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005)

Glaucoma
- May be related to ocular melanosis in this breed (see below)
- Prevalence of 1.82% in this breed in a US case series

(Gelatt & MacKay, 2004a)

Lens luxation – secondary
- Significant predisposition in this breed
- Swiss population

(Betschart *et al.*, 2014)

Ocular melanosis (abnormal pigment deposition)
- Familial, autosomal dominant inheritance suspected
- Predisposes to glaucoma
- Reported in US case series

(Petersen-Jones *et al.*, 2007)

Renal and urinary conditions

E. coli urinary tract infection
- Commonly reported in males of this breed in a large study of urolithiasis

(Ling *et al.*, 1998a)

Ectopic ureter
- Significant increased risk in this breed in a UK population

(Holt *et al.*, 2000)

Renal dysplasia
- Reported in a US case series of related animals

(Seiler *et al.*, 2010)

Reproductive conditions

Testicular neoplasia
- Breed at increased risk of Sertoli cell tumour in case series
- Mean age 9–11 years

(Weaver, 1983)

CANE CORSO

See *Italian Mastiff*

CATAHOULA LEOPARD DOG

Cardiovascular conditions

Heart block
- This breed reported to be predisposed to high-grade second-degree or third-degree heart block in a US case series

- Heavier, older and sexually intact female dogs over-represented

(Schrope & Kelch, 2006)

CAVALIER KING CHARLES SPANIEL

Behavioural conditions

Fear behaviour in puppies

- 53% of puppies in this breed exhibited fear behaviour in a UK and US study

(Morrow *et al.*, 2015)

Cardiovascular conditions

Femoral artery occlusion

- 2.3% of dogs of this breed had an undetectable right or left femoral pulse in one study
- A further 4.2% had a weak right or left femoral pulse
- Probably clinically insignificant, due to collateral circulation
- Possible genetic predisposition

(Buchanan *et al.*, 1997)

Mitral valve disease

- Higher hazard of death from this condition in this breed in a UK general practice study
- Heritability for grade of murmur for 4–5-year-old Cavaliers estimated at 0.67
- Inheritance not thought to be due to a single major gene effect
- Odds ratio of cardiovascular disease in this breed in an insured Japanese population of 16.2 (95% CI 14.4–18.2) compared to the Miniature Dachshund

(Lewis *et al.*, 2011a; French *et al.*, 2012; Mattin *et al.*, 2015a, 2015b; Inoue *et al.*, 2016)

Dermatological conditions

Ichthyosis

- Congenital and probably hereditary
- Often associated with keratoconjunctivitis sicca in this breed

(Barnett, 2006; Hartley *et al.*, 2012)

Persistent scratching

See under *Neurological conditions* (*Chiari malformation/syringomyelia*)

Gastrointestinal conditions

Exocrine pancreatic insufficiency (EPI)

- Breed at risk in case series

(Batchelor *et al.*, 2007)

Hepatic disease

- 11.1% of dogs of this breed had primary hepatic disease in a post-mortem population

(Kent *et al.*, 2016)

Pancreatitis

- Breed at risk of chronic pancreatitis in case series of post-mortem dogs
- Relative risk (RR) 3.2 (95% CI 2.5–4.1)

(Watson *et al.*, 2007)

Haematological/immunological conditions

Immunoglobulin deficiency

- Associated with a protozoal pneumonia (*Pneumocystis carinii*)
- Inheritance uncertain

See also under *Infectious conditions*

(Watson *et al.*, 2006)

Infectious conditions

Angiostrongylosis

- Increased risk of infection in this breed in a UK study

(Blehaut *et al.*, 2014)

Pneumocystis carinii infection

- Increased susceptibility in this breed due to immunodeficiency

See also under *Haematological/immunological conditions* (*Immunoglobulin deficiency*)

(Watson *et al.*, 2006)

Musculoskeletal conditions

Humeral condylar fractures

- Breed over-represented in a UK case series

(Cockett & Jones, 1985)

Inguinal/scrotal herniation

- Breed over-represented in an Australian population compared to hospital population

(Bellenger, 1996)

Patellar luxation

- May be inherited as an autosomal recessive trait
- Medial luxation more common in this breed
- OR 9.1 (95% CI 3.3–25.1) compared to mixed breeds

(LaFond *et al.*, 2002)

Temporomandibular joint dysplasia

- Usually asymptomatic

(Dickie *et al.*, 2002)

Neoplastic conditions

Anal sac adenocarcinoma

- OR 3.36 (95% CI 2.17–5.20) in the UK

(Polton *et al.*, 2006)

Neurological conditions

Chiari malformation/syringomyelia

- Also known as caudal occipital malformation syndrome; persistent scratching
- Heritability of syringomyelia 0.37 ± 0.15 SE in a UK population
- Prevalence of asymptomatic syringomyelia in this breed in the UK estimated at 25% by age 12 months and 70% at age 72 months or more
- In a UK general practice population, signs suggestive of this condition had a period prevalence in this breed of 1.6% (95% CI 1.2–2.06%) compared to 0.05% (95% CI 0.04–0.06%) for all breeds
- In a study of all Danish Kennel Club registered Cavaliers, prevalence of 15.4% was found, with heritability of symptomatic syringomyelia estimated at 0.81

(Lewis *et al.*, 2010; Parker *et al.*, 2011; Thøfner *et al.*, 2015; Sanchis-Mora *et al.*, 2016)

Episodic falling

- Reported in UK and USA
- Age of clinical onset: 3–4 months
- Mutation associated with the condition found in a US population
- 12.9% of US population were carriers for this mutation

(Gill *et al.*, 2012)

Idiopathic epilepsy

- Inherited in this breed
- Age of onset 6 months to 6 years
- All coat colours affected, but more common in lines originating from whole-colour ancestors from the late 1960s

(Rusbridge & Knowler, 2004; Rusbridge, 2005; Driver *et al.*, 2013)

Primary secretory otitis media

- Reported in Swedish and US case series

(Stern-Bertholtz, 2003; Cole *et al.*, 2015)

Ocular conditions

Cataract

- Prevalence of primary cataract 3.90%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005)

Corneal ulceration (ulcerative keratitis)

- OR 6.74 (95% CI 4.82–9.41; $p < 0.001$) compared to crossbreeds in a UK general practice population

(O'Neill *et al.*, 2017b)

Keratoconjunctivitis sicca

- 14/87 cases were this breed in a Danish case series
- One study suggested a predisposition for males
- Associated with ichthyosis in this breed

(Nicolet, 2006; Sanchez *et al.*, 2007; Hartley *et al.*, 2012)

Physiological conditions

Giant platelets and thrombocytopenia

- Affects around 50% of Cavaliers
- Giant platelets may lead to reduced count of platelets if using automated methods
- Plateletcrit gives a more accurate picture of the platelet mass than other automated techniques
- Inherited as an autosomal recessive trait

(Pedersen *et al.*, 2002; Cowan *et al.*, 2004; Kelley *et al.*, 2014)

Renal and urinary conditions

Chronic kidney disease

- Breed predisposed in a UK general practice population
- 52.2% of this breed had renal lesions at post-mortem examination. 16.7% in this series had an ante-mortem diagnosis of chronic kidney disease

(O'Neill *et al.*, 2013b; Kent *et al.*, 2016)

Reproductive conditions

Dystocia

- Odds ratio in a UK first-opinion practice survey of 2.0 (95% CI 1.1–3.9; $p = 0.033$)

(O'Neill *et al.*, 2017c)

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- Breed at increased risk in Swedish case series

(Egenvall *et al.*, 2001)

Respiratory conditions

Angiostrongylosis

See under *Infectious conditions*

Brachycephalic obstructive airway syndrome (BOAS)
- 20.5% of cases in an Australian referral population were this breed

(Torrez & Hunt, 2006)

Pneumonia due to *Pneumocystis carinii* infection

See under *Haematological/immunological conditions* and *Infectious conditions*

CHESAPEAKE BAY RETRIEVER

Dermatological conditions

Adult-onset hair loss
- Reported in a US case series

(Cerundolo *et al.*, 2005)

Haematological/immunological conditions

von Willebrand's disease
- This breed is affected by type III disease
- Inherited as an autosomal recessive trait

(Brooks, 1999)

Musculoskeletal conditions

Cranial cruciate ligament (CCL) disease
- This breed predisposed in a US case series
- Neutered individuals may be predisposed

(Duval *et al.*, 1999)

Hip dysplasia
- Neutered male dogs predisposed
- OR 4.4 (95% CI 3.0–6.5) compared to mixed breeds in a US study

(LaFond *et al.*, 2002)

Osteochondrosis – shoulder
- Males predisposed
- Age of onset usually 4–7 months, but can be older
- OR 7.7 (95% CI 3.3–17.8) compared to mixed breeds in a US study

(LaFond *et al.*, 2002)

Panosteitis (enostosis, eosinophilic panosteitis)
- Young males predisposed
- OR 1.8 (95% CI 1.1–3.0) compared to mixed breeds in a US study

(LaFond *et al.*, 2002)

Ocular conditions

Cataract
- Dominant mode of inheritance with incomplete penetration has been suggested
- Age of onset: young adult (6 months to 2 years), may progress
- 12.5% prevalence in a Norwegian population
- Prevalence of primary cataract 2.79%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Bjerkås, 1991; Gelatt & MacKay, 2005)

Progressive rod–cone degeneration
- Frequency of the disease-causing mutation found to be 0.14 in this breed in a Czech study

(Dostal *et al.*, 2011)

Neurological conditions

Exercise-induced collapse
- 56/320 dogs of this breed were heterozygous (carriers) and 8/320 were homozygous (affected) for the *DNM1* gene mutation causing this condition in a North American study

(Minor *et al.*, 2011)

CHIHUAHUA

Cardiovascular conditions

Mitral valve disease
- Odds ratios in a UK study 4.63 (95% CI 2.37–9.01) in males and 7.62 (3.41–17.01) in females

(Thrusfield *et al.*, 1985)

Patent ductus arteriosus
- Breed over-represented in a US case series

(Henrich *et al.*, 2011)

Gastrointestinal conditions

Gallbladder mucocoele
- OR 2.18 (95% CI 1.58–5.94; $p = 0.002$) in a US study, compared to hospital population

(Kutsunai *et al.*, 2014)

Infectious conditions

Parvovirus
- Breed over-represented in a US case series

(Lefebvre, 2013)

Musculoskeletal conditions

Atlantoaxial subluxation/instability

See under *Neurological conditions*

Avascular necrosis of the femoral head (Legg–Calvé–Perthes disease)

- OR 26.8 (95% CI 11.7–61.7) in one US study, compared to mixed breeds

(LaFond *et al.*, 2002)

Inguinal/scrotal herniation

- Breed over-represented in an Australian population compared to hospital population

(Bellenger, 1996)

Patellar luxation

- Mainly medial luxation observed
- OR 8.9 (95% CI 6.1–12.8) in a US study, compared to mixed breeds
- OR 5.9 (95% CI 4.4–7.9, $p < 0.001$) in a UK general practice case series

(LaFond *et al.*, 2002; Alam *et al.*, 2007; O'Neill *et al.*, 2016c)

Neurological conditions

Atlantoaxial subluxation/instability

- Congenital
- Mean age of presentation 2.7 years
- Over-represented in a UK case series

(Denny *et al.*, 1988)

Hydrocephalus

- Congenital
- Over-represented in a US case series

(Biel *et al.*, 2013)

Necrotizing meningoencephalitis

- Reported in a small US case series

(Higgins *et al.*, 2008)

Chiari malformation/syringomyelia

- Increased risk in a UK general practice epidemiological study (OR 7.4, 95% CI 1.24–44.71; $p = 0.028$)

(Sanchis-Mora *et al.*, 2016)

Ocular conditions

Cataract

- Prevalence of primary cataract 1.84%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005)

Corneal ulceration (ulcerative keratitis)

- OR 2.04 (95% CI 1.21–3.43; $p = 0.008$) compared to crossbreeds in a UK general practice population

(O'Neill *et al.*, 2017b)

Progressive rod cone degeneration

- Mutant allele detected with a frequency of 0.02 in this breed in a Japanese genetic study

(Kohyama *et al.*, 2016)

Renal and urinary conditions

Urolithiasis – calcium oxalate

- Breed significantly over-represented in a UK study

(Roe *et al.*, 2012)

Urolithiasis – cystine

- Almost all cases reported were male
- Significantly increased risk of cystine calculus formation in an American population

(Case *et al.*, 1992)

Reproductive conditions

Cryptorchidism

- Congenital defect believed to be inherited as a sex-limited, autosomal recessive trait
- Breed at increased risk in US case series

(Pendergrass & Hayes, 1975)

Dystocia

- Increased risk in a US case series
- Incidence rates (IR) per 1000 DYAR in a Swedish population were 31.9 (short-hair) and 31.4 (long-hair)
- Odds ratio in a UK first-opinion study was 12.3 (95% CI 8.2–18.2; $p < 0.001$)

(Gaudet, 1985; Bergström *et al.*, 2006; O'Neill *et al.*, 2017c)

Eclampsia (puerperal tetany)

- Breed over-represented compared to hospital population in US study

(Drobatz & Casey, 2000)

Respiratory conditions

Tracheal collapse

- 4/100 cases were this breed in a UK case series (fourth most common breed affected)
- 8% of cases were this breed in a Korean case series
- Usually acquired in older dogs but can be congenital

(White & Williams, 1994; KiChang *et al.*, 2004)

CHIN

See *Japanese Chin*

CHINESE CRESTED DOG

Dermatological conditions

Canine ectodermal dysplasia (hairlessness)

- Chinese Crested is a hairless breed
- The breed is produced by a dominant gene for hypotrichosis being combined with the gene for long hair
- Homozygotes (HH) for hypotrichosis die prenatally
- All Cresteds are Hh if hairless
- hh are coated (called 'powder puffs')
- Three sub-phenotypes have marked differences histologically

(Robinson, 1985; Drögemüller *et al.*, 2008b; Wiener *et al.*, 2013)

Neurological conditions

Canine multiple system degeneration

- Presents as a movement disorder
- Autosomal recessive inheritance

(O'Brien et al., 2005)

Ocular conditions

Cataract

- Prevalence of primary cataract 5.66%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005)

Keratoconjunctivitis sicca

- Predisposed in a Norwegian population compared to Papillons and Toy/Miniature Poodles

(Ulfeng *et al.*, 2009)

Lens luxation – primary

- This breed over-represented in a Swiss referral population

(Betschart *et al.*, 2014)

Progressive rod–cone degeneration (PRCD)

- Mutant allele detected with a frequency of 0.02 in a Czech genetic study

(Dostal *et al.*, 2011)

CHINESE SHAR PEI

See *Shar Pei*

CHOW CHOW

Cardiovascular conditions

Heart block

- This breed reported to be predisposed to high-grade second-degree or third-degree heart block in a US case series
- Heavier, older and sexually intact female dogs over-represented

(Schrope & Kelch, 2006)

Dermatological conditions

Alopecia X (castration-responsive alopecia)

- Relative risk 23.5 in a Canadian referral population

(Scott & Paradis, 1990)

Flea-bite hypersensitivity

- Most studies show no breed predisposition, but one French study showed this breed was predisposed

(Prélaud & Guaguere, 1998)

Pemphigus foliaceus

- No age or sex predispositions noted
- OR 12.3 for this breed in a US pathological case series

(Kuhl *et al.*, 1994)

Gastrointestinal conditions

Exocrine pancreatic insufficiency (EPI)

- Breed at risk in a UK clinicopathological case series
- Prevalence significantly higher in this breed than in a control population of insured dogs
- Females over-represented in this breed

(Batchelor *et al.*, 2007)

Gastric carcinoma

See under *Neoplastic conditions*

Melanoma – oral

See under *Neoplastic conditions*

Musculoskeletal conditions

Cranial cruciate ligament (CCL) disease

- Neutered individuals are predisposed
- Older animals are predisposed
- OR 1.73 (95% CI 1.55–1.93) compared to a US referral population

(Witsberger *et al.*, 2008)

Elbow dysplasia
- Fragmented coronoid process OR 16.6 (95% CI 8.0–34.7) compared to mixed breeds
- Ununited anconeal process OR 13.3 (95% CI 7.8–22.6)

(LaFond *et al.*, 2002)

Hip dysplasia
- Neutered male dogs predisposed
- OR in this breed 1.90 (95% CI 1.73–2.07) in one US study
- In another US study odds ratio compared to mixed breeds was 5.4 (95% CI 4.2–7.0)

(LaFond *et al.*, 2002; Witsberger *et al.*, 2008)

Myotonia
- Inherited condition
- Onset of signs at around 2 months of age
- Reported in one small case series from New Zealand and one from Australia

(Jones *et al.*, 1977; Farrow & Malik, 1981)

Panosteitis (enostosis, eosinophilic panosteitis)
- Young males predisposed
- OR 1.7 (95% CI 1.3–2.2) compared to mixed breeds

(LaFond *et al.*, 2002)

Patellar luxation
- OR 6.1 (95% CI 3.9–9.4) compared to mixed breeds

(LaFond *et al.*, 2002)

Pituitary dwarfism
- Reported predisposed in a US population

(Scott & Walton, 1986)

Neoplastic conditions

Gastric carcinoma
- OR 23.53 ($p < 0.01$) in an Austrian case series
- Also reported as one of the most frequently presented breeds in a German case series

(Bilek & Hirt, 2007; Babo *et al.*, 2012)

Melanoma – oral
- Breed at increased risk in case series (13/113 cases of oral melanoma at a US diagnostic investigation laboratory)
- Average age 11.4 years

(Ramos-Vara *et al.*, 2000; Schultheiss, 2006)

Neurological conditions

Dysmyelination of the central nervous system
- Tremors present from birth
- Reported in five Chow Chows from three different litters
- Not reported recently

(Vandevelde *et al.*, 1978)

Myotonia
See under *Musculoskeletal conditions*

Ocular conditions

Cataract
- Familial, congenital
- May be seen with other ocular anomalies but relationship unclear

(Collins *et al.*, 1992)

Glaucoma
- Prevalence of 4.7% in a US case series

(Gelatt & MacKay, 2004a)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)
- This breed represented 6.4% of cases of pyometra in a Belgian population despite the breed only comprising 1.6% of the population
- Pyometra also more severe in this breed, with anaemia and endotoxaemia

(Troyer & Schepper, 1989)

CLUMBER SPANIEL

Musculoskeletal conditions

Mitochondrial myopathy
- Primary defect is in mitochondrial function
- Reported in USA and UK

(Herrtage & Houlton, 1979; Shelton, 1999)

Pyruvate dehydrogenase phosphatase 1 deficiency
- 20% of current Clumber and Sussex Spaniel population are carriers for the affected gene

(Cameron *et al.*, 2007)

Ocular conditions

Cataract
- Prevalence of primary cataract 5.32%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005)

Reproductive conditions

Dystocia

- One of the top 10 breeds reported to need caesarean sections in a UK study
- Uterine inertia more common problem than physical blockage in this breed

(Evans & Adams, 2010a)

COCKER SPANIEL

Behavioural conditions

Aggression

- Reported to be at increased risk of aggression towards the owner, aggression towards strangers and indoor urination/defecation in a Danish study
- In a Spanish study, owner-directed aggression was more common in this breed than in other breeds, and the golden coat colour was more common in aggressive than in non-aggressive Cocker Spaniels

(Lund *et al.*, 1996; Amat *et al.*, 2009)

Cardiovascular conditions

Bradyarrhythmia

- This breed reported to be predisposed to high-grade second-degree or third-degree heart block in a US case series
- Heavier, older and sexually intact female dogs over-represented
- Also reported to be predisposed to sinus node dysfunction/sick sinus syndrome in US case series

(Schrope & Kelch, 2006; Wess *et al.*, 2006; Ward *et al.*, 2016)

Dilated cardiomyopathy (DCM)

- DCM in this breed is often related to taurine deficiency
- May respond to taurine and L-carnitine supplementation
- Increased prevalence with age
- Approximately three times as common in males as females in this breed
- Thought to be familial or genetic
- Reported common in this breed in a UK case series

(Kittleson *et al.*, 1997; Martin *et al.*, 2009)

Dermatological conditions

Atopic dermatitis (atopy)

- Reported to be strongly predisposed in a Greek population

(Saridomichelakis *et al.*, 1999)

Grass awn migration

- This breed over-represented in a Czech case series

(Crha *et al.*, 2003)

Idiopathic nasodigital hyperkeratosis

- Breed possibly predisposed in an American case series

(Scott & Miller, 2012a)

Malassezia dermatitis

- This breed significantly over-represented in American and UK case series

(Bond *et al.*, 1996; Mauldin *et al.*, 1997)

Otitis externa

- 60% of cases of severe otitis externa in one US case series were Cocker spaniels
- Significantly over-represented in a Greek study in which grass awns and *Malassezia* were a factor in this breed
- Cockers significantly over-represented in a UK case series

(Angus *et al.*, 2002; Saridomichelakis *et al.*, 2007; Zur *et al.*, 2011)

Tail injuries

- 56.6% of undocked working spaniels received a tail injury in one shooting season in a UK study
- Breed also predisposed in a UK general practice case–control study

(Diesel *et al.*, 2010; Lederer *et al.*, 2014)

Vitamin-A-responsive dermatosis

- Reported in a small case series in this breed

(Scott, 1986)

Endocrine conditions

Hyperadrenocorticism (Cushing's syndrome)

- Reported to be common in this breed in a case series of 153 dogs in an American population

(Wood *et al.*, 2007)

Hypoadrenocorticism (Addison's disease)

- Increased risk in an insured Swedish population
- Relative risk (RR) 2.94 (95% CI 1.87–4.43)

(Hanson *et al.*, 2016)

Hypothyroidism

- Breed at increased risk in a US case series from the 1960s and 1970s

- May occur at a younger age in breeds at risk (2–3 years)
- Females and neutered males at increased risk

(Milne & Hayes, 1981)

Chronic hepatitis

- American and English Cocker Spaniels
- Breed at increased risk
- Males predisposed
- Some cases may be associated with hepatic accumulation of alpha-1 antitrypsin in this breed
- Odds ratios in a 2008 UK population 21.6 (95% CI 9.7–47.9; $p<0.001$) (American cockers) and 2.4 (1.8–3.2; $p<0.001$) (English cockers)

(Sevelius *et al.*, 1994; Watson, 2004; Bexfield *et al.*, 2012a)

Gallbladder mucocoele

- OR 6.52 (95% CI 3.13–25.53; $p=0.002$) in a US study, compared to hospital population

(Kutsunai *et al.*, 2014)

Oropharyngeal neoplasia

- Breed at risk in a US 1960s and 1970s case series

(Dorn & Priester, 1976)

Pancreatitis

- Breed at risk of acute and chronic pancreatitis in a case series of post-mortem dogs
- RR 2.8 (95% CI 2.3–2.5) for acute and chronic pancreatitis combined

(Watson *et al.*, 2007)

Haematological/immunological conditions

Factor II deficiency

- Probably inherited as an autosomal recessive trait
- Severe signs in this breed

(Brooks, 1999)

Factor X deficiency

- Familial
- May be inherited as an autosomal recessive trait
- Severe signs in this breed

(Brooks, 1999)

Haemophilia A

- Severe factor VIII deficiency in this breed
- Familial in this breed

(Brooks, 1999)

Immune-mediated haemolytic anaemia (IMHA)

- Usually affects young adult and middle-aged animals
- May be more common in bitches
- May be seasonal variations
- OR 12.2 (95% CI4.5–33.1; $p<0.001$) in a US study, compared to hospital population
- Increased risk in a Canadian study ($p=0.012$)

(Carr *et al.*, 2002; Miller *et al.*, 2004)

Immune-mediated thrombocytopenia (IMTP)

- Breed over-represented compared to a US hospital population

(O'Marra *et al.*, 2011)

Platelet disorder

- Delta storage pool disorder in this breed

(Brooks, 1999)

Infectious conditions

Angiostrongylosis

- Increased risk of infection in this breed in a UK study

(Blehaut *et al.*, 2014)

Babesiosis

- Breed over-represented in a Brazilian case series
- 41.93% frequency of detection in suspicious clinical cases in this breed

(Ungar de Sá *et al.*, 2007)

Cryptococcosis

- American Cocker Spaniel
- Breed at increased risk in two US case series
- Usually seen in dogs < 4 years
- Living outdoors and exposure to bird droppings are risk factors

(Berthelin *et al.*, 1994; Trivedi *et al.*, 2011)

Rhipicephalus sanguineus

- Increased susceptibility to this tick compared to Beagles in experimental studies

(Louly *et al.*, 2009, 2010)

Metabolic conditions

Overweight/obesity

- Breed predisposed in a North American private practice population
- OR 1.9 (95% CI 1.6–2.2; $p<0.0001$)

(Lund *et al.*, 2006)

Musculoskeletal conditions

Cranial cruciate ligament (CCL) disease

- This breed reported to be at increased risk in a Czech study

(Nečas *et al.*, 2000)

Incomplete ossification of the humeral condyle

- Polygenic recessive mode of inheritance
- Males predisposed

(Marcellin-Little *et al.*, 1994)

Inguinal/scrotal herniation

- Breed over-represented in an Australian population compared to hospital population

(Bellenger, 1996)

Patellar luxation

- American Cocker Spaniel
- May be inherited as an autosomal recessive trait
- Lateral luxation more common in this breed
- OR 2.1 (95% CI 1.7–2.7) compared to mixed breeds in a US population

(LaFond *et al.*, 2002)

Temporomandibular joint dysplasia

- American Cocker Spaniels
- Congenital
- Usually affects dogs from 6 months of age

(Hoppe & Svalastoga, 1980)

Neoplastic conditions

Anal sac adenocarcinoma

- English Cocker Spaniel had an OR of 11.00 (95% CI 8.27–14.64) in the UK

(Polton *et al.*, 2006)

Canine acanthomatous ameloblastoma

- Breed over-represented in a US case series

(Fiani *et al.*, 2011)

Canine cutaneous histiocytoma

- Breed at increased risk in an Australian case series (9/80 cases were this breed)

(Er & Sutton, 1989)

Lingual plasma cell tumour

- Increased risk in a US case series

(Dennis *et al.*, 2006)

Lymphoma

- Relative risk (RR) 1.15 ($p < 0.001$) in a French study

(Pastor *et al.*, 2009)

Mammary neoplasia

- Significantly higher risk in this breed in a Czech case study ($p < 0.01$)
- In one US study of male dogs with mammary tumours, 7/18 dogs were Cocker Spaniels
- This breed consistently affected according to one Mexican study

(Zatloukal *et al.*, 2005; Bearss *et al.*, 2012; Salas *et al.*, 2015)

Melanoma

- Breed at increased risk in a US histopathological case series
- Mean age 8.9 years
- Predilection site of the lip in this breed

(Schultheiss, 2006)

Oropharyngeal neoplasia

See under *Gastrointestinal conditions*

Perianal (hepatoid) gland adenomas

- Breed at risk in US case series
- Average age was 10.5 years
- Relative risk compared to US veterinary medical database of 2.0 (95% CI 1.41–3.03) in males and 3.3 (95% CI 2.03–7.30) in females

(Hayes & Wilson, 1977)

Sebaceous gland carcinoma

- Incidence of 15.6% in a US case series

(Strafuss, 1976)

Neurological conditions

Intervertebral disc disease (IVDD)

- Reported to be common in this breed in a US case series
- English Cockers more likely to have caudal and midlumbar intervertebral disc extrusions than Dachshunds

(Mayhew *et al.*, 2004; Cardy *et al.*, 2016)

Multisystem neuronal degeneration

- Familial and suspected inherited
- Age of clinical onset 10–14 months

(Jaggy & Vandevelde, 1988)

Ocular conditions

Cataract

- Autosomal recessive inheritance suspected
- Relatively common condition in this breed, possibly higher incidence in females
- Prevalence of primary cataract 8.77% in American Cocker Spaniel and 8.23% in English

Cocker Spaniel, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)
- Lens-induced uveitis common in this breed

(Olesen *et al.*, 1974; van der Woerdt *et al.*, 1992; Adkins & Hendrix, 2005; Gelatt & MacKay, 2005)

Corneal ulceration (ulcerative keratitis)
- OR 2.33 (95% CI 1.58–3.42 < 0.001) compared to crossbreeds in a UK general practice population

(O'Neill *et al.*, 2017b)

Distichiasis
- Extremely high prevalence in a Danish study (49.3%)
- Females predisposed
- Heritability moderate to high (0.22–0.51)

(Petersen *et al.*, 2015)

Glaucoma
- Inheritance suspected
- Predisposition for females suggested
- May be associated with goniodysgenesis
- Glaucoma secondary to cataracts also seen
- In a North American study, prevalence among American Cocker Spaniels was 5.52%, and 1.35% in English Cockers

(Gelatt & MacKay, 2004a, 2004b; Johnsen *et al.*, 2006)

Keratoconjunctivitis sicca
- Breed at increased risk in a UK study
- One study suggested a female predisposition in English Cocker Spaniels

(Sanchez *et al.*, 2007)

Progressive rod–cone degeneration (PRCD)
- Frequency of the disease-causing mutation found to be 0.34 (English Cockers) and 0.08 (American Cockers) in a Czech study

(Dostal *et al.*, 2011)

Prolapse of the gland of the nictitating membrane ('cherry eye')
- American Cocker Spaniel
- Increased risk in this breed in a US case series

(Morgan *et al.*, 1993)

Retinal detachment
- One of the most common breeds affected in a US case series

(Hendrix *et al.*, 1993)

Retinal dysplasia – multifocal
- American Cocker Spaniels
- Congenital, autosomal recessive inheritance suspected

(MacMillan & Lipton, 1978)

Retinal pigment epithelial dystrophy (RPED, central progressive retinal atrophy)
- English Cocker Spaniels
- Inheritance suspected
- More prevalent in the UK than in the USA. Becoming less prevalent following the introduction of control schemes
- May be related to vitamin E deficiency due to an underlying metabolic abnormality in this breed

(McLellan *et al.*, 2002)

Traumatic proptosis
- One of the most commonly affected breeds in a Brazilian population

(Brandão *et al.*, 2005)

Renal and urinary conditions

Chronic kidney disease
- Breed predisposed in a UK general practice population

(O'Neill *et al.*, 2013b)

Familial renal disease (glomerular basement membrane disorder)
- English Cocker Spaniels
- Autosomal recessive inheritance suggested
- The condition is believed to be similar to Alport syndrome in humans
- Cases present at between 6 months and 2 years of age with proteinuria and chronic renal failure

(Lees *et al.*, 1998; Davidson *et al.*, 2007)

Urolithiasis – silica
- Breed at risk in a US series
- Mean age at diagnosis 5.8 years
- Males predisposed

(Osborne *et al.*, 1999)

Urolithiasis – struvite
- Breed at risk in case series
- Average age at diagnosis in one large study: males 6.0 years, females 5.7 years
- Females predisposed (16:1 in one large study)

(Osborne *et al.*, 1999; Houston *et al.*, 2004)

Urolithiasis – urate
- Breed at risk in a Czech case series
- Male dogs predisposed

(Kučera, 2007)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)
- English Cocker Spaniels
- Breed at risk in a Swedish case series

(Egenvall *et al.*, 2001)

XX sex reversal
- American Cocker Spaniels
- Autosomal recessive inheritance

(Meyers-Wallen & Patterson, 1988; Pujar *et al.*, 2005)

Respiratory conditions

Bronchiectasis
- American Cocker Spaniels had increased risk in a US case series
- Usually affects middle-aged to older dogs
- Usually occurs secondary to chronic pulmonary disease

(Hawkins *et al.*, 2003)

COLLIES – ROUGH AND SMOOTH

Behavioural conditions

Aggression and fearfulness
- Reported to be at increased risk of aggression to strangers and general fearfulness

(Arvelius *et al.*, 2014; Lund *et al.*, 1996)

Dermatological conditions

Bacterial folliculitis/furunculosis
- Relative risk (RR) 2.0 compared to Canadian hospital population

(Scott & Paradis, 1990)

Cutaneous lupus erythematosus
- Reported in two US case series

(Jackson, 2004; Jackson *et al.*, 2004)

Demodicosis
- Breed over-represented in a case series

(Scott & Miller, 2012b)

Dermatophytosis (ringworm)
- Collies were commonly represented in a Croatian case series

(Pinter *et al.*, 1999)

Familial canine dermatomyositis
- Inherited as an autosomal dominant trait with incomplete penetrance
- No predispositions for sex, coat colour or coat length

(Haupt *et al.*, 1985; Evans *et al.*, 2017)

Idiopathic sterile granuloma and pyogranuloma
- This breed over-represented in one study
- No age or sex predisposition

(Panich *et al.*, 1991)

Idiopathic ulcerative dermatosis in Shetland Sheepdogs and Collies
- No sex predisposition
- Affects middle-aged to older dogs

(Jackson & Olivry, 2001; Moriello, 2004)

Pemphigus foliaceus
- OR 3.9 for this breed in a US pathology case series

(Kuhl *et al.*, 1994)

Drug reactions

Ivermectin and milbemycin
- Associated with the mutant *MDR1* allele
- 22% of this breed were homozygous and 46.8% heterozygous for the mutation in US and UK populations

(Neff *et al.*, 2004; Mealey *et al.*, 2005)

Endocrine conditions

Diabetes mellitus
- One of the most common breeds affected in a UK population

(Davison *et al.*, 2005)

Insulinoma

See under *Neoplastic conditions*

Gastrointestinal conditions

Colorectal polyps
- This breed the most common in a US case series (4/17 cases were Collies)

(Seiler, 1979)

Exocrine pancreatic insufficiency (EPI)
- Rough Collies
- Typical age of onset: 36 months
- Prevalence in a clinicopathological case series (of animals with suggestive clinical signs) of 10.4% (95% CI 5.9–16.6%) in this breed

(Wiberg *et al.*, 1999; Batchelor *et al.*, 2007)

Gastric carcinoma
See under *Neoplastic conditions*

Gastric dilatation/volvulus (bloat, GDV)
- Incidence rate (IR) 21 cases per 1000 DYAR (95% CI 8–34) in a US study

(Glickman *et al.*, 2000a)

Pancreatitis
- Breed at risk of chronic pancreatitis in a case series of post-mortem dogs
- RR 2.0 (95% CI 1.2–3.2)

(Watson *et al.*, 2007)

Haematological/immunological conditions

Factor I deficiency
- Autosomal inheritance

(Brooks, 1999)

Platelet disorder
- Storage pool and signal transduction defect

(Brooks, 1999)

Immune-mediated haemolytic anaemia (IMHA)
- Increased risk in this breed in a UK case–control study

(Miller *et al.*, 2004)

Haemophilia A
- Familial and moderate severity in the rough collie

(Brooks, 1999)

Metabolic conditions

Hypomagnesaemia
- OR 3.9 (95% CI 1.3–6.8; $p < 0.02$) in a referral hospital population

(Khanna *et al.*, 1998)

Musculoskeletal conditions

Perineal herniation
- Older, intact males predisposed in a case series

(Robertson, 1984)

Neoplastic conditions

Gastric carcinoma
- Rough Collies
- Male dogs more commonly affected in case series
- Mean age of occurrence 8–10 years
- Proportional morbidity ratio of 26.1 (95% CI 6.4–106.5) in a Norwegian case series

(Sullivan *et al.*, 1987b; Seim-Wikse *et al.*, 2013)

Insulinoma
- Reported to be common in this breed in a US case series

(Kruth *et al.*, 1982)

Nasal cavity tumours
- Breed at increased risk in a US teaching hospital case series
- RR 2.9 (95% CI 2.05–4.12)
- Median age 9 years
- Males over-represented in most studies

(Hayes *et al.*, 1982)

Testicular neoplasia
- Rough Collies and Shetland Sheepdogs five times more likely to have testicular tumours than the rest of a Norwegian population
- Over-represented in a Slovenian study

(Nødtvedt *et al.*, 2011; Švara *et al.*, 2014)

Neurological conditions

Cerebellar degeneration
- Reported in an Australian case series
- Autosomal recessive inheritance

(Hartley *et al.*, 1978)

Idiopathic epilepsy
- *ABCB1* mutation, which has a > 50% prevalence in Collies, is associated with outcome

(Muñana *et al.*, 2012)

Ocular conditions

Collie eye anomaly
- Rough and Smooth Collies
- Congenital; autosomal recessive inheritance suspected. Some authors suggest polygenic inheritance
- High incidence in this breed throughout the world (50–90% has been reported), now reduced through selective breeding

(Bedford, 1982b; Wallin-Håkanson *et al.*, 2000)

Corneal dystrophy
- Rough Collies
- Inheritance suspected
- Reported in a UK case series
- Crystalline lipid stromal dystrophy
- Age of onset: 1–4 years
- May or may not be related to Collie eye anomaly

(Crispin, 1988)

Myopia (short-sightedness)
- Breed at increased risk in a large US study (Kubai *et al.*, 2008)

Nodular granulomatous episclerokeratitis
- Young to middle-aged Collies predisposed in a case series (Paulsen *et al.*, 1987)

Retinopathy (rod–cone dystrophy)
- Reported to be inherited in a recessive mode in this breed (Wolf *et al.*, 1978)

Renal and urinary conditions

Renal amyloidosis
- Breed at increased risk in a US case series
- Most cases > 6 years at diagnosis
- Females predisposed
- Renal amyloidosis may be seen secondary to dermatomyositis in this breed (DiBartola *et al.*, 1989)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)
- Rough Collie
- Breed at increased risk in a Swedish insurance database
- This breed may have increased risk at an earlier age compared to other breeds
- OR 2.05 (95% CI 1.21–3.47) in a UK population (Niskanen & Thrusfield, 1998; Egenvall *et al.*, 2001)

COONHOUND

Dermatological conditions

Blastomycosis

See under *Infectious conditions*

Infectious conditions

Blastomycosis
- Breed at increased risk in case series
- Young (2–4 years) entire males predisposed
- Geographic distribution: mainly North America (Mississippi, Missouri, Ohio River valleys, mid-Atlantic States, Quebec, Manitoba and Ontario)
- Proximity to a body of water is a risk factor in endemic areas (Rudmann *et al.*, 1992; Arceneaux *et al.*, 1998)

Histoplasmosis
- Reported to be common in this breed in a US case series (Burk *et al.*, 1978)

Musculoskeletal conditions

Hip dysplasia
- Treeing Walker Coonhound predisposed
- Neutered male dogs predisposed
- OR 3.1 (95% CI 1.3–7.4) compared to mixed breeds in a US study (LaFond *et al.*, 2002)

Renal and urinary conditions

Renal amyloidosis
- Treeing Walker Coonhounds at increased risk in case series
- Most cases > 6 years at diagnosis
- Females predisposed in one study (DiBartola *et al.*, 1989)

CORGI

See *Welsh Corgi*

COTON DE TULEAR

Neurological conditions

Neonatal cerebellar ataxia
- Also known as Bandera's neonatal ataxia
- Found in 7/32 pups from five litters in one US study
- In a genetic study of 112 dogs of this breed, 15 were homozygous for the mutant gene and were affected, 43 were heterozygotes, and 54 were homozygous for the ancestral gene
- Ataxia started at 2 weeks of age
- Autosomal recessive inheritance (Coates *et al.*, 2002; Zeng *et al.*, 2011)

Ocular conditions

Multifocal retinopathy
- Autosomal recessive inheritance
- Develops from 11 weeks of age
- Reported in 10 affected dogs of this breed which were compared to 20 unaffected dogs of this breed, in a Canadian study (Grahn *et al.*, 2006, 2008)

Renal and urinary conditions

Primary hyperoxaluria

- Autosomal recessive inheritance
- Onset from 3–4 weeks
- Reported in 7 dogs from four apparently unrelated litters in a Finnish study

(Vidgren *et al.*, 2012)

CURLY-COATED RETRIEVER

Musculoskeletal conditions

Glycogen storage disease type III

- Also known as Cori's disease
- Females predisposed
- Signs first seen at 2 months of age
- Carriers reported in the USA, Australia, New Zealand and Finland

(Gregory *et al.*, 2007)

Ocular conditions

Cataract

- Hereditary
- 12.1% prevalence in a Norwegian study

(Bjerkås, 1991)

Neurological conditions

Exercise-induced collapse

- 84/251 dogs of this breed were heterozygous (carriers) and 49/251 were homozygous (affected) for the *DNM1* gene mutation causing this condition in a North American study

(Minor *et al.*, 2011)

DACHSHUND

Behavioural conditions

Aggression

- This breed predisposed to increased inter-dog aggression in a Danish study
- In a Dutch study, breed predisposed to aggression against both humans and other dogs

(Rugbjerg *et al.*, 2003; Duffy *et al.*, 2008)

Cardiovascular conditions

Mitral valve disease

- Odds ratios in a UK study 1.97 (95% CI 1.07–3.62) in males and 2.31 (1.09–4.89) in females
- Mitral valve prolapse is common in this breed
- Polygenic mode of inheritance suspected
- Dachshunds frequently affected by mitral type murmurs in a French study of six breeds

(Thrusfield *et al.*, 1985; Olsen *et al.*, 1999; Serfass *et al.*, 2006)

Dermatological conditions

Atopic dermatitis (atopy)

- 6% prevalence in this breed in an Italian study

(Tognetti *et al.*, 1987)

Colour dilution alopecia

- Coat-colour genes are involved in the pathogenesis
- Autosomal recessive inheritance

(Beco *et al.*, 1996)

Sterile nodular panniculitis

- Miniature Dachshunds predisposed in a Japanese case series
- Neutered and younger dogs predisposed

(Yamagishi *et al.*, 2007)

Endocrine conditions

Diabetes mellitus

- More likely to develop anti-insulin antibodies than crossbreeds in a UK study
- 14/77 cases in a Swedish case series were this breed

(Forsberg, 1986; Holder *et al.*, 2015)

Hyperadrenocorticism (Cushing's syndrome)

- Reported to be common in this breed in a case series of 153 dogs in an American population

(Reusch & Feldman, 1991; Wood *et al.*, 2007)

Hypothyroidism

- Breed at increased risk in a US 1960s and 1970s case series
- May occur at a younger age in breeds at risk (2–3 years)
- Females and neutered males at increased risk

(Milne & Hayes, 1981)

Thyroid neoplasia

- Breed at increased risk in Swiss study

(Wenger *et al.*, 2005)

Gastrointestinal conditions

Bacterial cholecystitis and bactibilia

- 5/10 cases in a retrospective case–control series were Dachshunds

(Lawrence *et al.*, 2015)

Colorectal polyps
- Reported in a Japanese case series
- Reported to be associated with dysbiosis in a Japanese population
- More commonly found ventrally

(Ohmi *et al.*, 2012; Igarashi *et al.*, 2015; Uchida *et al.*, 2016)

Pancreatitis
- Breed at increased risk in a Hungarian case series

(Pápa *et al.*, 2011)

Sialocoele
- Dachshunds significantly over-represented in an Australian study compared to hospital population

(Bellenger & Simpson, 1992)

Haematological/immunological conditions

Haemophilia A
- Miniature Dachshunds
- Moderate factor VIII deficiency in this breed
- Familial in this breed

(Brooks, 1999)

Immunoglobulin deficiency
- Causes a protozoal pneumonia (*Pneumocystis carinii*)
- Associated with low IgG levels
- Inheritance uncertain

See also under *Infectious conditions*

(Lobetti *et al.*, 1996; Lobetti, 2000)

von Willebrand's disease (vWD)
- Type I seen in this breed

(Brooks, 1999)

Infectious conditions

Pneumocystis carinii infection
- Age affected: < 1 year

See also under *Haematological/immunological conditions* (*Immunoglobulin deficiency*)

(Lobetti *et al.*, 1996; Lobetti, 2000)

Metabolic conditions

Overweight/obesity
- Breed predisposed in a North American private practice population
- OR 1.6 (95% CI 1.2–2.2; $p = 0.0005$)

(Lund *et al.*, 2006)

Musculoskeletal conditions

Avascular necrosis of the femoral head (Legg–Calvé–Perthes disease)
- OR 4.8 (95% CI 2.0–11.2) in one US study, compared to mixed breeds

(LaFond *et al.*, 2002)

Inguinal/scrotal herniation
- Breed over-represented in an Australian population compared to hospital population

(Bellenger, 1996)

Olecranon fracture
- 43/67 dogs in a German case series were Dachshunds or Dachshund crosses

(Brunnberg *et al.*, 1983)

Osteogenesis imperfecta
- Reported in two related litters of Dachshunds
- Associated with a recessive mutation which had a prevalence of 12.9% in this breed in a European study

(Seeliger *et al.*, 2003; Eckardt *et al.*, 2013)

Patellar luxation
- 7.9% of cases in a German series were this breed

(Schafer *et al.*, 1982)

Pes varus
- Reported in two case series
- Seen from 5–6 months of age
- Possible autosomal recessive inheritance

(Radasch *et al.*, 2008; Petazzoni *et al.*, 2012)

Tail anomalies
- Congenital tail anomalies found in 0.93% of short-haired, 0.56% of rough-haired and 2.21% of long-haired Dachshunds in a German population in the 1970s
- Thought to be inherited as an autosomal recessive trait

(Fritsch & Ost, 1983)

Neoplastic conditions

Adrenocortical tumour resulting in hyperadrenocorticism
- Breed at risk
- Females slightly over-represented

See also under *Endocrine conditions*

(Reusch & Feldman, 1991)

Haemangiosarcoma – cardiac
- 7/51 cases with this condition in a Japanese case series were Miniature Dachshunds

(Yamamoto *et al.*, 2013)

Mammary neoplasia
- This breed accounted for 37.3% of cases in a German case series
- Significantly increased risk in this breed in a Czech series

(Bomhard & Dreiack, 1977; Zatloukal *et al.*, 2005)

Mast cell tumour (MCT)
- Breed over-represented in a German case series

(Kessler *et al.*, 1997)

Melanoma
- Dachshunds reported to be predisposed to amelanotic melanoma in a Brazilian case series
- Miniature Dachshunds predisposed to oral melanoma in a Thai case series

(Rolim *et al.*, 2012; Choisunirachon *et al.*, 2014)

Oral fibrosarcoma
- Reported to be at increased risk compared to mixed-breed dogs in a Polish case series

(Sapierzyński *et al.*, 2007b)

Pituitary tumour resulting in hyperadrenocorticism
See under *Endocrine conditions*

Squamous cell carcinoma – digit
- Breed at increased risk in case series
- Middle-aged to older dogs

(Henry *et al.*, 2005)

Neurological conditions
Idiopathic epilepsy
- Thought to be familial in this breed
- Age of onset 6 months to 6 years

(Cunningham & Farnbach, 1988)

Intervertebral disc disease (IVDD)
- Prevalence of 15.7 % (95 % CI 14.1–17.3) in a UK epidemiological study
- Standard short-haired Dachshunds had the highest risk compared to other varieties of Dachshund
- Older and neutered dogs at increased risk

(Mayhew *et al.*, 2004; Packer *et al.*, 2016a)

Vestibular disease
- Breed over-represented in a Brazilian case series
- 2/3 of cases in this series involved central vestibular disease

(Chaves *et al.*, 2014)

Ocular conditions
Cataract
- Prevalence of primary cataract in long-haired Dachshunds 2.10%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005)

Progressive retinal atrophy (PRA)
- Miniature long-haired Dachshunds
- Autosomal recessive inheritance
- Rod–cone dystrophy
- Onset and progression variable
- Reported in a UK case series and a Norwegian breeding study

(Turney *et al.*, 2007; Ropstad *et al.*, 2008)

Keratoconjunctivitis sicca
- 12/200 cases were this breed in a US case series
- Females predisposed

(Sansom & Barnett, 1985)

Sudden acquired retinal degeneration (SARD, amaurosis)
- This breed reported to be frequently diagnosed in a US case series

(Montgomery *et al.*, 2008)

Physiological conditions
Chondrodysplasia
- Accepted as breed standard
- Short, bowed legs, but normal skulls seen

(Martinez *et al.*, 2000)

Haematological differences
- Haematocrit (PCV, packed cell volume), haemoglobin and red cell count were higher in this breed than in mixed-breed dogs

(Torres *et al.*, 2014)

Heart rate
- Lower mean heart rate in this breed under anaesthesia compared to other breeds

(Harrison *et al.*, 2012)

Renal and urinary conditions

Urolithiasis – cystine

- Almost all cases reported were male
- Significantly increased risk of cystine calculus formation in an American population
- Reported to be common in this breed in a Swedish study and a large American study

(Case *et al.*, 1992; Wallerström *et al.*, 1992; Ling *et al.*, 1998b)

Reproductive conditions

Dystocia

- Breed predisposition to obstructive dystocia due to a narrow maternal pelvic canal, and also dystocia due to uterine inertia
- 5.5% of cases of dystocia were this breed in a US case series
- Also over-represented in a German case series
- Odds ratio in a UK first-opinion practice (Miniature Dachshund) 7.9 (95% CI 4.0–15.4; $p < 0.001$)

(Gaudet, 1985; Trautmann & Nolte, 2003; O'Neill *et al.*, 2017c)

Respiratory conditions

Nasopharyngeal stenosis

- Reported in a South African case series or seven smooth-haired Dachshunds
- Mean age at presentation 3 years

(Kirberger *et al.*, 2006)

Pneumonia due to *Pneumocystis carinii* infection

See under *Infectious conditions*

DALMATIAN

Dermatological conditions

Actinic (solar) keratosis

- Breed at increased risk
- Areas of light-coloured/sparse haircoat affected. Exposure to sun increases the risk
- May undergo neoplastic transformation

(Power & Prélaud, 2011)

Atopic dermatitis (atopy)

- Dogs between 1 and 2 years of age have the highest probability of an insurance claim for atopy
- Breed at increased risk in a US series of 264 cases (1981–1984)
- Some studies show no sex predilection, others show females predisposed
- This breed had a risk factor of 5.4 cases per 1000 DYAR, compared to 1.7 for the general population

(Schick & Fadok, 1986; Nødtvedt *et al.*, 2006)

Cutaneous neoplasia

See under *Neoplastic conditions*

Sterile nodular panniculitis

- Breed identified at high risk in a hospital review when compared to all other dogs seen during the study period at University of California, Davis, USA

(Contreary *et al.*, 2015)

Endocrine conditions

Hypothyroidism (lymphocytic thyroiditis)

- Breed with a higher prevalence of thyroid hormone autoantibodies (THAA)
- In a cohort study of 287 948 serum samples from dogs in the USA with clinical signs of hypothyroidism, Dalmatians had an OR of 1.74 ($p = 0.001$) of being affected compared to dogs of all other breeds
- Across the study, females were over-represented and the highest prevalence was in dogs 2–4 years old

(Nachreiner *et al.*, 2002)

Gastrointestinal conditions

Chronic hepatitis

- Breed at increased risk in a UK-based study of 551 cases (OR 4.1, 95% CI 2.2–7.7; $p < 0.001$) compared to a control population. Across the whole study, median age was 4 years 7 months and females were over-represented
- Some studies suggest Dalmatians are at risk of copper-associated hepatitis

(Webb *et al.*, 2002; Watson, 2004; Bexfield *et al.*, 2012a)

Infectious conditions

Cryptococcosis

- Breed at increased risk in a case series in Australia
- Usually seen in dogs < 4 years
- Living outdoors and exposure to bird droppings are risk factors

(O'Brien *et al.*, 2004)

Musculoskeletal conditions

Osteochondrosis – shoulder

- Males predisposed
- Age of onset usually 4–7 months, but can be older

- OR 3.1 (95% CI 1.6–6.2) compared to mixed breeds in a large retrospective case series based on cases recorded in the VMDB, 1986–1995

(Nečas, 1999; LaFond *et al.*, 2002)

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- OR 2.5 (95% CI 2.0–3.1) compared to mixed breeds in a large retrospective case series based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Neoplastic conditions

Conjunctival haemangiosarcoma

- Uncommon tumour, representing 1% of all ocular tumours
- Dalmatians were over-represented (compared to VMDB population) in a retrospective case series in North America
- Exposure to ultraviolet (UV) light may be a risk factor

(Pirie *et al.*, 2006)

Primary brain tumour

See under *Neurological conditions*

Squamous cell carcinoma – cutaneous

- Breed at increased risk of cutaneous squamous cell carcinoma in a retrospective study of VMDB data, 1964–2002: OR 6.94 (95% CI 4.26–11.32) compared to all other dogs
- Increased frequency noted in Australian Dalmatians

(Rothwell *et al.*, 1987; Villamil *et al.*, 2011)

Neurological conditions

Congenital deafness

- Up to 30% of the breed reported to be affected in the USA. Lower percentages reported in Europe
- Mode of inheritance unclear
- Dogs with blue eyes more commonly affected
- More commonly unilateral than bilateral

(Juraschko *et al.*, 2003; Cargill *et al.*, 2004; Strain, 2004)

Idiopathic epilepsy

- Breed at increased risk in case series

(Licht *et al.*, 2002; Short *et al.*, 2011)

Laryngeal paralysis–polyneuropathy syndrome

See *under Respiratory conditions*

Neuronal ceroid lipofuscinosis

- Rare
- Inheritance suspected
- Clinical onset 6 months. Can be diagnosed at 4–5 months by skin biopsy
- Signs include tremors, dysmetria, ataxia and visual deficits

(Goebel *et al.*, 1988)

Primary brain tumour – choroid plexus neoplasm

- Breed at significantly increased risk compared to the general population, in a study of post-mortem results of 435 dogs with intracranial neoplasia

(Song *et al.*, 2013)

Ocular conditions

Neuronal ceroid lipofuscinosis

See under *Neurological conditions*

Renal and urinary conditions

Familial renal disease (familial nephropathy)

- Autosomal dominant inheritance
- Dalmatians suffer from a glomerular basement membrane disorder. Renal failure is seen at a median age of 18 months
- Condition is believed to be similar to Alport syndrome in humans

(Hood *et al.*, 2002b)

Hyperuricosuria

- Hyperuricosuria (associated with an *SLC2A9* mutation) is inherited recessively and predisposes to urate urolithiasis

(Bannasch *et al.*, 2008)

Urolithiasis – urate

- Common in this breed. Prevalence was 34% in male Dalmatians in one 2004 study
- Average age at diagnosis in one large study: males 5.5 years, females 4.6 years
- In a retrospective case series of 25 499 laboratory stone submissions in the USA, 1985–2006, OR was 32 (95% CI 29–35.3) compared to mixed-breed dogs. Dogs < 7 years old at increased risk ($p < 0.001$) across all breeds
- In a retrospective study of 14 008 uroliths from dogs in the UK, 1997–2006, OR was 130.20 (95% CI 113.43–149.44; $p < 0.0001$) compared to the national insurance database
- Males predisposed (OR 14.0 in one study)

(Bannasch *et al.*, 2004; Albasan *et al.*, 2005; McCue *et al.*, 2009; Low *et al.*, 2010; Roe *et al.*, 2012)

Respiratory conditions

Laryngeal paralysis–polyneuropathy syndrome

- Autosomal recessive inheritance suspected
- Affects young dogs (9 months or younger)
- In this condition, laryngeal paralysis is associated with a more generalized polyneuropathy

(Braund *et al.*, 1994a)

Respiratory distress syndrome

- Rare condition; two separate reports of cases seen in young related dogs
- Possibly inherited as an autosomal recessive trait

(Järvinen *et al.*, 1995; Syrjä *et al.*, 2009)

DANDIE DINMONT TERRIER

Gastrointestinal conditions

Congenital portosystemic shunt

- Breed at increased risk in case series: OR 31.7 compared to mixed-breed dogs
- Clinical signs usually seen in young dogs < 1 year

(Tobias & Rohrbach, 2003)

Ocular conditions

Glaucoma – primary

- Breed at increased risk of pectinate ligament dysplasia. 22.1% were moderately or severely affected in a survey of 95 Dandie Dinmont Terriers in the UK
- Age of onset 7 years and older

(Oliver *et al.*, 2016a)

Reproductive conditions

Delivery by caesarean section

- In the top 10 breeds in a cross-sectional study conducted by the Kennel Club in the UK
- The study found a caesarean rate of 41.4% in litters of Dandie Dinmont Terriers born over a 10-year period

(Evans & Adams, 2010a)

DANISH CHICKEN DOG (GAMMEL DANSK HØNSEHUND)

Neurological conditions

Congenital myasthenia gravis

- Autosomal recessive inheritance
- This form of myasthenia gravis is not improved by anticholinesterase

(Flagstad *et al.*, 1989)

DANISH/SWEDISH FARMDOG

Dermatological conditions

Atopic dermatitis (atopy)

- In a study of Swedish insurance data, Danish/Swedish Farmdogs had a risk factor of 3.6 cases per 1000 DYAR, compared to 1.7 cases per 1000 DYAR for all breeds combined
- Birth in autumn or summer is a predisposing factor
- Dogs between 1 and 2 years of age have highest probability of an insurance claim for atopy
- Some studies show no sex predilection, others show females predisposed

(Nødtvedt *et al.*, 2006)

Reproductive conditions

Dystocia

- Breed at increased risk in a retrospective study of Swedish insurance data (195 931 bitches 1995–2002)
- Incidence in the Danish/Swedish Farmdog was 11.1 cases per 1000 DYAR, compared to 5.7 cases per 1000 DYAR for the general population

(Bergström *et al.*, 2006)

DEERHOUND

See *Scottish Deerhound*

DEUTSCHER WACHTELHUND

See *Wachtelhund*

DOBERMANN PINSCHER (DOBERMANN)

Behavioural conditions

Flank-sucking

- High incidence reported in Dobermanns
- Dogs with flank-sucking have a higher incidence of pica (the eating of non-food substances) than the normal population

(Moon-Fanelli *et al.*, 2007; Ogata *et al.*, 2013)

Cardiovascular conditions

Atrial fibrillation (AF)

- Breed at increased risk in case series
- In a study of 109 cases of AF from two North American veterinary teaching hospitals,

Dobermanns were over-represented ($p < 0.0001$) in the group of cases where structural heart disease and overt congestive failure was present
- Males were found to be significantly over-represented
- OR 5.66 in a separate large study of 3542 cases in the VMDB

(Menaut *et al.*, 2005; Westling *et al.*, 2008)

Atrial septal defect
- Uncommon disease
- Congenital – inheritance not known

(Lee *et al.*, 2007; Meurs, 2010)

Dilated cardiomyopathy (DCM)
- Very common in Dobermann Pinschers. One study suggests a cumulative prevalence of 58.2% in Dobermanns > 7 years old in Europe. Prevalence in North America has been reported as 45–63%
- Autosomal dominant inheritance suggested
- Prevalence increases with age
- Earlier reports suggested DCM is twice as common in males as in females. A recent study has suggested that females are equally affected but tend to have a disease that progresses more slowly, with only ECG abnormalities rather than the echocardiographic changes more commonly seen in males. They are therefore less likely to be diagnosed and may also develop congestive heart failure later in life
- Screening has been recommended by Holter ECG and echocardiography from 2 years of age and repeated annually

(Tidholm & Jonsson, 1997; Tidholm *et al.*, 2001; Borgarelli *et al.*, 2006; Wess *et al.*, 2010)

Patent ductus arteriosus
- Breed at increased risk (OR 2.8; $p = 0.0007$) compared to the general hospital population in a retrospective study of the medical records of 976 dogs diagnosed with congenital heart disease at a cardiology clinic in Italy
- This study found a female predisposition (OR 2.7)

(Oliveira *et al.*, 2011)

Dermatological conditions

Blastomycosis
See under *Infectious conditions*

Colour dilution alopecia
- Reported in blue or fawn Dobermanns and Miniature Pinschers
- Frequency of the disease may be as high as 93% in blues and 75% in fawns
- Coat-colour genes play a role in the inheritance of this condition

(Miller, 1990a)

Cryptococcosis
See under *Infectious conditions*

Cutaneous neoplasia
See under *Neoplastic conditions*

Demodicosis
- Breed at increased risk in a number of case series
- Most common in dogs < 1 year of age

(Nayak *et al.*, 1997; Solanki *et al.*, 2007)

Follicular dysplasia
- Affects black or red Dobermanns
- Age of onset: 1–4 years
- Affects caudodorsum and flanks

(Miller, 1990b)

Oculocutaneous albinism
- Affected dogs have white coats, pale irises, and increased risk of melanoma

(Winkler *et al.*, 2014)

Drug reactions

Sulfonamide-associated hypersensitivity
- Dobermanns are at increased risk of cutaneous reactions and polyarthropathy following the use of this drug

(Trepanier, 1999)

Endocrine conditions

Hypothyroidism (lymphocytic thyroiditis)
- Breed at increased risk in case series. OR 6.06 ($p = 0.001$) compared to a large university hospital population. Association with a rare MHC class 2 haplotype documented in Dobermanns. May occur at a younger age in at-risk breeds (2–3 years of age). Neutered animals (both sexes) were at increased risk
- Breed with higher prevalence of thyroid hormone autoantibodies (THAA). In a cohort study of 287 948 serum samples from dogs in the USA with clinical signs of hypothyroidism, Dobermanns had an OR of 1.24 ($p = 0.001$) of being affected compared to dogs of all other breeds

- Across the study, females were over-represented, and the highest prevalence was in dogs 2–4 years old

(Panciera, 1994; Nachreiner *et al.*, 2002; Kennedy *et al.*, 2006a)

Gastrointestinal conditions

Chronic hepatitis

- Breed at increased risk in a UK-based study of 551 cases: OR 11.5 (95% CI 7.6–17.3; $p < 0.001$) compared to a control population. Median age was 5 years 4 months, and females were over-represented across the whole study
- A very aggressive form of hepatitis, sometimes referred to as chronic active hepatitis, is seen in Dobermanns
- Increased hepatocellular copper is seen and may be secondary to cholestasis rather than a primary defect in hepatic copper metabolism, but this is debated
- An autoimmune pathogenesis has been proposed

(Speeti *et al.*, 2003; Mandigers *et al.*, 2004; Bexfield *et al.*, 2012a)

Gastric dilatation/volvulus (bloat, GDV)

- Breed at increased risk in case series
- One of the four most common breeds represented in an internet-based survey of dog owners (2551 submissions)

(Mackenzie *et al.*, 2010; Pipan *et al.*, 2012)

Parvovirus enteritis

See under *Infectious conditions*

Haematological/immunological conditions

Haemophilia B

- Factor IX deficiency
- X-linked recessive inheritance

(Brooks, 1999)

von Willebrand's disease (vWD)

- High incidence in Dobermanns: 73% had abnormal (<50%) von Willebrand factor (vWF) in a study of 5554 Dobermanns in 1988
- Autosomal dominant inheritance with incomplete penetration suspected
- Mean age of affected Dobermanns was 4.6 years in one study
- Not all at-risk dogs will bleed

(Brooks *et al.*, 1992; Riehl *et al.*, 2000; Gentilini & Turba, 2013)

Infectious conditions

Blastomycosis

- Breed at increased risk in case series
- Young dogs (2–4 years) predisposed
- Geographic distribution: mainly North America (Mississippi, Missouri, Ohio River valleys, mid-Atlantic States, Quebec, Manitoba and Ontario)
- Proximity to a body of water is a risk factor in endemic areas

(Kerl, 2003)

Cryptococcosis

- Breed at increased risk in a case series of 195 cases (1981–2001) in Australia
- Usually seen in dogs < 4 years
- Living outdoors and exposure to bird droppings are risk factors

(Malik *et al.*, 1995; O'Brien *et al.*, 2004)

Demodicosis

See under *Dermatological conditions*

Parvovirus enteritis

- Breed at increased risk in a number of case series
- OR 3.1 compared to the general hospital population in a University of Pennsylvania study
- Age 6 weeks to 6 months at higher risk
- One study has suggested increased risk is associated with a stronger pro-inflammatory cytokine response

(Glickman *et al.*, 1985; Houston *et al.*, 1996; Nemzek *et al.*, 2007)

Musculoskeletal conditions

Carpal laxity syndrome

- Breed at increased risk in case series
- Puppies affected at 6–12 weeks of age. Males over-represented
- Usually self-limiting

(Cetinkava *et al.*, 2007)

Osteosarcoma

See under *Neoplastic conditions*

Neoplastic conditions

Cutaneous neoplasia

- In a retrospective study of 104 histopathological samples examined at a Bulgarian university clinical pathology department (1991–2000), the Dobermann was the breed with the third-highest prevalence

- Average age across the study was 9.58 years (range 6–11.7)
- Males were significantly more affected

(Dinev, 2002)

Lipoma
- Breed at increased risk
- Most common in middle-aged, obese female dogs
- Dobermanns may be predisposed to infiltrative lipomas

(Kim *et al.*, 2005)

Mammary neoplasia
- 42% of insured Swedish Dobermanns had developed mammary tumours at 10 years of age (ranked second), compared to 13% for the general population
- Increased risk is reflected in case studies in other parts of the world
- Risk increases with age
- Risk significantly decreased with early neutering

(Jitpean *et al.*, 2012)

Melanoma
- Breed at increased risk of cutaneous melanoma in a retrospective study of VMDB data, 1964–2002: OR 3.02 (95% CI 2.32–3.93) compared to all other dogs

(Villamil *et al.*, 2011)

Neoplasia – overall
- Several studies have suggested a higher risk

(Michalska & Michalski, 1997; Srivastava *et al.*, 2009)

Osteosarcoma
- Breed at increased risk in case series
- OR 2.3 (95% CI 1.8–3.0) compared to German Shepherd Dogs in a retrospective study of VMDB data, 1980–1994
- Across all breeds there was an increased risk with increasing age, plateauing at 10 years
- Across all breeds there was a slight predisposition for males, but an almost twofold increase for neutered dogs of both sexes
- Breed also at high risk of malignant bone tumours in one study of Swedish insurance data (1995–2002). Dobermanns had an overall incidence of 24 cases (95% CI 13–35) per 10 000 DYAR, compared to the risk in all dogs combined of 5.5 cases per 10 000 DYAR
- Males over-represented
- Median age was 7.5 years in Dobermanns; risk increases with increasing age

(Ru *et al.*, 1998; Egenvall *et al.*, 2007)

Synovial myxoma
- 4/6 cases in a USA-based series were Dobermanns or their crosses (66.7%; $p < 0.0001$)
- Mean age 9.2 (6–13) years
- The stifle was the most commonly affected joint

(Craig *et al.*, 2002)

Neurological conditions

Cervical spondylomyelopathy (cervical vertebral malformation, wobbler syndrome)
- Breed at high risk
- Defects are stenosis of the vertebral canal and malformation of cervical vertebrae (C5–C7, most commonly C6–C7 in the Dobermann)
- Mean age 6.8 years in the Dobermann

(da Costa, 2010)

Dancing Dobermann disease
- Uncommon
- Age of clinical onset 6 months to 7 years
- Poorly understood but thought to be a peripheral neuropathy

(Chrisman, 1990)

Deafness and vestibular disease
- Autosomal recessive inheritance suspected
- Affected puppies are deaf and demonstrate a head tilt and circling behaviour from 3 weeks

(Wilkes & Palmer, 1990)

Discospondylitis
- Dobermanns were at higher risk in a study of 513 cases in North America: OR 2.3 (95% CI 1.3–4.0) compared to mixed-breed dogs
- Higher risk with increasing age
- Males twice as likely to be affected as females: OR 2.0 (95% CI 1.7–2.4)

(Burkert *et al.*, 2005)

Idiopathic head tremor syndrome
- Breed at increased risk in a case series (retrospective study of 291 cases)
- Average age of onset 29 months
- Possible trigger events found in 21% of cases
- Mentation was normal in 93% cases

(Wolf *et al.*, 2011; Shell *et al.*, 2015)

Intervertebral disc disease (IVDD)
- Breed at increased risk in a review of Swedish insurance data
- Dobermanns had 88.6 occurrences per 10 000 DYAR (third-highest), compared to 27.8 occurrences per 10 000 DYAR for the general population
- Incidence higher in males than females

(Bergknut *et al.*, 2012)

Narcolepsy–cataplexy
- Autosomal recessive inheritance
- Symptoms appear around 4 weeks, increase with age and plateau around 10–32 weeks

(John *et al.*, 2004; Tonokura *et al.*, 2007)

Ocular conditions
Multiple ocular defects
- Congenital; autosomal recessive inheritance suspected
- May include microphthalmia, anterior segment dysgenesis, congenital cataract and retinal dysplasia

(Bergsjø *et al.*, 1984; Lewis *et al.*, 1986)

Persistent hyperplastic tunica vasculosa lentis and persistent hyperplastic primary vitreous (PHPV)
- Congenital; dominant inheritance with incomplete penetration suggested
- Reported widely in Europe, but rare in the USA

(Boevé, 1988; Leppänen & Saloniemi, 1998)

Physiological conditions
Blood group
- In a study of 274 dogs in Portugal in which 56.9% were DEA 1.1-positive and 43.1% were DEA 1.1-negative, all 12 Dobermanns in the study were negative

(Ferreira *et al.*, 2011)

Renal and urinary conditions
Familial renal disease (familial nephropathy)
- Mode of inheritance unknown
- Dobermanns are believed to suffer from membranoproliferative glomerulonephritis, a glomerular basement membrane disorder which may progress to glomerulonephritis
- The disease presents at 1–6 years with proteinuria and chronic renal failure

(Wilcock & Patterson, 1979; Chew *et al.*, 1983)

Urethral sphincter mechanism incompetence
- Breed at increased risk in case series
- Spayed females predisposed

(Holt & Thrusfield, 1993; Arnold, 1997)

Urolithiasis – calcium oxalate
- Breed at increased risk in a Canadian case series of urolith submissions, 1998–2001: OR 5.60 (95% CI 1.83–17.18) compared to mixed-breed dogs

(Ling *et al.*, 2003)

Reproductive conditions
Mammary neoplasia
See under *Neoplastic conditions*

Prostate disease
- Dobermann was the breed at greatest risk of prostate disease in a study of 177 cases over 5.5 years
- Mean age of onset 8.9 years
- The study included all types of prostate disease; prostatic adenocarcinoma was the most common type in neutered male dogs across the study

(Krawiec & Heflin, 1992)

Pyometra (cystic endometrial hyperplasia–pyometra complex)
- 43% of insured Swedish Dobermanns had developed pyometra at 10 years of age (ranked 17th) compared to 19% for the general population

(Jitpean *et al.*, 2012)

DOGO ARGENTINO

Neoplastic conditions
Mast cell tumour (MCT)
- Breed at increased risk in case series

(Leidinger *et al.*, 2014)

Neurological conditions
Congenital deafness
- Prevalence of hearing disorders in a study of 299 Dogo Argentino dogs was 27%
- The Dogo Argentino seems to be affected by complete cochleosaccular degeneration, which can be bilateral or unilateral

(Pellegrino *et al.*, 2009; Blum & Distl, 2013)

DOGUE DE BORDEAUX (FRENCH MASTIFF)

Cardiovascular conditions

Aortic stenosis – subaortic stenosis (SAS)

- Autosomal recessive inheritance proposed
- OR 11.2 ($p < 0.0001$) compared to the hospital population in a retrospective series of 976 cases of congenital heart disease in Italy
- Both healthy and affected dogs had a smaller aortic annulus than other breeds

(Höllmer *et al.*, 2008; Oliveira *et al.*, 2011; Ohad *et al.*, 2013)

Tricuspid valve dysplasia

- Autosomal recessive inheritance proposed
- In Israel, Dogue de Bordeaux had the highest prevalence of all dogs in the country

(Oliveira *et al.*, 2011; Ohad *et al.*, 2013)

Dermatological conditions

Footpad hyperkeratosis

- Familial
- Lesions appear by 6 months of age

(Lachaume *et al.*, 1998)

Endocrine conditions

Hypothyroidism

- In a study of 44 Dogue de Bordeaux, prevalence of hypothyroidism was 4.5%
- 7 of the 10 male dogs in the study had low T_4 levels (although 6 of these had normal TSH levels)

(Segalini *et al.*, 2009)

Neurological conditions

Thoracic spinal stenosis

- Breed at increased risk in case series
- 8/23 dogs with thoracic spinal stenosis were Dogue de Bordeaux
- 21/23 dogs were male
- Mean age was 23 months (range 4–105 months)
- Most common sites were T2–3 and T3–4
- Symptoms included proprioceptive deficits in the hindlimbs

(Johnson *et al.*, 2012)

Renal and urinary conditions

Familial renal disease (familial nephropathy)

- Autosomal recessive inheritance suspected
- Progressive disease, mean age at death 20 months
- In a study of 102 adult Dogue de Bordeaux dogs, 33% had abnormal proteinuria likely to be related to a glomerulopathy

(Lavoué *et al.*, 2010, 2015)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- Breed at increased risk in a case series based on the populations of five RSPCA hospitals in the UK between 2006 and 2011
- Dogue de Bordeaux had a prevalence of 4.6%, compared to 2.2% for all dogs over the study period
- Mean age was 3.3 years for the Dogue de Bordeaux, compared to a mean age of 7.7 years for the overall population

(Gibson *et al.*, 2013)

DUTCH PARTRIDGE DOG (DRENTSE PATRIJSHOND)

Gastrointestinal conditions

Stomatocytosis–hypertrophic gastritis

- Autosomal recessive inheritance suspected
- Rare
- Mean age at presentation 9.5 months old
- Affected dogs had diarrhoea, haemolytic anaemia and ataxia

(Slappendel *et al.*, 1991)

Haematological/immunological conditions

Stomatocytosis–hypertrophic gastritis

See under *Gastrointestinal conditions*

DUTCH SHEEPDOG

See *Schapendoes*

DUTCH SPANIEL

See *Wetterhoun*

ELKHOUND

See *Norwegian Elkhound*; *Swedish Elkhound*

ENGLISH BULLDOG

See *Bulldog – English*

ENGLISH COCKER SPANIEL

See *Cocker Spaniel*

ENGLISH SETTER

Dermatological conditions

Atopic dermatitis (atopy)

- Breed at increased risk in a US series of 264 cases (1981–1984)
- Birth in autumn or summer is a predisposing factor
- One study showed dogs between 1 and 2 years of age have the highest probability of an insurance claim for atopy
- Some studies show no sex predilection, others show females predisposed

(Schick & Fadok, 1986; Nødtvedt *et al.*, 2006)

Cutaneous neoplasia

See under *Neoplastic conditions*

Malassezia dermatitis

- Breed at increased risk: OR 7.7 (compared to the hospital population) in a retrospective study of 86 cases at a US university pathology department
- Age of incidence 6 months to 15 years
- Spayed females (RR 4.51) and castrated males (RR 4.19) were at increased risk compared to the hospital population
- May be seasonal

(Mauldin *et al.*, 1997)

Symmetric lupoid onychodystrophy

- Rare condition
- Breed at increased risk
- Affects dogs at 3–8 years of age

(Dahlgren *et al.*, 2016)

Endocrine conditions

Hypothyroidism (lymphocytic thyroiditis)

- English Setters may be predisposed to lymphocytic thyroiditis

(Graham *et al.*, 2007)

Gastrointestinal conditions

Intestinal adenoma

See under *Neoplastic conditions*

Musculoskeletal conditions

Elbow dysplasia

- Common cause of forelimb lameness
- Increased risk of ununited anconeal process: OR 3.7 (95% CI 1.6–8.3) compared to mixed breeds in a study of 847 cases from the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Hip dysplasia

- Breed at increased risk in case series
- OR 1.49 (95% CI 1.35–1.65; $p < 0.001$) compared to all other dogs in a large retrospective study of VMDB cases, 1964–2003. Male neutered dogs and dogs < 4 years of age (of all breeds) combined found to be at increased risk

(Witsberger *et al.*, 2008)

Osteochondrosis – shoulder

- OR 10.1 (95% CI 6.5–15.9) compared to mixed breeds in a large study of 1242 cases from the VMDB, 1986–1995
- Males predisposed
- Age of onset usually 4–7 months, but can be older

(LaFond *et al.*, 2002)

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- Breed at increased risk in case series
- OR 1.9 (95% CI 1.3–2.8) compared to mixed breeds in a large study of 5633 cases from the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Neoplastic conditions

Intestinal adenoma

- Breed at increased risk ($p < 0.01$) in a case series of 3827 gastrointestinal biopsies in the Czech Republic

(Frgelecová *et al.*, 2013)

Mast cell tumour (MCT)

- Breed at increased risk of cutaneous MCT in a retrospective study of VMDB data, 1964–2002: OR 1.88 (95% CI 1.34–2.64) compared to all other dogs

(Villamil *et al.*, 2011)

Primary brain tumour

See under *Neurological conditions*

Neurological conditions

Congenital deafness

- 7.9% prevalence in one study of 3656 English Setters
- Signs seen from birth

(Strain, 2004)

Neuronal ceroid lipofuscinosis

- Rare
- Autosomal recessive inheritance. Mutation identified
- Signs seen at 1–2 years

(Lingaas *et al.*, 1998; Katz *et al.*, 2005)

Primary brain tumour – choroid plexus neoplasm

- Breed at significantly increased risk compared to the general population in a study of post-mortem results of 435 dogs with intracranial neoplasia

(Song *et al.*, 2013)

Ocular conditions

Neuronal ceroid lipofuscinosis

See under *Neurological conditions*

ENGLISH SHEPHERD

Drug reactions

Ivermectin and milbemycin

- High doses can cause tremors, ataxia, coma and death
- Associated with the mutant *MDR1* allele

(Dowling, 2006)

ENGLISH SPRINGER SPANIEL

See *Springer Spaniel*

ENGLISH TOY SPANIEL

See *King Charles Spaniel*

ENTLEBUCHER MOUNTAIN DOG

Ocular conditions

Cataract

- Autosomal recessive inheritance
- In a Swiss study of 285 of this breed over 10 years, 20.4% had cataracts
- Age at diagnosis was 5.34 ± 2.71 years
- Localization: posterior pole. Non-progressive

(Speiss, 1994; Kuster *et al.*, 2011)

Progressive retinal atrophy (PRA)

- Autosomal recessive inheritance suspected
- In a Swiss study of 285 of this breed over 10 years, 6.3% had PRA
- Age at diagnosis was 4.93 ± 1.32 years

(Heitmann *et al.*, 2005; Kuster *et al.*, 2011)

Renal and urinary conditions

Ectopic ureter

- High incidence
- In a study of 565 dogs, 67.1% had at least one ectopic ureter
- Males more often affected than females
- Mode of inheritance not determined

(Fritsche *et al.*, 2014)

ESKIMO DOG

Haematological/immunological conditions

Bone marrow necrosis

- Significantly over-represented in a retrospective study of 34 cases

(Weiss, 2005)

Immune-mediated polyarthritis

See under *Musculoskeletal conditions*

Musculoskeletal conditions

Immune-mediated polyarthritis

- Breed at increased risk in case series
- Over-represented for both reactive immune-mediated non-erosive polyarthritis (11% of 18 cases) and idiopathic non-erosive immune-mediated polyarthritis (7% of 43 cases)
- Median ages respectively 6.7 years and 4.8 years

(Stull *et al.*, 2008)

Ocular conditions

Cataract

- Prevalence of primary cataract 1.84%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005)

Progressive retinal atrophy (PRA)
- American Eskimo Dog
- Autosomal recessive inheritance
- Progressive rod–cone degeneration
- Age of onset: 3–5 years

(Moody *et al.*, 2005)

ESTRELA MOUNTAIN DOG

Musculoskeletal conditions

Hip dysplasia
- In a study of 313 Estrela Mountain Dogs, 66% were found to be affected

(Ginja *et al.*, 2009)

FINNISH HOUND

Endocrine conditions

Diabetes mellitus
- Breed at increased risk in a retrospective review of Swedish insurance data, 1995–2004
- Incidence in the Finnish Hound was 36 cases per 10 000 DYAR, compared to an overall incidence in all breeds of 13 cases per 10 000 DYAR
- Females at significantly increased risk overall

(Fall *et al.*, 2007)

Neurological conditions

Cerebellar ataxia
- Inherited, mutation identified
- Early onset (clinical signs from 3 months) and rapidly progressive

(Kyöstilä *et al.*, 2012)

FINNISH LAPPHUND

Neurological conditions

Lysosomal storage disease – glycogen storage disease type II (Pompe disease)
- Autosomal recessive inheritance
- In one study 5% (5/95) dogs carried the genetic mutation for this disease

(Seppälä *et al.*, 2013)

Ocular conditions

Progressive retinal atrophy (PRA)
- Autosomal recessive inheritance suspected
- Progressive rod–cone degeneration
- Late onset: clinical signs at 3–6 years

(Aguirre-Hernández *et al.*, 2007)

FINNISH SPITZ

Endocrine conditions

Diabetes mellitus
- OR 2.32 (95% CI 1.22–4.41) compared to mixed-breed dogs in a retrospective report of 6860 dogs with diabetes mellitus from the VMDB, 1970–1999
- Females predisposed (OR 1.37)

(Guptill *et al.*, 2003)

Gastrointestinal conditions

Atresia ani
- Breed at increased risk of this rare disease: OR 19.401 compared to mixed-breed dogs
- Females predisposed: OR 1.796
- Symptoms seen at weaning

(Vianna & Tobias, 2005)

Haematological/immunological conditions

Immune-mediated haemolytic anaemia (IMHA)
- Breed at increased risk in case series
- Usually affects young adult and middle-aged animals
- Females predisposed

(Miller *et al.*, 2004)

Neurological conditions

Idiopathic epilepsy
- Inherited as a polygenic trait
- In a study of 2141 Finnish Spitz in Finland, over 10 years, the prevalence was 5.36%
- Males predisposed
- Median age of onset was 3 years
- 85% of seizures had a focal onset, 54% were secondary generalized

(Viitmaa *et al.*, 2007, 2013)

Ocular conditions

Cataract
- Prevalence of primary cataract 2.47%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005)

FLAT-COATED RETRIEVER

Musculoskeletal conditions

Bone tumour

See under *Neoplastic conditions*

Hip dysplasia
- Breed at increased risk described in several countries
- High heritability, with a greater degree in dams than sires, has been described

(Leppänen & Saloneiemi, 1999; Wood *et al.*, 2000, 2004)

Patellar luxation
- Breed at increased risk in a retrospective report of cases from the VMDB, 1986–1995: OR 2.9 (95% CI 1.0–8.2) compared to mixed-breed dogs
- Males predisposed (OR 1.8) in a separate retrospective report of patellar luxation in large-breed dogs (>15 kg)

(LaFond *et al.*, 2002; Gibbons *et al.*, 2006)

Spondylosis deformans and diffuse idiopathic skeletal hyperostosis (DISH)
- Breed at increased risk in a retrospective radiographic study at a Netherlands veterinary teaching hospital (2003–2008)
- OR 2.834 ($p < 0.001$) for spondylosis and OR 7.671 ($p < 0.001$) for DISH compared to all dogs having radiographs taken during the study period
- Prevalence increases with age

(Kranenburg *et al.*, 2011)

Neoplastic conditions

Bone tumour
- Breed at high risk of malignant bone tumours in one study of Swedish insurance data (1995–2002). Flat-coated Retrievers had an overall incidence of 35 cases (95% CI 27–43) per 10 000 DYAR compared to the risk in all dogs combined of 5.5 cases per 10 000 DYAR
- Males over-represented
- Median age was 8.6 years in Flat-coated Retrievers; risk increases with increasing age

(Egenvall *et al.*, 2007)

Sarcoma – soft tissue
- Breed at increased risk of histiocytic sarcoma
- May affect muscle/fascia of limbs or visceral organs (primarily spleen)
- Average age of onset for soft-tissue sarcomas is 8–9 years, but it may be seen earlier in this breed

(Morris *et al.*, 2002; Constantino-Casas *et al.*, 2011)

Ocular conditions

Glaucoma – primary
- Breed at increased risk of glaucoma associated with pectinate ligament dysplasia
- In a UK study, 34.7% of 389 randomly selected Flat-coated Retrievers examined between 1994 and 1996 had a degree of pectinate ligament dysplasia

(Read *et al.*, 1998; Wood *et al.*, 1998)

FOX TERRIER

Cardiovascular conditions

Pulmonic stenosis
- Described as a predisposed breed in a number of papers

(Darke, 1989)

Ventricular septal defect
- Breed at increased risk in case series
- Fox Terriers represented 4 of the 56 cases (7%)
- Mean age at diagnosis was 9 months (range 2.2 months to 11.8 years)

(Bomassi *et al.*, 2015)

Dermatological conditions

Atopic dermatitis (atopy)
- Reported as a breed at increased risk (OR 2.9 compared to the general hospital population) in a study in the USA of 383 cases
- Some studies show no sex predilection, others show females are predisposed

(Scott, 1981; Nødtvedt *et al.*, 2006; Nicorescu & Crivineanu, 2007)

Endocrine conditions

Diabetes mellitus
- OR 3.02 (95% CI 1.94–4.70) compared to mixed-breed dogs in a retrospective report of 6860 dogs with diabetes mellitus from the VMDB, 1970–1999
- Females predisposed: OR 1.37

(Guptill *et al.*, 2003)

Hypothyroidism – congenital
- Toy Fox Terriers
- Autosomal recessive inheritance
- Affected pups had delayed eye-opening, abnormal haircoat, inactivity and goitre

(Fyfe *et al.*, 2003)

Gastrointestinal conditions

Congenital megaoesophagus

- Wire-haired and Smooth-haired Fox Terriers
- Autosomal recessive inheritance
- Presumed secondary to myasthenia gravis (see under *Neurological conditions*)

(Jenkins *et al.*, 1976; Miller *et al.*, 1983)

Pancreatitis

- Breed at increased risk in a series of 80 cases

(Pápa *et al.*, 2011)

Sialorrhoea with spirocercosis

- Breed at increased risk
- In a retrospective study of 298 spirocercosis cases, sialorrhoea was present in 33. Fox Terriers comprised 36% of cases with sialorrhoea but only 5% of the whole group

(van der Merwe *et al.*, 2012)

Musculoskeletal conditions

Congenital myasthenia gravis

See under *Neurological conditions*

Patellar luxation

- Breed at increased risk in case series
- In a large retrospective case series based on cases recorded in the VMDB, 1986–1995, odds ratios were 12.8 (95% CI 4.1–40.1) (Toy Fox Terrier) and 2.2 (95% CI 1.1–4.5) (Wire-haired Fox Terrier) compared to mixed breeds

(LaFond *et al.*, 2002)

Neurological conditions

Congenital myasthenia gravis

- Smooth-haired Fox Terrier
- Autosomal recessive inheritance
- Rare
- Age of clinical onset: 6–8 weeks

(Miller *et al.*, 1983, 1984)

Hereditary ataxia

- Smooth-haired and Toy Fox Terriers
- Autosomal recessive inheritance suspected
- Originally reported in Sweden
- Rare
- Age of clinical onset: 2–6 months

(Rohdin *et al.*, 2015)

Ocular conditions

Cataract

- Breed at increased risk compared to mixed-breed dogs in a retrospective report of dogs with primary cataracts from the VMDB, 1964–2003
- Prevalence of primary cataract was 11.7% in the Smooth-haired Fox Terrier, 4.88% in the Wire-haired Fox Terrier, and 3.78% in the Toy Fox Terrier, compared to 1.61% in mixed-breed dogs

(Gelatt & MacKay, 2005)

Glaucoma – primary

- Toy and Wire-haired Fox Terriers
- Breed at increased risk compared to the overall population of dogs in a retrospective study of 9778 dogs with primary glaucoma from the VMDB, 1964–2002
- Prevalence was 2.28% in Wire-haired Fox Terriers for the years 1994–2002, compared to an overall prevalence in all dogs of 0.89% in the same period
- Prevalence was 2.64% in Toy Fox Terriers and 1.97% in Wire-haired Fox Terriers for the years 1984–1993, compared to an overall prevalence in all dogs of 0.76% in the same period

(Gelatt & MacKay, 2004a)

Glaucoma – secondary

- Toy and Wire-haired Fox Terriers
- Breed at increased risk compared to the overall population of dogs in a retrospective study of 9695 dogs with secondary glaucoma from the VMDB, 1964–2003
- Wire-haired Fox Terriers were at increased risk of glaucoma secondary to cataracts, lens luxation, cataract surgery and uveitis, compared to mixed-breed dogs
- Toy Fox Terriers were at increased risk of glaucoma secondary to lens luxation, and cataract surgery, compared to mixed-breed dogs

(Gelatt & MacKay, 2004b)

Lens luxation – primary

- Toy and Wire-haired Fox Terriers
- Autosomal recessive inheritance
- Age of onset between 3 and 8 years

(Curtis & Barnett, 1980; Gould *et al.*, 2011)

Renal and urinary conditions

Ectopic ureter

- Congenital anomaly
- Breed at increased risk in a series of 217 cases in female dogs recorded in the VMDB (1964–1981)

- OR 5.5 compared to all female dogs seen in the same period
- Usually presents < 1 year of age
- More commonly diagnosed in females

(Hayes, 1984)

FOXHOUND

Haematological/immunological conditions

Pelger–Huet anomaly

- Inherited leucocyte anomaly which is often asymptomatic

(Bowles *et al.*, 1979)

Infectious conditions

Leishmaniasis

- Visceral form is endemic in Foxhounds in North America
- In the absence of the insect vector, the disease may be transmitted directly or vertically in kennels

(Schantz *et al.*, 2005)

FRENCH ALPINE MASTIFF

See *Savoy Sheepdog*

FRENCH BULLDOG

Cardiovascular conditions

Pulmonic stenosis

- Breed at greatly increased risk (OR 19.1; $p < 0.0001$ compared to the general hospital population) in a retrospective study of the medical records of 976 dogs diagnosed with congenital heart disease at a cardiology clinic in Italy
- This study found a male predisposition across all breeds (OR 1.5)

(Oliveira *et al.*, 2011)

Ventricular septal defect

- Breed at greatly increased risk (OR 7.2; $p = 0.0003$) compared to the general hospital population) in a retrospective study of the medical records of 976 dogs diagnosed with congenital heart disease at a cardiology clinic in Italy
- 48% of the cases of ventricular septal defect in this study were seen with another cardiac defect, most commonly pulmonic stenosis

(Oliveira *et al.*, 2011)

Dermatological conditions

Atopic dermatitis (atopy)

- Breed at increased risk in a Swiss case series
- Breed at increased risk in a study of Hamburg cases: OR 46.9 (95% CI 16.7–131.3) compared to the general hospital population
- Prevalence was found to vary with geographical location

(Picco *et al.*, 2008; Jaeger *et al.*, 2010)

Demodicosis

- French Bulldogs are at increased risk of juvenile-onset, generalized demodicosis, based on a large retrospective case–control study of a US practice database: OR 5.0 (95% CI 1.4–18.0) compared to the hospital population
- Juvenile onset was defined as < 18 months old
- Other risk factors associated with demodicosis included pyoderma, short hair and concurrent coccidiosis

(Plant *et al.*, 2011)

Gastrointestinal conditions

Gastrointestinal changes seen with BOAS

- French Bulldogs have a high incidence of brachycephalic obstructive airway syndrome (BOAS: see under *Respiratory conditions*)
- Gastrointestinal changes (inflammatory disease of the oesophagus, stomach and duodenum) are commonly seen with this condition

(Garcia-Sancho *et al.*, 2013)

Ulcerative colitis (histiocytic ulcerative colitis)

- Predisposed to a condition similar to that seen in Boxers
- Believed to be associated with intramucosal *E. coli*, and has been shown to be responsive to fluoroquinolones

(Tanaka *et al.*, 2003; Manchester *et al.*, 2013)

Musculoskeletal conditions

Fracture of the thoracic limb – humeral condyle

- Breed at increased risk: OR 59.0 (95% CI 18.44–166.89) in a retrospective series of 189 cases seen at the Norwegian College of Veterinary Medicine, 1971–1991 (control group was the Norwegian Kennel club population over the same period)

- Lateral condyle more commonly affected than medial (OR 90.3)
- Most fractures occurred at 3–4 months old

(Rørvik, 1993)

Hemivertebrae (wedge-shaped vertebrae)

See under *Neurological conditions*

Patellar luxation

- Breed at increased risk: OR 5.4 (95% CI 3.1–9.3; $p < 0.001$) compared to mixed-breed dogs, using the data of 210 824 dogs attending 119 clinics across England
- The study found that females (OR 1.3) and neutered dogs (OR 2.4) were at increased risk

(O'Neill *et al.*, 2016c)

Neoplastic conditions

Primary brain tumour

See under *Neurological conditions*

Neurological conditions

Arachnoid cyst – spinal

- Rare condition
- Breed at increased risk in a retrospective case series of 122 cases
- French Bulldogs were the third most common breed with 13 of the 122 cases
- All cases in French Bulldogs were in the thoracolumbar spine
- Across the study, males were over-represented (95/122 cases were male)
- In a separate study of 343 French Bulldogs presenting with neurological disease, 2002–2016, 25 were affected by spinal arachnoid cysts, of which 88% were thoracic and 12% were cervical

(Mauler *et al.*, 2014; Mayousse *et al.*, 2017)

Hemivertebrae (wedge-shaped vertebrae)

- Selection for 'screw tail' (hemivertebrae in the tail) in French Bulldogs predisposes to hemivertebrae in other areas of the spine
- May be associated with neurological signs including weakness of the hindlimbs, faecal and urinary incontinence

(Schlensker & Distl, 2016)

Intervertebral disc disease (IVDD)

- Breed at increased risk
- In common with other chondrodystrophoid breeds, the disease can occur at a younger age in French Bulldogs and peaks at 3–7 years
- Males were predisposed (57.4%) in French Bulldogs in one study
- French Bulldogs were in the top five breeds affected in a large USA-based retrospective study of 90 004 dogs presented to a university teaching hospital. 27.06% were affected, compared to 4.43% of mixed breeds
- In a separate study of 343 French Bulldogs presenting with neurological disease, 2002–2016, 156 were affected by IVDD. 39.8% of cases were cervical and 60.2% were non-cervical. C3–C4 was the most commonly affected site

(Bellumori *et al.*, 2013; Aikawa *et al.*, 2014; Mayousse *et al.*, 2017)

Primary brain tumour – oligodendroglioma

- Breed at significantly increased risk compared to the general population in a study of post-mortem results of 435 dogs with intracranial neoplasia
- In a separate study of 343 French Bulldogs presenting with neurological disease, 2002–2016, 25 were affected by brain tumours, of which 17 were gliomas

(Song *et al.*, 2013; Mayousse *et al.*, 2017)

Ocular conditions

Corneal ulceration (ulcerative keratitis)

- In a UK-based study of first-opinion practice, the prevalence in the French Bulldog was 1.87% (95% CI 0.97–3.24), compared to an overall prevalence of 0.8% (95% CI 0.75–0.86)

(O'Neill *et al.*, 2017b)

Prolapse of the gland of the nictitating membrane ('cherry eye')

- Breed at increased risk in a retrospective study of 114 cases
- Males over-represented (74/114)
- 75.4% cases occurred in dogs < 1 year
- Often bilateral in French Bulldogs

(Mazzucchelli *et al.*, 2012)

Renal and urinary conditions

Urolithiasis – cystine

- Breed at increased risk in a retrospective case series of 2543 uroliths examined at the Budapest Urolith Centre in Hungary (2001–2012)
- Mutation in the *SLC3A1* and *SLC7A9* genes suspected

(Harnevik *et al.*, 2006; Bende *et al.*, 2015)

Reproductive conditions

Delivery by caesarean section

- French Bulldogs were in the top 10 breeds in a cross-sectional study conducted by the Kennel Club in the UK. The study found a caesarean rate of 84% in 80 litters of French Bulldogs born over a 10-year period
- Dystocia is usually a result of fetopelvic disproportion in French Bulldogs
- French Bulldogs are excluded from insurance cover for caesarean section by Swedish pet insurance companies

(Bergström *et al.*, 2006; Evans & Adams, 2010a)

Respiratory conditions

Brachycephalic obstructive airway syndrome (BOAS)

- Breed at increased risk due to conformation
- Risk increases with shorter muzzle length, increased neck girth and obesity
- French Bulldog kennel club registrations in the UK have grown from 350 in 2004 to 6990 in 2013 making this a condition of enormous welfare concern
- Concurrent gastrointestinal lesions may occur in this breed

(Poncet *et al.*, 2005; Emmerson, 2014; Liu *et al.*, 2015)

FRENCH MASTIFF

See *Dogue de Bordeaux*

FRENCH SPANIEL

Dermatological conditions

Acral mutilation and analgesia

- Rare condition. 13 cases identified in French Spaniels in Canada
- Signs noted between 3.5 and 12 months of age

(Paradis *et al.*, 2005)

FRISIAN WATER DOG

See *Wetterhoun*

GALGOS ESPAÑOL

See *Spanish Greyhound*

GERMAN PINSCHER

Cardiovascular conditions

Vascular ring anomaly – persistent right aortic arch (PRAA)

See under *Gastrointestinal conditions*

Gastrointestinal conditions

Vascular ring anomaly – persistent right aortic arch (PRAA)

- High prevalence noted in the German Pinscher
- Symptoms of regurgitation are seen at weaning

(Menzel & Distl, 2011)

Ocular conditions

Cataract

- Autosomal recessive inheritance suspected
- In a retrospective review of ophthalmological examinations of 122 German Pinschers in Finland, 6.5% were found to have cataracts
- In a retrospective review of examinations of 409 German Pinschers in Germany (1997–2013) by certified veterinary ophthalmologists, 15.6% were diagnosed with primary cataracts

(Leppänen *et al.*, 2001; Pfahler *et al.*, 2015)

Persistent hyperplastic tunica vasculosa lentis

- Congenital, autosomal recessive inheritance suspected
- In a retrospective review of ophthalmological examinations carried out in 122 German Pinschers in Finland, 8.4% were affected
- In a retrospective review of examinations of 409 German Pinschers in Germany (1997–2013) by certified veterinary ophthalmologists, 3.2% were affected

(Leppänen *et al.*, 2001; Pfahler *et al.*, 2015)

GERMAN SHEPHERD DOG (GSD or ALSATIAN)

Cardiovascular conditions

Aortic stenosis – subaortic stenosis (SAS)

- Breed at mildly increased risk (OR 1.8; $p = 0.0166$) compared to the general hospital population in a retrospective study of the medical records of 976 dogs diagnosed with congenital heart disease at a cardiology clinic in Italy
- This study found a male predisposition (OR 1.7). Previous studies have found no gender difference

- Inheritance possibly autosomal dominant with variable penetrance

(Oliveira *et al.*, 2011)

Haemangiosarcoma – right atrial

See *Pericardial effusion*, below, and under *Neoplastic conditions* (*Haemangiosarcoma*)

Patent ductus arteriosus

- Breed at markedly increased risk (OR 5.2; $p < 0.0001$) compared to the general hospital population) in a retrospective study of the medical records of 976 dogs diagnosed with congenital heart disease at a cardiology clinic in Italy
- This study found a female predisposition (OR 2.7)

(Oliveira *et al.*, 2011)

Pericardial effusion

- Breed at increased risk in a number of studies
- Average age at diagnosis 9.7 years
- Haemangiosarcoma of the right atrium is a common cause in GSDs

(Mellanby & Herrtage, 2005; MacDonald *et al.*, 2009)

Vascular ring anomaly – persistent right aortic arch (PRAA)

See under *Gastrointestinal conditions*

Ventricular arrhythmia and sudden death

- Polygenic inheritance likely
- Affects young dogs, with a window of vulnerability for sudden death at 3–18 months (peak 6–7 months)
- Sudden death occurs more frequently during rapid-eye-movement (REM) sleep and after exercise

(Cruickshank *et al.*, 2009)

Ventricular septal defect

- Breed at markedly increased risk (OR 3.7; $p = 0.001$) compared to the general hospital population) in a retrospective study of the medical records of 976 dogs diagnosed with congenital heart disease at a cardiology clinic in Italy
- Almost half of the ventricular septal defect cases in this study were seen with another cardiac defect, most commonly pulmonic stenosis

(Oliveira *et al.*, 2011)

Dermatological conditions

Anal furunculosis (perianal fistula)

- GSDs represent > 80% of reported cases
- Most common in middle-aged to older dogs
- Some similarities to perianal Crohn's disease in humans
- Immune-mediated pathogenesis suspected

(Kennedy *et al.*, 2008; Massey *et al.*, 2014)

Atopic dermatitis (atopy)

- Breed at increased risk in a study of Hamburg cases: OR 6.6 (95% CI 3.9–11.2) compared to the general hospital population
- The same study showed an increased risk in Munich cases: OR 5.0 (95% CI 2.9–8.6) compared to the general hospital population
- The same study showed an increased risk in Melbourne cases: OR 2.4 (95% CI 1.4–4.1) compared to the general hospital population
- This study suggests that the overall breed risk profile varies substantially depending on geographical location

(Nødtvedt *et al.*, 2006; Jaeger *et al.*, 2010; Tengvall *et al.*, 2013)

Cutaneous neoplasia

See under *Neoplastic conditions*

Discoid lupus erythematosus

- Uncommon disease of the nasal planum
- GSDs and their crosses were over-represented in one study (44% of 27 cases)

(Wiemelt *et al.*, 2004)

Erythema multiforme

- Rare condition
- Breed at increased risk ($p = 0.0039$) in a small study of 16 cases seen at a dermatology referral centre at Cornell University, US

(Scott & Miller, 1999)

Familial vasculopathy

- Autosomal recessive inheritance
- Seen in Canada, plus one case report from the UK
- Occurs at 4–7 weeks of age
- Possible association with vaccination

(Weir *et al.*, 1994; Rest *et al.*, 1996)

Focal metatarsal fistulation (sterile idiopathic pedal panniculitis)

- Rare disease, seen almost exclusively in GSDs
- Age of onset usually 2.5–4 years

(Kunkle *et al.*, 1993; Paterson, 1995)

German Shepherd Dog pyoderma

- Described as a distinct clinical entity in the GSD. Also known as folliculitis–furunculosis and cellulitis syndrome (FFCS)
- In a prospective study in France, 80/277 cases of pyoderma (superficial and deep) were GSDs
- 23 of the GSDs in this study had no underlying disease
- Of these, middle-aged dogs were predisposed (mean age 7.5 years)
- Males were over-represented (20 of the 23)
- Abnormalities of cell-mediated immunity and low IgA levels have been implicated in the pathogenesis

(Denerolle *et al.*, 1998)

Leishmaniasis

See under *Infectious conditions*

Mucocutaneous pyoderma

- Uncommon condition; may be difficult to differentiate from discoid lupus erythematosus
- The GSD and its crosses appear to be predisposed

(Bassett *et al.*, 2004; Wiemelt *et al.*, 2004)

Multiple collagenous naevi (nodular dermatofibrosis)

- Autosomal dominant inheritance
- Occurs with renal cystadenocarcinomas and uterine leiomyomas

(Castellano & Idiart, 2005; Zanatta *et al.*, 2013)

Otitis externa

- Breed at increased risk ($p < 0.001$) when compared with the hospital's normal population in a study of 430 cases at a veterinary teaching hospital in Jerusalem

(Zur *et al.*, 2011)

Symmetric lupoid onychodystrophy

- GSD at increased risk in a number of studies
- GSDs represented 22.2% cases but only 4% of the hospital population in one retrospective study (RR 5.6)

(Scott *et al.*, 1995; Harvey & Maxwell, 1996)

Systemic lupus erythematosus

See under *Haematological/immunological conditions*

Drug reactions

Ivermectin and milbemycin

- Breed at increased risk of ivermectin and milbemycin toxicosis
- High doses can cause tremors, ataxia, coma and death

(Merola *et al.*, 2009)

Endocrine conditions

Acromegaly

- Rare condition, seen mainly in intact female dogs
- GSDs were found to be at increased risk in a retrospective study of the medical records of 34 380 dogs attending two referral veterinary hospitals in Italy between 2004 and 2008. The incidence in the intact female GSD population was 1.65%, significantly higher ($p < 0.0001$) than the incidence of 0.15% in the overall entire female population

(Fracassi *et al.*, 2014)

Pituitary dwarfism

- Rare
- Autosomal recessive mode of inheritance suggested
- Clinical signs (failure to grow) seen at 2–3 months

(Voorbij *et al.*, 2011; Tsai *et al.*, 2012)

Gastrointestinal conditions

Acquired megaoesophagus

- Breed at increased risk in case series
- Megaoesophagus can be idiopathic, or secondary to peripheral neuropathies, myasthenia gravis, oesophagitis and chronic or recurrent gastric dilatation

(Gaynor *et al.*, 1997)

Anal furunculosis (perianal fistula)

See under *Dermatological conditions*

Antibiotic-responsive diarrhoea (small intestinal bacterial overgrowth)

- Breed at increased risk in case series
- May be associated with IgA deficiency in GSDs (see under *Haematological/immunological conditions*)

(Batt *et al.*, 1991; German *et al.*, 2000b)

Congenital megaoesophagus

- Autosomal dominant inheritance with incomplete penetrance has been proposed

- Varies in severity, with mild cases resolving spontaneously after several months

(Tsai *et al.*, 2012)

Exocrine pancreatic insufficiency (EPI)

- Very high prevalence in the GSD (approximately 60% of all cases)
- The underlying cause is pancreatic acinar atrophy (PAA)
- Typical age of onset 36 months
- Higher prevalence in females

(Batchelor *et al.*, 2007; Tsai *et al.*, 2012, 2013)

Gastric dilatation/volvulus (bloat, GDV)

- Breed at increased risk in case series
- 28.6% of dogs were GSDs in a series of 112 cases

(Brockman *et al.*, 1995; Buber *et al.*, 2007)

Haemangiosarcoma – splenic

See under *Neoplastic conditions*

Hypocobalaminaemia

- Breed at increased risk of decreased cobalamin (vitamin B_{12}) (<100 ng/l)
- In a UK-based study of 9960 dogs, GSDs were found to have an OR of 1.5 (95% CI 1.7–3.9; $p < 0.004$) compared to all dogs in the study
- This study found a lower risk of decreased folate (<3.5 µg/dl): OR 0.7 (95% CI 0.6–0.8; $p = 0.004$) for GSDs

(Dandrieux *et al.*, 2013)

Inflammatory bowel disease

- Breed at increased risk in a case series (18/80 cases were GSDs)
- Mean age 4.9 years
- May be associated with antibiotic responsive diarrhoea and IgA deficiency

(Batt *et al.*, 1991; Craven *et al.*, 2004; Lee *et al.*, 2015)

Intussusception – gastro-oesophageal

- Rare condition seen relatively more frequently in this breed
- Usually seen in dogs < 3 months old
- Higher incidence in males
- May be associated with congenital megaoesophagus

(Roach & Hecht, 2007; Shilby *et al.*, 2014)

Parvovirus enteritis

See under *Infectious conditions*

Small intestinal volvulus

- Rare condition
- Few cases are reported in the literature, but a high proportion of those cases are in GSDs, suggesting a predisposition
- Usually associated with chronic intestinal disorders

(Cairo *et al.*, 1999)

Splenic masses

- Breed at increased risk in case series
- In a retrospective study, 25/249 cases were in GSDs
- Median age at diagnosis was 10 years
- Male:female ratio was 2:1
- 53% of cases were malignant (73.5% of those were haemangiosarcoma)

(Eberle *et al.*, 2012)

Splenic torsion

- Rare condition
- Breed at increased risk in a retrospective review of case records at seven North American referral hospitals. GSDs represented 24/102 cases (23.5%)
- Males were at increased risk

(DeGroot *et al.*, 2016)

Vascular ring anomaly – persistent right aortic arch (PRAA)

- High prevalence noted in the GSD (12/52 cases in one study, and 16/44 cases in another, were GSDs)
- Symptoms of regurgitation are seen at weaning

(Buchanan, 2004; Krebs *et al.*, 2014)

Haematological/immunological conditions

Babesiosis

See under *Infectious conditions*

Ehrlichiosis

See under *Infectious conditions*

Haemophilia A

- Factor VIII deficiency
- X-linked recessive inheritance
- Male dogs predominantly affected
- A moderately severe form of the disease in this breed allows survival to adulthood

(Parry *et al.*, 1988; Aslanian *et al.*, 2014)

Haemophilia B
- Factor IX deficiency
- X-linked recessive inheritance

(Brooks, 1999)

Hypocobalaminaemia
See under *Gastrointestinal conditions*

Selective IgA deficiency
- Breed at increased risk in case series
- 14% of 319 GSDs were found to have low serum IgA in one 2014 study
- Immunodeficiency is associated with recurrent infections of mucosal sites and increased susceptibility to immune-mediated disease
- In GSDs, low IgA levels may be associated with antibiotic-responsive diarrhoea, inflammatory bowel disease, atopy and pancreatic acinar atrophy

(Batt *et al.*, 1991; Olsson *et al.*, 2014)

Systemic lupus erythematosus
- Uncommon (incidence is approximately 0.03% of the general canine population)
- Affects mainly males in the GSD
- Average age of 5 years
- Symptoms may include skin lesions, pyrexia and polyarthrtitis

(Fournel *et al.*, 1992)

Infectious conditions

Babesiosis
- Breed at increased risk of testing seropositive to *Babesia* organisms in a study of 651 blood samples from dogs in Hungary
- A genetic predisposition towards carrier status is proposed

(Hornok *et al.*, 2006)

Cryptococcosis
- Breed at increased risk in a case series in Australia (where cryptococcosis is the most common systemic mycosis)
- Usually seen in dogs < 4 years
- Living outdoors and exposure to bird droppings are risk factors

(O'Brien *et al.*, 2004)

Disseminated aspergillosis
- Breed at increased risk in case series
- In a retrospective study which reviewed the medical records of the University of California, Davis, teaching hospital, GSDs had an OR of 43.0 (95% CI 20.0–91.0; $p < 0.0001$) compared to the general hospital population
- Females were over-represented: OR 2.9 (95% CI 1.2–6.7; $p = 0.02$)
- Median age 4.5 years (range 2–8 years)

(Schultz *et al.*, 2008)

Ehrlichiosis
- Breed considered to be at high risk in many areas of the world
- In a Kenyan study of 514 dogs with ehrlichiosis, GSDs represented 42.6% cases
- In a retrospective case–control study in Peru, the odds ratio was 12.2 ($p < 0.01$) compared to the general population

(Contreras *et al.*, 2009; Kitaa *et al.*, 2014)

Leishmaniasis
- Breed at increased risk in a study of 390 cases seen at a university veterinary clinic in Barcelona
- GSDs represented 13.6% of dogs with leishmaniasis, compared to 7.5% of the general population ($p < 0.001$)
- Bimodal age distribution, with peaks at 2–4 years and 7+ years
- Male dogs are predisposed

(Miranda *et al.*, 2008)

Parvovirus enteritis
- Breed at increased risk in several case series from a variety of continents
- Dogs aged between 6 weeks and 6 months are at highest risk
- Absence of, or inadequate vaccination is a risk factor

(Houston *et al.*, 1996)

Musculoskeletal conditions

Calcinosis circumscripta
- GSDs < 2 years old account for > 50% of reported cases
- May affect periarticular soft tissues resulting in lameness, soft tissues surrounding the spinal cord resulting in spinal cord compression or lingual soft tissue resulting in lesions on the tongue

(Roudebush *et al.*, 1988; Dennis *et al.*, 2006)

Elbow dysplasia
- Common cause of forelimb lameness in young dogs
- Breed at increased risk in a number of case series

- In a large retrospective case series based on cases recorded in the VMDB, 1986–1995, GSDs were recorded with the following risks: fragmentation of the medial coronoid process, OR 43.7 (95% CI 30.1–63.2) compared to mixed breeds; ununited anconeal process, OR 8.2 (95% CI 6.2–10.9) compared to mixed breeds
- Polygenic inheritance. Primary lesions of elbow dysplasia may be inherited separately

(LaFond *et al.*, 2002; Stock *et al.*, 2011)

Gracilis contracture (fibrotic myopathy)

- Uncommon condition which is mainly seen in young male GSDs
- Commonly occurs in athletic individuals
- May affect other muscles including sartorius, semimembranosus, semitendinosus, and biceps femoris

(Lewis *et al.*, 1997; Steiss, 2002; Spadari *et al.*, 2008)

Hip dysplasia

- Breed at increased risk in case series
- OR 3.61 (95% CI 3.52–3.71; $p < 0.001$) compared to all other dogs in a large retrospective study of VMDB cases, 1964–2003. Male neutered dogs and dogs < 4 years of age of all breeds combined found to be at increased risk
- OR 5.7 (95% CI 5.0–6.3) compared to mixed-breed dogs in a separate retrospective study of VMDB data, 1986–1995
- Prevalence in GSDs has been estimated as 35%

(LaFond *et al.*, 2002; Witsberger *et al.*, 2008; Fels & Distl, 2014)

Lumbosacral disease

See under *Neurological conditions*

Lumbosacral transitional vertebrae

- Significantly higher prevalence in GSDs (5.7%) compared to all other breeds combined (3.5%; $p < 0.001$), in a Swiss study reviewing radiographs of 4000 dogs of medium-large breeds
- Predisposes to lumbosacral disease (see under *Neurological conditions*)

(Damur-Djuric *et al.*, 2006)

Metaphyseal osteopathy (hypertrophic osteodystrophy)

- Affects dogs aged 2–6 months
- Males may be predisposed
- OR 9.6 (95% CI 4.3–21.0) compared to mixed breeds in a retrospective study of VMDB data, 1986–1995

(LaFond *et al.*, 2002; Safra *et al.*, 2013)

Osteochondrosis – sacrum

See under *Neurological conditions* (*Lumbosacral disease*)

Osteochondrosis – shoulder

- Breed at increased risk in case series. OR 2.1 (95% CI 1.4–3.1) compared to mixed-breed dogs in a retrospective study of VMDB data, 1986–1995
- Age at presentation 4–14 months
- Males over-represented (25/36 cases in one study in Poland)

(LaFond *et al.*, 2002; Biezyński *et al.*, 2012)

Osteochondrosis – stifle

- Breed at increased risk in case series. OR 17.5 (95% CI 7.5–40.7) compared to mixed-breed dogs in a retrospective study of VMDB data, 1986–1995
- Mean age at presentation 5.9 months
- Males over-represented (103/135 cases of multiple breeds in a review of cases in Europe and the USA)

(Montgomery *et al.*, 1989; LaFond *et al.*, 2002)

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- Breed at increased risk
- OR 3.3 (95% CI 2.9–3.7) compared to mixed breeds in a retrospective study of VMDB data, 1986–1995

(LaFond *et al.*, 2002)

Spondylosis deformans

- Common condition in ageing dogs
- Breed at increased risk in a retrospective study of radiographic records (OR 3.327; $p < 0.001$)
- Usually clinically insignificant but may be associated with type II intervertebral disc disease

(Levine *et al.*, 2006; Kranenburg *et al.*, 2011)

Systemic lupus erythematosus

See under *Haematological/immunological conditions*

Neoplastic conditions

Anal sac adenocarcinoma

- Breed at increased risk in a number of small studies (7/42 cases in one study)
- Mean age 10.2–10.8 years
- Some surveys suggest a female predisposition

(Bennett *et al.*, 2002; Potanas *et al.*, 2015)

Haemangiosarcoma

- Breed at high risk of haemangiosarcoma in all locations
- In one retrospective study of 104 cases, 34 were GSDs
- Most common location was the spleen, then the skin/subcutis, liver, heart and lung
- Mean age was reported as 10 years
- In another study of 92 dogs with splenic haemangiosarcoma, GSDs had an OR of 4.7 (95% CI 2.7–7.8) compared with all other purebred dogs
- Haemangiosarcoma is the most common tumour of the heart

(Brown *et al.*, 1985; Ng & Mills, 1985; Prymak *et al.*, 1988)

Mammary neoplasia

- Most common tumour in entire female dogs
- Breed at increased risk compared to the general population of insured dogs in a study based on Swedish insurance data: OR 3.2 (99% CI 2–4.9)

(Egenvall *et al.*, 2005)

Melanoma

- Breed at increased risk of limbal melanoma
- In a retrospective histopathological study of 244 cases submitted to the Comparative Ocular Pathology Laboratory of Wisconsin, 1988–1998, 41% of limbal melanomas were from GSDs
- In another retrospective report of 30 cases seen at the Animal Health Trust in England, the GSD was not found to be at increased risk compared to the general population

(Giuliano *et al.*, 1999; Donaldson *et al.*, 2006)

Perianal adenocarcinomas

- Breed at increased risk (compared to the hospital population at the time) in a series of 41 cases in male dogs at Colorado State University
- Entire males at significantly greater risk than neutered males

(Vail *et al.*, 1990)

Renal cystadenocarcinomas

See under *Renal and urinary conditions*

Sinonasal neoplasia

- In a retrospective review of cases seen at the Animal Medical Center in New York, GSDs represented 27.2% (9/33) of chondrosarcomas and 12.5% (2/16) of osteosarcomas
- Average age was 7 years (chondrosarcomas) and 10 years (osteosarcomas)
- Males were over-represented

(Patnaik *et al.*, 1984b)

Testicular neoplasia

See under *Reproductive conditions*

Thymoma

- Uncommon tumour
- In one retrospective study, GSDs represented 5/18 cases, suggesting a possible predisposition
- In a more recent retrospective study, GSDs represented only 4/116 cases
- Middle-aged and older dogs affected
- May be associated with myasthenia gravis, hypercalcaemia or immune-mediated disease

(Aronsohn, 1985; Day, 1997b; Robat *et al.*, 2013)

Trichoepithelioma

- Breed at increased risk in case series
- Mean age 8.6 years
- Predilection sites: limbs, back and trunk

(Scott & Anderson, 1991)

Uterine leiomyoma

Occurs with renal cystadenocarcinomas (see under *Renal and urinary conditions*)

Neurological conditions

Degenerative myelopathy

- Common in GSDs
- Caused by a mutation in the superoxide dismutase 1 (*SOD1*) gene which has a high degree of penetrance
- Age of clinical onset > 5 years

(Tsai *et al.*, 2012; Holder *et al.*, 2014)

Discospondylitis

- GSDs were at higher risk in a study of 513 cases in North America: OR 2.6 (95% CI 1.8–3.9) compared to mixed-breed dogs
- Risk increases with increasing age

- Males twice as likely to be affected as females: OR 2.0 (95% CI 1.7–2.4)

(Burkert *et al.*, 2005)

Giant axonal neuropathy

- Rare condition
- Autosomal recessive inheritance suspected
- Age of clinical onset 14–15 months

(Duncan & Griffiths, 1981)

Idiopathic epilepsy

- GSDs had an increased risk compared to crossbreeds, with an OR of 1.9 (95% CI 1.28–2.80; $p = 0.001$) in a large retrospective study of data from 92 UK-based primary veterinary practices
- Males over 1.5 times more likely to be affected than females (95% CI 1.44–2.06; $p < 0.001$)
- Age of onset 6 months to 6 years
- GSDs are also at increased risk of cluster seizures

(Kearsley-Fleet *et al.*, 2013; Packer *et al.*, 2016b)

Intervertebral disc disease (IVDD)

- GSDs were found to be at higher risk when compared to other dogs in a number of studies
- GSDs were the third most commonly affected breed after mixed-breed dogs and Dachshunds in one retrospective study of 946 cases seen at a referral hospital in Switzerland (representing 7% of cases)
- GSDs accounted for 52.4% of 21 cases in a retrospective study of dogs with T1–T9 lesions diagnosed by MRI at a New York referral hospital
- GSDs were found to be the breed at highest risk of L7–S1 disc lesions amongst non-chondrodystrophic breeds
- Older dogs are more likely to be affected; GSDs often had lesions at multiple sites

(Fluehmann *et al.*, 2006; Suwankong *et al.*, 2008; Hearon *et al.*, 2014)

Lumbosacral disease

- GSDs are frequently reported as the breed at highest risk
- Factors include early degeneration of the lumbosacral (LS) intervertebral disc, instability of the LS joint, sacral osteochondrosis, LS transitional vertebrae and LS step formations, which are higher in the GSD than in other large-breed dogs
- Congenital, with developmental and acquired factors believed to be involved

(Suwankong *et al.*, 2008; Amort *et al.*, 2012; Ondreka *et al.*, 2012)

Lumbosacral transitional vertebrae

- Predisposes to lumbosacral disease. See above and under *Musculoskeletal conditions*

(Damur-Djuric *et al.*, 2006)

Ocular conditions

Chronic superficial keratitis (pannus)

- GSDs have the highest incidence of all breeds
- Immune-mediated basis, linked to MHC class 2 genes
- Median age 4 years
- When seen in younger dogs it is rapidly progressive and more severe
- Prevalence and severity increase at higher altitude
- May be associated with plasma cell infiltration of the nictitating membrane

(Jokinen *et al.*, 2011)

Melanoma

See under *Neoplastic conditions*

Plasma cell infiltration of the nictitating membrane (plasmoma)

- Breed at increased risk
- May be associated with pannus

(Jokinen *et al.*, 2011)

Renal and urinary conditions

Renal cystadenocarcinomas

- Autosomal dominant inheritance suggested
- Mean age at diagnosis: 8.2 years
- Multiple, bilateral tumours are seen, with generalized nodular dermatofibrosis and (in female dogs) multiple uterine leiomyomas

(Lium & Moe, 1985; Castellano *et al.*, 2000; Castellano & Idiart, 2005)

Urolithiasis – silica

- Breed at increased risk in several case series
- However, a more recent large retrospective study of 1697 cases over 20 years failed to show a predisposition in the GSD
- Mean age at diagnosis 5.8 years
- Males predisposed

(Osborne *et al.*, 1981, 1999; Aldrich *et al.*, 1997)

Reproductive conditions

Cryptorchidism

- Congenital defect believed to be inherited as a sex-limited, autosomal recessive trait
- Breed at increased risk in case series

(Romagnoli, 1991; Yates *et al.*, 2003)

Mammary neoplasia

See under *Neoplastic conditions*

Prostate disease

- Breed at increased risk: OR 2.1 (95% CI 1.5–2.9; $p < 0.001$) compared to the general hospital population a large retrospective study conducted at Alfort Veterinary College, France (2002–2009)
- Study included dogs with benign prostatic hypertrophy, prostatitis, cysts, abscesses, neoplasia and squamous metaplasia
- Mean age was 8.6 ± 3.2 years
- Entire males were at significantly increased risk: OR 3.096 (95% CI 1.466–6.541) except for prostatic neoplasia

(Polisca *et al.*, 2016)

Testicular neoplasia

- In a study of 232 routine necropsy cases, 16/59 dogs found to have testicular tumours were GSDs
- Mean age 9–11 years
- Retained testicles at increased risk
- One study suggests GSDs have an increased risk of seminoma

(Hayes & Pendergrass, 1976; Sapierzyński *et al.*, 2007a; Grieco *et al.*, 2008)

Uterine leiomyoma

Seen with renal cystadenocarcinomas; see under *Renal and urinary conditions*

GERMAN SPANIEL

See *Wachtelhund*

GLEN OF IMAAL TERRIER

Ocular conditions

Progressive retinal atrophy (PRA)

- Autosomal recessive inheritance
- Mutation in the ADAM 9 gene identified
- Late-onset rod–cone dystrophy

(Kropatsch *et al.*, 2010)

GOLDEN RETRIEVER

Behavioural conditions

Aggression

- Breed identified with significantly lower levels of aggression towards both humans and other dogs in a study based on Canine Behavioural Assessment and Research Questionnaires (C-BARQ) completed by owners in the USA

(Duffy *et al.*, 2008)

Cardiovascular conditions

Aortic stenosis – subaortic stenosis (SAS)

- OR 9.63 (95% CI 4.21–22.01) compared to the general hospital population, in an Australian retrospective study of 40 dogs with SAS seen between 2001 and 2012
- In an Italian study of 241 cases OR was 3.6 ($p < 0.0001$)

(Oliveira *et al.*, 2011; Aherne & Beijerink, 2013)

Cardiomyopathy – X-linked muscular dystrophy

- Also known as Golden Retriever muscular dystrophy
- Similar to Duchenne muscular dystrophy in humans
- Rare
- Most clinically affected cases are male

(Jeanson-Leh *et al.*, 2014)

Haemangiosarcoma – right atrial

- A cause of pericardial effusion (see below)
- Breed at increased risk
- Golden Retrievers represented 8/23 cases in a retrospective report of cases confirmed by histopathology as haemangiosarcoma
- Mean age was 9.1 years

See also under *Neoplastic conditions*

(Weisse *et al.*, 2005)

Mitral valve dysplasia

- OR 25.36 (95% CI 6.04–106.49) compared to the general hospital population, in an Australian retrospective study of 8 dogs with mitral valve dysplasia seen between 2001 and 2012
- Golden retrievers represented 3/13 dogs with mitral valve dysplasia in a retrospective study of 151 cases of congenital heart disease seen in a Swedish referral hospital (1989–1996)

(Tidholm, 1997; Aherne & Beijerink, 2013)

Pericardial effusion
- Breed at increased risk
- May be idiopathic or a result of a cardiac mass
- Golden Retrievers represented 20/107 pericardial effusion cases in a retrospective study carried out at University of California, Davis, USA, 1985–2006
- Golden Retrievers represented 47/143 cases in a retrospective study at a referral centre in the UK. 40 of these cases were negative for a cardiac mass on echocardiogram (mean age of these dogs was 8.5 years). 7 cases had a cardiac mass on echocardiogram (mean age of these dogs was 9.5 years)

(Stafford Johnson *et al.*, 2004; MacDonald *et al.*, 2009)

Tricuspid valve dysplasia
- In an Italian retrospective case series of 976 dogs with congenital heart defects, Golden Retrievers had an OR of 6.6 ($p = 0.0022$)

(Oliveira *et al.*, 2011)

Dermatological conditions

Atopic dermatitis (atopy)
- Breed at increased risk in a study of Munich cases (OR 8.6; 95% CI 4.7–15.6) compared to the general hospital population
- Breed at increased risk in a study of Campbell, USA cases. OR 5.1 (95% CI 3.1–8.4) compared to the general hospital population
- This study suggested that overall breed risk profile varies substantially depending on geographical location

(Scott & Paradis, 1990; Jaeger *et al.*, 2010)

Cutaneous neoplasia
See under *Neoplastic conditions*

Grass awn migration
- Breed at increased risk in case series. May be due to behaviour/lifestyle
- Common in the summer months

(Brennan & Ihrke, 1983)

Ichthyosis
- Autosomal recessive inheritance, mutation identified
- Usually diagnosed in young dogs median age 2.29 years

(Mauldin *et al.*, 2008; Grall *et al.*, 2012)

Pyotraumatic folliculitis (acute moist dermatitis, hot spot, wet eczema)
- Breed at increased risk in case series. Relative risk 1.31 compared to the general hospital population
- Dogs < 4 years old at increased risk ($p < 0.0001$)

(Holm *et al.*, 2004)

Endocrine conditions

Hypothyroidism
- Breed at increased risk in a case series. OR 2.86 ($p = 0.036$) compared to a large university hospital population. Neutered animals (both sexes) were at increased risk
- Breed with higher prevalence of thyroid hormone autoantibodies (THAA). In a cohort study of 287 948 serum samples from dogs in the US with clinical signs of hypothyroidism, Golden Retrievers had an OR 1.9 (p 0.001) of being affected compared to dogs of all other breeds. Across the study, females were overrepresented and the highest prevalence was in dogs 2–4 years old
- Hypothyroidism seems to occur at a younger age (2–3 years) in at risk breeds

(Panciera, 1994; Nachreiner *et al.*, 2002)

Thyroid neoplasia
May be associated with hyper- or hypothyroidism, but most are euthyroid. See under *Neoplastic conditions*

Gastrointestinal conditions

Acquired megaoesophagus
- Breed at increased risk in case series
- Megaoesophagus can be idiopathic or secondary to peripheral neuropathies, myasthenia gravis, oesophagitis and chronic or recurrent gastric dilatation

(Gaynor *et al.*, 1997)

Congenital portosystemic shunt
- Breed at increased risk in case series
- Golden Retrievers represented 11/100 cases in a retrospective case series of intrahepatic shunts at the University of Pennsylvania
- Golden Retrievers represented 4/11 cases of intrahepatic shunts in a retrospective case series at Tufts University
- Clinical signs usually seen in young dogs < 1 year
- Golden Retrievers have intrahepatic shunts more commonly than extrahepatic shunts

(D'Anjou *et al.*, 2004; Weisse *et al.*, 2014)

Cricopharyngeal dysfunction

- Inheritance has been demonstrated; a single recessive allele of large effect contributes to the disease in Golden Retrievers

(Davidson *et al.*, 2004)

Folate – low serum level

- Breed at increased risk of low serum folate level in a retrospective study of 9960 samples over 12 years at Liverpool University, UK
- OR 1.9 (95% CI 1.6–2.3)
- This indicates that either the reference interval is lower in Golden Retrievers or that they are at increased risk of proximal small intestinal disease

(Dandrieux *et al.*, 2013)

Haemangiosarcoma – splenic

- Often metastasizes to the liver, omentum or lungs
- Breed at increased risk. Golden Retrievers represented 13/59 cases in a retrospective report of cases at the University of Guelph, Canada

See also under *Neoplastic conditions*

(Kim *et al.*, 2007)

Melanoma

See under *Neoplastic conditions*

Haematological/immunological conditions

Haemophilia A

- Golden Retrievers experience a mild factor VIII deficiency
- X-linked recessive inheritance

(Brooks *et al.*, 2005)

Haemophilia B

- Factor IX deficiency
- X-linked recessive inheritance

(Brooks, 1999)

Hereditary spectrin deficiency

- Spectrin deficiency has been estimated to be present in 11–24.6% of Dutch Golden Retrievers
- Autosomal dominant inheritance
- Causes spherocytosis and fragility of red blood cells

(Slappendel *et al.*, 2005)

Selective IgA deficiency

- Breed at increased risk in case series
- 13% of 168 Golden Retrievers were found to have low serum IgA (<0.07 g/l) in one 2014 study
- Immunodeficiency is associated with recurrent infections of mucosal sites and increased susceptibility to immune-mediated disease

(Olsson *et al.*, 2014)

Infectious conditions

Blastomycosis

- Breed at increased risk in case series
- Golden Retrievers represented 15.2% of 125 cases in a retrospective series of dogs with pulmonary blastomycosis seen at the University of Minnesota, 1989–2006. Mean age was 4 years
- Entire males were predisposed
- Geographic distribution: mainly North America (Mississippi, Missouri, Ohio River valleys, mid-Atlantic States, Quebec, Manitoba and Ontario)
- Proximity to a body of water is a risk factor in endemic areas

(Rudmann *et al.*, 1992; Crews *et al.*, 2008)

Borreliosis (Lyme disease)

- Breed at increased risk of nephritis (protein-losing nephropathy)

(Dambach *et al.*, 1997)

Metabolic conditions

Overweight/obesity

- 51.9% of Golden Retrievers attending veterinary clinics in China were classified as obese

(Courcier *et al.*, 2010; Mao *et al.*, 2013; Raffan *et al.*, 2016)

Musculoskeletal conditions

Cranial cruciate ligament (CCL) disease

- Breed at increased risk in a number of studies
- OR 1.9 (95% CI 1.1–3.3) compared to mixed-breed dogs in one retrospective study of data from UK first-opinion practices (VetCompass data)
- In this study dogs of all breeds which had high body weight within their breed were at increased risk (OR 3.4; $p < 0.001$) compared to dogs of low body weight within their breed; dogs 9–11.9 years old were at increased risk (OR 4.4; $p < 0.001$) compared to dogs < 3 years old; neutered female dogs were at increased risk (OR 2.1; $p < 0.001$) compared to entire females

- In a large retrospective case series based on cases recorded in the VMDB, 1964–2003, OR 1.11 (95% CI 1.05–1.17; $p = 0.007$) compared to all dogs. Neutered males, neutered females and dogs > 4 years of age of all breeds combined were at increased risk

(Witsberger *et al.*, 2008; Guthrie *et al.*, 2012; Torres de la Riva *et al.*, 2013; Taylor-Brown *et al.*, 2015)

Elbow dysplasia

- Developmental joint disease. Common cause of forelimb lameness in young dogs
- Breed at increased risk in a number of studies
- In a large retrospective case series based on cases recorded in the VMDB, 1986–1995 Golden Retrievers were recorded with the following risks: fragmentation of the medial coronoid process, OR 5.5 (95% CI 3.3–9.2) compared to mixed breeds; ununited anconeal process, OR 4.9 (95% CI 3.6–6.7) compared to mixed breeds; osteochondrosis, OR 42.2 (95% CI 18.7–95.3)
- Polygenic inheritance. Primary lesions of elbow dysplasia may be inherited separately

(LaFond *et al.*, 2002; Lavrijsen *et al.*, 2012)

Hip dysplasia

- Breed at increased risk in a number of studies
- OR 3.3 (95% CI 3.0–3.8) compared to mixed breeds in a large retrospective case series based on cases recorded in the VMDB, 1986–1995
- In a large retrospective case series based on cases recorded in the VMDB, 1964–2003, OR 2.70 (95% CI 2.61–2.8; $p < 0.001$) compared to all dogs. Neutered males and dogs < 4 years of age of all breeds combined were at increased risk

(LaFond *et al.*, 2002; Witsberger *et al.*, 2008)

Metaphyseal osteopathy (hypertrophic osteodystrophy)

- Affects dogs aged 2–6 months
- Males may be predisposed
- OR 5.4 (95% CI 2.5–11.7) compared to mixed breeds in a large retrospective case series based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Muscular dystrophy – X-linked

- X-linked recessive inheritance
- Similar to Duchenne muscular dystrophy in humans
- Degenerative muscular condition resulting in death usually from cardiac or respiratory failure

See also under *Cardiovascular conditions* and *Respiratory conditions*

(Cooper *et al.*, 1988; Jeanson-Leh *et al.*, 2014)

Osteochondrosis – shoulder

- Breed at increased risk (9/36 cases were Golden Retrievers in one Polish study). Males predisposed across all breeds (25 of the 36 cases were male)
- Age of onset usually 4–7 months but can be older
- OR 12.6 (95% CI 10.00–15.9) compared to mixed breeds in a large retrospective series based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002; Biezyński *et al.*, 2012)

Osteochondrosis – stifle

- Males predisposed
- Age of onset usually 5–12 months, but may be earlier
- OR 3.9 (95% CI 1.2–12.8) compared to mixed breeds in a large retrospective series based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Osteosarcoma

See under *Neoplastic conditions*

Neoplastic conditions

Canine acanthomatous amelioblastoma

- Increased risk based on retrospective case series at University of California, Davis, USA
- Mean age 8.8 years
- Commonly located in the rostral mandible
- Neutered dogs of both sexes were overrepresented

(Fiani *et al.*, 2011)

Fibrosarcoma – lingual

- Breed at increased risk
- OR 3.64 (95% CI 1.56–8.47) compared to all other breeds in a retrospective case series in Colorado, 1995–2004

(Dennis *et al.*, 2006)

Fibrosarcoma – oral

- Breed at increased risk
- 13/25 dogs were Golden Retrievers in a retrospective case series in Colorado, USA

- Males may be predisposed
- Mean age of onset is 7.5 years, but up to 25% of cases have been seen at < 5 years of age

(Ciekot *et al.*, 1994)

Haemangiosarcoma

- 20% of Golden Retrievers in the USA develop haemangiosarcomas
- Most common sites are the spleen (28–50%), right atrium/auricle (3–30%), skin and subcutaneous tissue (13%)
- Breed at increased risk of cutaneous haemangiosarcoma in a retrospective study of VMDB data, 1964–2002: OR 2.80 (95% CI 2.25–3.49) compared to all other dogs
- Neutered females are at 4 times higher risk than entire females
- Shared predisposing genetic loci with lymphosarcoma have been identified

(Villamil *et al.*, 2011; Kahn *et al.*, 2013; Torres de la Riva *et al.*, 2013; Thomas *et al.*, 2014; Tonomura *et al.*, 2015)

Histiocytic sarcoma

- Breed at increased risk in case series
- OR 5.0 in a series of 73 cases in Japan

(Affolter & Moore, 2002; Takahashi *et al.*, 2014)

Lymphoma

- Most common haematological malignancy
- Golden Retrievers are predisposed to B- and T-cell lymphoma
- 13% of Golden Retrievers in the USA develop lymphoma
- Cutaneous lymphoma – Golden Retrievers have an OR of 2.35 (95% CI 1.76–3.13) compared to all other dogs, based on data from the VMDB, 1964–2002
- Neutered male Golden Retrievers are 3 times more at risk than entire males
- Most cases are seen in middle-aged dogs (mean 6–7 years)
- Shared predisposing genetic loci with haemangiosarcoma have been identified

(Villamil *et al.*, 2011; Torres de la Riva *et al.*, 2013; Boerkamp *et al.*, 2014; Elvers *et al.*, 2015; Tonomura *et al.*, 2015)

Mast cell tumour (MCT)

- Breed at increased risk
- In a large UK study based on VetCompass data, Golden Retrievers had a prevalence of 1.39%, compared to an overall prevalence of 0.27% in all dogs
- Golden Retrievers are at increased risk of multiple tumours compared to all breeds (OR 3.8)
- Neutered female Golden Retrievers are at higher risk than entire females
- May be seen at any age (from 4 months onwards), but usually seen in older animals

(Murphy *et al.*, 2006; Torres de la Riva *et al.*, 2013; Shoop *et al.*, 2015)

Melanoma – cutaneous

- Breed at increased risk of cutaneous melanoma in a retrospective study of VMDB data, 1964–2002: OR 2.59 (95% CI 2.01–3.35) compared to all other dogs

(Villamil *et al.*, 2011)

Melanoma – ocular

- Breed at increased risk of limbal and canine anterior uveal melanoma in a retrospective case series at the Animal Health Trust, UK
- Mean age was 6.2 years (with a bimodal distribution of 3–4 years and 7–10 years)

(Donaldson *et al.*, 2006)

Melanoma – oral

- Breed at increased risk of oral melanoma in a retrospective study of the University of Missouri, USA, database
- OR 1.84 ($p < 0.001$) compared to a database population
- Average age 11.4 years

(Ramos-Vara *et al.*, 2000)

Osteosarcoma

- Breed at increased risk in case series
- OR 2.1 (95% CI 1.6–2.8) compared to German Shepherd Dogs in a retrospective study of VMDB data, 1980–1994
- Across all breeds there was an increased incidence with age, plateauing at 10 years
- Across all breeds there was a slight predisposition for males, but an almost twofold increase for neutered dogs of both sexes

(Ru *et al.*, 1998)

Primary brain tumour

See under *Neurological conditions*

Sarcoma – soft tissue
- Breed at increased risk of cutaneous soft-tissue sarcoma in a retrospective study of VMDB data, 1964–2002: OR 2.88 (95% CI 2.46–3.36) compared to all other dogs

(Villamil *et al.*, 2011)

Sweat gland tumour
- Breed at increased risk of apocrine ductal adenoma in a case series
- Mean age was 9.1 years

(Kalaher *et al.*, 1990)

Thyroid neoplasia
- Represents 1.1% of all neoplasms
- Breed at increased risk in case series
- OR 2.2 (95% CI 1.75–2.84) compared to all dogs in a retrospective study of data from the VMDB, 1995–2006
- Older animals at increased risk: 57% were between 10 and 15 years of age

(Wucherer & Wilke, 2010)

Trichoepithelioma
- Breed at increased risk in case series
- Mean age 8.6 years

(Scott & Anderson, 1991)

Neurological conditions

Horner's syndrome
- Golden Retrievers represented 110/155 dogs with Horner's syndrome referred to a UK veterinary ophthalmologist over a 10-year period
- 95 of the 110 Golden Retrievers were male

(Boydell, 2000)

Idiopathic epilepsy
- Breed at increased risk
- In a retrospective review of 394 cases seen at a Munich Veterinary teaching hospital, 2002–2008, Golden Retrievers had an OR of 2.04 ($p < 0.001$) compared to the hospital population
- Age of onset: 6 months to 6 years

(Zimmermann *et al.*, 2009)

Primary brain tumour
- Breed at increased risk in a number of case series
- Approximately 50% of primary brain tumours in the Golden Retriever are meningiomas
- Golden Retrievers are also at increased risk of choroid plexus tumours
- Older dogs affected

(Snyder *et al.*, 2006; Westworth *et al.*, 2008; Song *et al.*, 2013)

Sensory ataxic neuropathy
- Reported in Swedish Golden Retrievers
- Mutation identified
- Insidious onset between 2 and 8 months of age

(Jaderlund *et al.*, 2007; Baranowska *et al.*, 2009)

Trigeminal neuropathy
- Breed at increased risk in case series

(Mayhew *et al.*, 2002)

Ocular conditions

Cataract
- Dominant inheritance with incomplete penetration suggested
- In a UK study of eye examinations of 2251 Golden Retrievers the incidence of cataracts was 7.4%
- Prevalence of primary cataract 2.20%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)
- Localization: posterior subcapsular cortex
- Age of onset 6–18 months; slow-growing or non-progressive
- Usually bilateral
- Perinuclear cataracts are seen less frequently. These usually progress to generalized opacity
- Cataracts may also be seen secondary to pigmentary uveitis/iridociliary cysts

(Curtis & Barnett, 1989; Gelatt & MacKay, 2005)

Glaucoma – secondary
- Associated with pigmentary uveitis and iridociliary cysts
- Autosomal dominant inheritance with partial penetrance suspected
- Usually bilateral
- May be associated with secondary cataracts

(Deehr, 1998; Sapienza *et al.*, 2000; Townsend & Gornik, 2013; Holly *et al.*, 2016)

Melanoma
See under *Neoplastic conditions*

Pigmentary uveitis
See *Glaucoma – secondary*

Progressive retinal atrophy (PRA)
- Autosomal recessive inheritance suspected
- A number of different forms exist in Golden Retrievers, each having a different causal mutation. Three forms with identified mutations exist at the time of writing, and these have been termed prcd-PRA, PRA_GR1 and PRA2

(Downs *et al.*, 2014b)

Retinal dysplasia – geographic
- Inheritance suspected

(Holle *et al.*, 1999)

Retinal dysplasia – multifocal
- Congenital, autosomal recessive inheritance suspected

(Long & Crispin, 1999)

Retinal pigment epithelial dystrophy (RPED, central progressive retinal atrophy)
- More prevalent in the UK than in the USA. Becoming less prevalent following the introduction of control schemes

(Curtis, 1988)

Spontaneous chronic corneal epithelial defects (refractory corneal ulceration, indolent ulcers)
- Breed at increased risk in case study
- Mean age 9.25 years

(Murphy *et al.*, 2001)

Uveal cysts
- Often associated with pigmentary uveitis and secondary glaucoma in Golden Retrievers

See also *Glaucoma – secondary*

(Deehr, 1998; Sapienza *et al.*, 2000)

Renal and urinary conditions

Ectopic ureter
- Uncommon congenital anomaly
- Breed at increased risk in case series
- Golden Retrievers represented 16.6% of 24 cases in one study at Ohio State University veterinary teaching hospital, USA
- Usually presents < 1 year of age
- More commonly diagnosed in females

(Holt & Moore, 1995; Cannizzo *et al.*, 2003)

Familial renal disease (familial nephropathy)
- Reported in young dogs < 3 years old
- Cases present in renal failure

(Kerlin & Van Winkle, 1995; de Morais *et al.*, 1996)

Lyme nephritis
- Breed at increased risk to developing protein-losing nephropathy as a result of *Borrelia burgdorferi* infection

(Dambach *et al.*, 1997)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)
- Breed at increased risk in case series
- In a study of data from five RSPCA hospital populations in the UK between 2006 and 2011. The prevalence in Golden Retrievers was 5.4%, compared to 2.2% in all dogs over the study period
- Common disease of older entire bitches (mean age 7.25 years)
- Most cases present within 12 weeks of oestrus

(Egenvall *et al.*, 2001; Gibson *et al.*, 2013)

Respiratory conditions

Muscular dystrophy – X-linked
- May affect the diaphragm muscle, trachea and alveoli resulting in respiratory failure

See also under *Musculoskeletal conditions*

(Lessa *et al.*, 2014)

GORDON SETTER

Dermatological conditions

Black hair follicular dysplasia
- Reported in Gordon Setters in Norway
- Males over-represented
- Antinuclear antibodies were found in some cases, leading to a suspicion that there may be an autoimmune basis
- May be related to symmetric lupoid onychodystrophy, suggesting a common genetic predisposition

(Øvrebø Bohnhorst *et al.*, 2001)

Canine juvenile cellulitis
- Uncommon condition
- One report suggested that 24.4% of Gordon Setter litters were affected, 1985–1988
- Age of onset usually 1–4 months

(Mason & Jones, 1989)

Symmetric lupoid onychodystrophy
- Reported in Gordon Setters in Norway
- One report suggested 12.6% prevalence
- Males over-represented

- Immune-mediated disease, autoimmune basis suspected
- May be related to black hair follicular dysplasia, suggesting a common genetic predisposition

(Øvrebø Bohnhorst *et al.*, 2001; Wilbe *et al.*, 2010b; Dahlgren *et al.*, 2016)

Endocrine conditions

Hypothyroidism

- Breed at increased risk in a case series at the University of Montreal, Canada
- In a Norwegian study of 291 8-year-old Gordon Setters, 2.7% had hypothyroidism
- Mean age 6.4 years

(Scott & Paradis, 1990; Bianchi *et al.*, 2015; Ziener *et al.*, 2015)

Gastrointestinal conditions

Gastric dilatation/volvulus (bloat, GDV)

- Breed at increased risk in a case series based on data from the VMDB, 1980–1989
- OR 4.1 (95% CI 1.8–9.3)

(Glickman *et al.*, 1994)

Musculoskeletal conditions

Elbow dysplasia

- Fragmentation of the medial coronoid process is common in Gordon Setters
- OR 19.8 (95% CI 9.2–42.8) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Hip dysplasia

- OR 2.0 (95% CI 1.4–3.0) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995
- Decreasing prevalence seen in Gordon Setters in a French study
- One study in Norway suggested Gordon Setters that were puppies in spring and summer had a lower incidence than those that were puppies in autumn and winter

(Hanssen, 1991; LaFond *et al.*, 2002; Genevois *et al.*, 2008)

Neurological conditions

Cerebellar degeneration

- Rare
- Autosomal recessive inheritance suspected
- Signs seen at 6 months to 4 years of age
- Affected dogs develop a slowly progressive ataxia

(de Lahunta *et al.*, 1980; Agler *et al.*, 2014)

Lethal astrocytosis

- Rare
- Autosomal recessive inheritance is suspected
- Signs are seen from 3–4 weeks
- Affected puppies have hair abnormalities, progressive weakness and recumbency by 5–6 weeks of age

(Yaeger *et al.*, 2000)

Ocular conditions

Progressive retinal atrophy (PRA)

- Rod–cone degeneration 4
- Affected dogs suffer night blindness progressing to total blindness
- Autosomal recessive inheritance
- Late onset

(Downs *et al.*, 2014a)

Retinopathy (rod–cone dystrophy)

- Affected dogs suffer day blindness

(Good *et al.*, 2016)

GRAND BLEU DE GASCOGNE HOUND

Gastrointestinal conditions

Gastric dilatation/volvulus (bloat, GDV)

- Breed at increased risk in a cross-sectional study of data from a health survey of purebred dogs conducted by questionnaires relating to the 10 years prior to 2004
- Prevalence ratio for GDV mortality was 20.6 (95% CI 5.1–82.1; $p < 0.001$) compared to all other breeds combined
- Prevalence ratio for GDV morbidity was 31.1 (95% CI 11.32–85.45; $p < 0.001$) compared to all other breeds combined

(Evans & Adams, 2010b)

GREAT DANE

Cardiovascular conditions

Atrial fibrillation (AF)

- Breed at increased risk in a North American retrospective study of 109 cases
- Great Danes were over-represented both in the group with AF but no structural or

functional heart disease ($p < 0.05$) and in the group with AF, structural or functional heart disease and ascites or pulmonary oedema ($p < 0.001$)
- Males were over-represented: 80/109 (73.4%; $p < 0.01$)

(Menaut *et al.*, 2005)

Dilated cardiomyopathy (DCM)
- Autosomal dominant inheritance proposed
- In a UK study of a population of 107 Great Danes prevalence was 35.5%
- Males were predisposed
- Median age of onset was 5 years
- Median survival time following diagnosis was 5 weeks for Great Danes in one study
- Hypothyroidism has been seen associated with myocardial failure in some Great Danes. Heart function improved with management of the hypothyroidism

(Meurs *et al.*, 2001; Phillips & Harkin, 2003; Martin *et al.*, 2010; Stephenson *et al.*, 2012)

Mitral valve dysplasia
- Rare
- In one study of 29 dogs with mitral valve dysplasia, 13 were Great Danes

(Liu & Tilley, 1975; Matic, 1988)

Dermatological conditions

Cryptococcosis
See under *Infectious conditions*

Demodicosis
- Great Danes are at increased risk of juvenile-onset, generalized demodicosis: OR 2.6 (95% CI 1.2–5.5) based on a large retrospective case control study of a US practice database
- Juvenile onset was defined as < 18 months old
- Other risk factors associated with demodicosis included pyoderma, short hair and concurrent coccidiosis

(Plant *et al.*, 2011)

Epidermolysis bullosa acquisita
- Rare immune-mediated skin disease seen in humans and dogs
- In a USA-based retrospective study of 20 cases (1994–2014) 11 were Great Danes
- 10 of these were male (intact or neutered)
- Median age was 1.2 years

(Bizikova *et al.*, 2015)

Ichthyosis
- Inherited disorder; mutation in Great Danes has been identified
- Great Danes suffer from a severe form

(Metzger *et al.*, 2015)

Idiopathic sterile granuloma and pyogranuloma
- Uncommon
- No age or sex predisposition
- Great Danes were over-represented compared to the general hospital population in a retrospective study in New York

(Panich *et al.*, 1991)

Endocrine conditions

Hypoadrenocorticism (Addison's disease)
- Great Danes were at increased risk ($p = 0.001$) in a retrospective study of cases at University of Pennsylvania. 7/79 cases were Great Danes, compared to 1/200 dogs in the control population
- Median age was 3.2 years
- Females may be predisposed

(Peterson *et al.*, 1996; Adler *et al.*, 2007)

Hypothyroidism (lymphocytic thyroiditis)
- Breed at increased risk of having thyroglobulin autoantibodies predisposing to lymphocytic thyroiditis
- May occur at a younger age in at-risk breeds (2–3 years)
- Neutered animals (both sexes) at increased risk
- Hypothyroidism has been seen associated with myocardial failure in some Great Danes. Heart function improved with management of the hypothyroidism

(Nesbitt *et al.*, 1980; Haines *et al.*, 1984; Phillips & Harkin, 2003)

Gastrointestinal conditions

Chronic hepatitis
- Breed at increased risk in a UK-based study of 551 cases: OR 4.0 (95% CI 1.9–8.9; $p = 0.004$) compared to a control population
- Median age was 6 years 2 months
- Females were over-represented across the whole study

(Bexfield *et al.*, 2012a)

Gastric dilatation/volvulus (bloat, GDV)
- Highest incidence was found in Great Danes in a prospective cohort study in the USA involving 1914 dogs of 11 large and giant breeds
- Incidence in Great Danes was 53 cases per 1000 DYAR, compared to 26 cases per 1000 DYAR in all giant breeds (>45 kg body weight) and 23 cases per 1000 DYAR in all large breeds (23–45 kg body weight)
- Males slightly over-represented
- Risk increased with age

(Glickman *et al.*, 2000b)

Splenic torsion
- Breed at increased risk in a retrospective series of 102 cases (1992–2014)
- Great Danes accounted for 15 cases (14.7%)

(DeGroot *et al.*, 2016)

Infectious conditions

Cryptococcosis
- Breed at increased risk in case series
- Usually seen in dogs < 4 years
- Living outdoors and exposure to bird droppings are risk factors

(Malik *et al.*, 1995; O'Brien *et al.*, 2004)

Infectious skin diseases
See under *Dermatological conditions*

Musculoskeletal conditions

Calcium phosphate deposition
- Familial disease seen in Great Danes
- Paraplegia and incoordination are seen in very young pups, caused by mineral deposits in the vertebral bodies
- Periarticular and soft-tissue mineralization is also seen

(Woodard *et al.*, 1982)

Hip dysplasia
- Breed at increased risk in case series
- OR 1.6 (95% CI 1.2–2.1) compared to mixed breeds in a large retrospective series based on cases recorded in the VMDB, 1986–1995
- Neutered male dogs predisposed

(LaFond *et al.*, 2002)

Inherited myopathy of Great Danes
- Previously known as central core myopathy
- Rare condition
- Affects dogs < 1 year of age
- Autosomal recessive inheritance likely
- Mutation identified

(Feliu-Pascual *et al.*, 2006; Böhm *et al.*, 2013)

Metaphyseal osteopathy (hypertrophic osteodystrophy)
- Affects dogs aged 2–6 months
- Males may be predisposed
- OR 189.8 (95% CI 82.7–435.6) compared to mixed breeds in a large retrospective series based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.* 2002, Safra *et al.*, 2016)

Osteochondrosis – elbow
- Breed at increased risk in case series
- Males predisposed
- OR 87.0 (95% CI 32.9–230.3) compared to mixed breeds in a large retrospective series based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002; Kirberger & Stander, 2007)

Osteochondrosis – shoulder
- Breed at increased risk in case series
- Males predisposed
- Age of onset usually 4–7 months, but can be older
- OR 32.8 (95% CI 23.8–45.3) compared to mixed breeds in a large retrospective series based on cases recorded in the VMDB, 1986–1995

(Rudd *et al.*, 1990; LaFond *et al.*, 2002)

Osteochondrosis – stifle
- Breed at increased risk in case series
- Males predisposed
- Age of onset usually 5–12 months, but may be earlier
- OR 309.4 (95% CI 123.4–775.5) compared to mixed breeds in a large retrospective series based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Osteosarcoma
See under *Neoplastic conditions*

Panosteitis (enostosis, eosinophilic panosteitis)
- Seen in rapidly growing young dogs
- OR 2.3 (95% CI 1.8–3.0) compared to mixed breeds in a large retrospective series

based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Neoplastic conditions

Osteosarcoma

- Common bone tumour accounting for 85% of primary bone tumours and 5% of all canine neoplasms. Breed at increased risk in several case series
- OR 12.0 (95% CI 5.8–24.5; $p < 0.001$) compared to mixed-breed dogs in a retrospective study of 179 cases seen at the University of Florida, 1996–2005
- Mean age in this study was 7.8 years for the Great Dane
- Across all breeds there was an increased incidence with increasing age, plateauing at 10 years
- Across all breeds there was a slight predisposition for males, but an almost twofold increase for neutered dogs of both sexes
- Breed at high risk of malignant bone tumours in a study of Swedish insurance data (1995–2002). Great Danes had an overall incidence of 45 cases (95% CI 25–65) per 10 000 DYAR, compared to the risk in all dogs combined of 5.5 cases per 10 000 DYAR
- Median age was 7.2 years in Great Danes in this study

(Ru *et al.*, 1998; Egenvall *et al.*, 2007; Rosenberger *et al.*, 2007)

Neurological conditions

Cervical spondylomyelopathy (cervical vertebral malformation, wobbler syndrome)

- Common condition in large and giant breeds
- Breed at increased risk in case series. 15/27 dogs were Great Danes in one USA-based retrospective case series (2000–2012)
- Median age at presentation was 2 years
- Great Danes are predisposed to the osseous form, with C5–C6 and C6–C7 being the most commonly affected locations

(Delamaide Gasper *et al.*, 2014; Martin-Vaquero & da Costa, 2014)

Congenital deafness

- Great Danes homozygous for the merle gene are at increased risk of deafness

(Strain *et al.*, 2009)

Discospondylitis

- Breed at increased risk in a case–control study of 513 USA-based cases (1980–2001)
- Great Danes were at the highest risk: OR 7.3 (95% CI 4.3–12.6) compared to mixed breeds
- Males twice as likely to be affected as females
- Risk increased with age: dogs > 10 years had an OR of 4.1 (95% CI 2.9–5.8)

(Burkert *et al.*, 2005)

Primary orthostatic tremor

- Uncommon condition of unknown cause
- Muscle tremor while standing at rest

(Garosi *et al.*, 2005)

Ocular conditions

Eversion of the cartilage of the nictitating membrane

- Breed at increased risk
- In a study of 12 cases in 10 dogs, 3 were Great Danes
- Seen in young dogs (6–19 months)

(Allbaugh & Stuhr, 2013)

Glaucoma – primary

- Breed at increased risk of glaucoma associated with goniodysgenesis
- Age of onset 1–9 years
- Glaucoma is also seen associated with uveal cysts in Great Danes

(Speiss *et al.*, 1998; Wood *et al.*, 2001, 2004)

Multiple ocular defects

- Congenital
- Seen in homozygous merles with predominantly white coats
- Also referred to as merle ocular dysgenesis
- Defects may include microphthalmia, microcornea, cataract, equatorial staphylomas and retinal dysplasia; these dogs may also be deaf

(Bauer *et al.*, 2015)

Prolapse of the gland of the nictitating membrane ('cherry eye')

- Breed at increased risk in a retrospective review of 155 cases in Europe (2001–2008)
- 75.4% of cases (all breeds) occurred before 1 year of age
- Great Danes are at increased risk of a bilateral occurrence with a short interval between prolapses

(Mazzucchelli *et al.*, 2012)

Uveal cysts
- Great Danes have been found to have uveal cysts associated with glaucoma

(Speiss *et al.*, 1998)

Reproductive conditions

Dystocia
- Breed at increased risk in a retrospective study of Swedish insurance data of 195 931 bitches (1995–2002)
- Incidence in Great Danes was 15.6 cases per 1000 DYAR (eighth-highest), compared to 5.7 cases per 1000 DYAR for the overall population

(Bergström *et al.*, 2006)

GREAT PYRENEES

See *Pyrenean Mountain Dog*

GREATER SWISS MOUNTAIN DOG

See *Swiss Mountain Dog*

GREYHOUND

Cardiovascular conditions

Hypertension
- Breed at increased risk
- In a USA-based cross-sectional study of 47 retired racing Greyhounds, 62% were hypertensive (systolic blood pressure > 160 mmHg)
- One study suggests Greyhounds have an increased risk of ischaemic stroke, which may result from hypertension
- One report suggests that the tendency to higher blood pressure in greyhounds results from the particular profile of eicosanoid metabolites of arachidonic acid which promote vascular dysfunction
- Hypertension may be associated with microalbuminaemia

(Cox *et al.*, 1976; Surman *et al.*, 2012; Kent *et al.*, 2014; Martinez *et al.*, 2016)

Vascular ring anomaly – persistent right aortic arch (PRAA)

See under *Gastrointestinal conditions*

Dermatological conditions

Corns (on the foot pad)
- In a study of 30 cases, 20 were greyhounds
- Males were predisposed (25/30 dogs)
- Corns affected the foot pads of the forelimbs more frequently than those of the hindlimbs
- One study suggested corns may be associated with papilloma virus infection

(Guilliard *et al.*, 2010; Anis *et al.*, 2016)

Cutaneous and renal glomerular vasculopathy
- Uncommon condition with unknown aetiology, also known as Alabama rot
- Affected dogs have cutaneous ulcers on the extremities, thrombocytopenia and acute renal failure
- The condition is often fatal

(Cowan *et al.*, 1997)

Cutaneous neoplasia

See under *Neoplastic conditions*

Pattern baldness (follicular dysplasia, bald thigh syndrome)
- Bilateral hair loss on the caudal thighs
- Cause unknown

(Schoning & Cowan, 2000; Freeman, 2005)

Ventral comedone syndrome
- Common cosmetic syndrome
- Comedones on the ventral thorax

(Burkett, 2000; Freeman, 2005)

Drug reactions

Thiobarbiturates
- Reduced hepatic clearance results in an increased sensitivity to thiobarbiturates in Greyhounds
- Prolonged recovery times are seen
- Use of this drug is not recommended in Greyhounds

(Robinson *et al.*, 1986; Freeman, 2005)

Gastrointestinal conditions

Vascular ring anomaly – persistent right aortic arch (PRAA)
- Inheritance suspected in Greyhounds
- 4/52 cases were Greyhounds in one study
- Symptoms of regurgitation are seen at weaning

(Gunby *et al.*, 2004; Krebs *et al.*, 2014)

Haematological/immunological conditions

Grey eosinophils

- Eosinophils with non-staining granules are common in Greyhounds (53% of 49 Greyhounds in one study)
- This may reflect different staining properties and is of no clinical significance

(Iazbik & Couto, 2005)

Hyperhomocysteinaemia

- Frequent occurrence in Greyhounds
- May be associated with low serum folate and cobalamin (vitamin B_{12})

(Heilmann *et al.*, 2017)

Postoperative bleeding

- Noted frequently in retired Greyhounds. In one study 26% of retired racing Greyhounds were affected, compared to 0–2% in other breeds
- Primary or secondary haemostatic defects are not detected in these cases
- Bleeding may be related to altered fibrinolysis

(Lara-Garcia *et al.*, 2008)

Infectious conditions

Babesiosis

- 46% of Greyhounds from 10 racing kennels in Florida tested positive in one study

(Taboada *et al.*, 1992)

Musculoskeletal conditions

Avulsion of the tibial tuberosity

- Growth plate fracture
- Seen in dogs < 12 months old

(Power, 1976; Skelly *et al.*, 1997)

Distal limb fractures and dislocations

- Common in this breed due to the counter-clockwise direction of racing, the repetitive nature of racing and the track conditions
- Include spontaneous tibial fracture, accessory carpal bone fracture, calcaneoquartal subluxation due to plantar tarsal ligament rupture, calcaneus fracture, central tarsal bone fracture and superficial digital flexor tendon luxation
- Many fractures include or are distal to the carpus and tarsus

(Anderson *et al.*, 1995a, 1995b)

Medial displacement of the biceps brachii tendon

- Uncommon
- Occurs secondary to rupture of the transverse humeral ligament
- Biceps brachii or brachialis tendon avulsions have also been documented as acute injuries in racing Greyhounds

(Boerno & Eaton-Wells, 1995; Schaaf *et al.*, 2009)

Osteosarcoma

See under *Neoplastic conditions*

Polyarthritis

- Erosive
- Affects animals aged 3–30 months
- Distal joints are affected
- Idiopathic

(Huxtable & Davis, 1976; Ralphs & Beale, 2000)

Sacrocaudal fusion

- In a retrospective study of anatomical specimens and x-rays, 41% of 81 racing greyhounds were affected, compared to 15% of 91 non-Greyhound dogs
- Possibly due to selection of greyhounds for speed
- Clinical significance unknown

(Oheida *et al.*, 2016)

Sesamoid disease

- Sesamoid fractures are common in racing greyhounds
- Believed to result from the action of the digital flexor tendon on the sesamoids at high impact

(Harasen, 2009)

Neoplastic conditions

Cutaneous haemangiosarcoma

- Breed at increased risk of cutaneous haemangiosarcoma in a retrospective study of VMDB data, 1964–2002: OR 3.08 (95% CI 1.74–5.45) compared to all other dogs
- Mean age 9.7 years for cutaneous haemangiosarcoma in another study

(Schultheiss, 2004; Villamil *et al.*, 2011)

Osteosarcoma

- Breed at increased risk in a USA-based retrospective case series of 179 dogs
- OR 17.3 (95% CI 9.3–32.1) compared to mixed-breed dogs

- Greyhounds were older at diagnosis than other predisposed breeds. Mean age 9.9 years
- Most common sites: proximal humerus, distal radius and proximal femur
- Also breed at high risk of malignant bone tumours in a study of Swedish insurance data, 1995–2002. Greyhounds had an overall incidence of 30 cases (95% CI 14–46) per 10 000 DYAR, compared to the risk in all dogs combined of 5.5 cases per 10 000 DYAR
- Males over-represented
- Median age was 6.2 years in Greyhounds in this study; risk increases with increasing age

(Egenvall *et al.*, 2007; Rosenberger *et al.*, 2007; Karlsson *et al.*, 2013)

Neurological conditions

Ischaemic stroke

- Breed at increased risk in a retrospective study
- OR 6.6 (95% CI 4.2–10.7) compared to all other breeds combined
- Hypertension is believed to be a contributing factor

(Kent *et al.*, 2014)

Meningoencephalitis

- Seen in Greyhounds in Ireland
- Age at presentation 5–18 months
- No infectious organism found
- Demonstration of an association with the DLA class 2 haplotype suggests an immunogenetic risk

(Shiel *et al.*, 2010a, 2014)

Polyneuropathy

- Seen in juvenile Greyhounds
- Uncommon
- Monogenic autosomal recessive inheritance; mutation identified

(Drögemüller *et al.*, 2008a)

Ocular conditions

Chronic superficial keratitis (pannus)

- Breed at increased risk in case series
- Age of onset 2 years
- Prevalence and severity increase at higher altitude

(Chavkin *et al.*, 1994; Cheng *et al.*, 2016)

Physiological conditions

Biochemical differences

- Several biochemical differences have been noted in normal Greyhounds compared to other breeds
- Reduced serum globulin concentration: IgM and IgA concentrations are significantly lower than other breeds, but IgG is unaffected
- Greyhounds have significantly higher creatinine levels than non-Greyhound dogs. This is believed to be due to their higher muscle mass
- In a retrospective study of 28 675 serum cobalamin tests, Greyhounds had an increased incidence of values below the lower limit of the reference interval (251 ng/l), OR 2.5 (95% CI 2.1–3.1)

(Drost *et al.*, 2006; Clemente *et al.*, 2010; Grützner *et al.*, 2012)

Blood group

- In a study of 206 Greyhounds, 13.1% were DEA-1.1 positive, which was significantly lower than the 66 non-Greyhound dogs, of which 60.6% were positive
- A majority of Greyhounds in the study met the criteria for universal donor

(Iazbik *et al.*, 2010)

Cardiac hypertrophy

- Greyhounds have a higher vertebral heart score (mean 10.5) and thicker left ventricular wall than other breeds
- Additionally, systemic arterial pressure is higher, stroke volume is higher and systemic vascular resistance is lower in racing Greyhounds than non-racing Greyhounds and other breeds

(Pape *et al.*, 1986; Marin *et al.*, 2007)

Haematological differences

- Several haematological differences have been noted in normal Greyhounds compared to other breeds
- Higher haematocrit (packed cell volume, PCV), haemoglobin and red cell counts
- Red blood cells are larger (higher mean corpuscular volume, MCV), and mean red cell haemoglobin concentration (MCHC) is higher
- Total and individual white blood cell counts (WCC) are lower
- Platelet counts are lower

(Shiel *et al.*, 2007b; Campora *et al.*, 2011)

Heart murmur

- Greyhounds commonly have a low-grade left-sided basilar systolic murmur of no clinical significance
- Slightly increased aortic velocities noted

(Fabrizio *et al.*, 2006)

NT-proBNP measurement

- NT-proBNP is a cardiac biomarker elevated in some dogs with congestive heart failure
- Healthy greyhounds have naturally higher levels than healthy non-Greyhound dogs; in one study 946 vs. 632 pmol/l ($p < 0.005$). 46% of greyhounds had levels > 1000 pmol/l in this study

(Couto *et al.*, 2015)

Polyodontia

- Present in 36.4% of dogs in a study of 55 Greyhounds
- Usually the first premolar and usually in the upper arcade

(Dole & Spurgeon, 1998)

Thyroid hormones

- Total T_4 and free T_4 are significantly lower in healthy Greyhounds than in other breeds, leading to lower reference ranges being developed for these values in Greyhounds
- Mean circulating TSH is the same as for other breeds

(Shiel *et al.*, 2007a; Chastain & Panciera, 2002)

Renal and urinary conditions

Renal arteriosclerosis

- Seen with high frequency in young race-trained Greyhounds
- Higher blood pressure and sheer stresses may be contributing factors

(Bjotvedt *et al.*, 1988)

Reproductive conditions

Dystocia

- Breed at increased risk in a study of Swedish insurance data (1995–2002) involving 3894 reimbursed claims for dystocia in an overall population of 195 931 bitches
- Incidence rate for greyhounds was 10.4 per 1000 DYAR, compared to 5.7 per 1000 DYAR for the overall population

(Bergström *et al.*, 2006)

GREYHOUND – SPANISH

See *Spanish Greyhound*

GRIFFON BRUXELLOIS

Neurological conditions

Chiari malformation/syringomyelia

- Breed at increased risk
- In a US prospective study of 84 American Kennel Club registered Griffon Bruxellois dogs, 65% had Chiari malformation, 52% had syringomyelia, 28% had neurologic deficits and 20% had neck pain

(Rusbridge *et al.*, 2009; Freeman *et al.*, 2014)

Ocular conditions

Cataract

- Prevalence of primary cataract 5.41%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)
- Prevalence decreased over the 40 years of the study
- Trend towards an increased number of males affected

(Gelatt & MacKay, 2005)

Vitreoretinopathy

- Vitreal liquefaction predisposes to retinal detachment in Griffon Bruxellois dogs

(Papaioannou & Dubielzig, 2013)

HAMILTON HOUND (HAMILTONSTÖVARE)

Endocrine conditions

Diabetes mellitus

- Breed at increased risk in a retrospective review of Swedish insurance data, 1995–2004
- Incidence in the Hamilton Hound was 29 cases per 10 000 DYAR, compared to an overall incidence for all breeds of 13 cases per 10 000 DYAR
- Females at significantly increased risk

(Fall *et al.*, 2007)

Neurological conditions

Idiopathic epilepsy

- Breed at increased risk of mortality due to epilepsy in a retrospective review of Swedish insurance data, 1995–2006
- Mortality rate in the Hamilton Hound was 24.9 cases per 10 000 DYAR, compared to an

overall incidence for all breeds of 11 cases per 10 000 DYAR
- Males at increased risk (1.4:1) across all breeds

(Heske *et al.*, 2014)

HAVANESE

Cardiovascular conditions

Heart murmur

- One study suggests Havanese are predisposed to heart murmurs, though detail for the underlying cause is lacking

(Starr *et al.*, 2007)

Dental conditions

Abnormal dentition

- May be inherited alongside cataracts, cardiac abnormalities and osteochondrodysplasia

(Starr *et al.*, 2007)

Dermatological conditions

Sebaceous adenitis

- 35% of Havanese dogs were affected in a retrospective study of dogs presented at a dermatology referral service in the USA
- Seen in young adults

(Frazer *et al.*, 2011; Bensignor & Guaguere, 2012)

Gastrointestinal conditions

Congenital portosystemic shunt

- Breed at increased risk in a retrospective case study of 2400 cases from VMDB data (1980–2002)
- OR 64.9 (95% CI 8.9–234.3) compared to mixed-breed dogs
- Female:male ratio was 1.14:1 across all breeds
- Clinical signs are usually seen in young dogs < 1 year
- Extrahepatic shunts more common in the Havanese

(Tobias & Rohrbach, 2003; Starr *et al.*, 2007)

Musculoskeletal conditions

Osteochondrodysplasia

- May be inherited alongside cataracts, cardiac abnormalities and abnormal dentition

(Starr *et al.*, 2007)

Various skeletal defects

- Including bowed forelimbs, avascular necrosis of the femoral head (Legg–Calvé–Perthes disease), patellar luxation: suggested as frequent findings in one study

(Starr *et al.*, 2007)

Ocular conditions

Cataract

- Prevalence of primary cataract 11.57%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)
- May be inherited alongside osteochondrodysplasia, cardiac abnormalities and abnormal dentition

(Gelatt & MacKay, 2005; Starr *et al.*, 2007)

Vitreoretinopathy

- Vitreal liquefaction predisposes to retinal detachment in Havanese dogs

(Papaioannou & Dubielzig, 2013)

Reproductive conditions

Dystocia

- Breed at increased risk in a retrospective study of Swedish insurance data (195 931 bitches, 1995–2002)
- Incidence in Havanese dogs was 12.2 cases per 1000 DYAR, compared to 5.7 cases per 1000 DYAR in the overall population

(Bergström *et al.*, 2006)

HOKKAIDO

Ocular conditions

Collie eye anomaly

- Inherited; mutation identified
- In a study of 17 Hokkaido dogs, 5 were affected and 12 were heterozygous carriers

(Mizukami *et al.*, 2012)

HOVAWART

Dermatological conditions

Sebaceous adenitis

- Breed suggested to be at increased risk in a number of studies

(Linek *et al.*, 2005; Lortz *et al.*, 2010)

Endocrine conditions

Hypothyroidism (lymphocytic thyroiditis)

- Heritability described as moderate to high in one study of Finnish Hovawarts

- High levels of autoantibodies to thyroglobulin found in 12.6% of this breed, predisposing to autoimmune lymphocytic thyroiditis

(Ferm *et al.*, 2009; Bianchi *et al.*, 2015; Ahlgren & Uimari, 2016)

Gastrointestinal conditions

Intestinal adenocarcinoma

- In a Czech study of gastrointestinal biopsies, Hovawart dogs were found to be predisposed to intestinal adenocarcinoma ($p < 0.05$)
- Age at risk (across all affected breeds) was 7–8 years

(Frgelecová *et al.*, 2013)

Haematological/immunological conditions

Selective IgA deficiency

- Breed at increased risk in case series
- 32% of 19 Hovawarts were found to have low serum IgA (<0.07 g/l) in one 2014 study
- Immunodeficiency is associated with recurrent infections of mucosal sites and increased susceptibility to immune-mediated disease

(Olsson *et al.*, 2014)

Musculoskeletal conditions

Bone tumour

See under *Neoplastic conditions*

Neoplastic conditions

Bone tumour

- Breed at high risk of malignant bone tumours in one study of Swedish insurance data (1995–2002). Hovawarts had an overall incidence of 28 cases (95% CI 12–43) per 10 000 DYAR, compared to the risk in all dogs combined of 5.5 cases per 10 000 DYAR
- Males over-represented
- Median age was 6.9 years in Hovawarts, risk increases with increasing age

(Egenvall *et al.*, 2007)

Intestinal adenocarcinoma

See under *Gastrointestinal conditions*

Neurological conditions

Degenerative myelopathy

- Breed at increased risk in a retrospective Swiss study of 50 cases
- OR 44.1 (95% CI 17.9–108.7; $p < 0.0001$) compared to the overall hospital population
- Mean age at diagnosis across all breeds was 9.1 years

(Kathmann *et al.*, 2006)

HUNGARIAN KUVASZ

Endocrine conditions

Hypothyroidism (lymphocytic thyroiditis)

- Breed with a higher prevalence of thyroid hormone autoantibodies (THAA)
- In a cohort study of 287 948 serum samples from dogs in the USA with clinical signs of hypothyroidism, Kuvasz had an OR of 2.18 ($p = 0.001$) of being affected compared to dogs of all other breeds
- Across the study, females were over-represented and the highest prevalence was in dogs 2–4 years old

(Nachreiner *et al.*, 2002)

Musculoskeletal conditions

Hip dysplasia

- Breed at increased risk
- OR 10.2 (95% CI 4.3–23.9) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995
- Neutered male dogs predisposed

(LaFond *et al.*, 2002)

Osteochondrosis – shoulder

- Breed at increased risk
- OR 29.1 (95% CI 12.8–66.3) compared to mixed breeds in a large retrospective case series based on cases recorded in the VMDB, 1986–1995
- Males predisposed
- Age of onset usually 4–7 months, but can be older

(Rudd *et al.*, 1990; LaFond *et al.*, 2002)

Neurological conditions

Degenerative myelopathy

- Breed at increased risk in case series ($p < 0.05$)
- Mean age at diagnosis across breeds was 9.1 years

(Kathmann *et al.*, 2006)

Lumbosacral disease

- Breed at increased risk in case series
- Average age of onset across all breeds was 6.3 years

(Jaggy *et al.*, 1987)

HUNGARIAN PULI (HUNGARIAN WATER DOG)

Neoplastic conditions

Mammary neoplasia

- In a Hungarian study of 521 cases, Pulis were over-represented
- The number of mammary tumours was found to be highest in spring and autumn

(Boldizsar *et al.*, 1992)

Ocular conditions

Cataract

- Prevalence of primary cataract 3.40%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005)

HUNGARIAN VIZSLA

Dermatological conditions

Atopic dermatitis (atopy)

- Breed at increased risk in Swiss and Hungarian case series compared to the general population
- Inheritance suspected

(Tarpataki *et al.*, 2006; Picco *et al.*, 2008; Jaeger *et al.*, 2010)

Cutaneous neoplasia

See under *Neoplastic conditions*

Demodicosis

- Vizsla was described as a predisposed breed in a Swedish study

(Holm, 2003)

Sebaceous adenitis

- Uncommon condition
- Affects young to middle-aged dogs
- Vizslas have been seen with a severe ulcerative form affecting the pinnae

(Zur & Botero-Anug, 2011; Bensignor & Guaguere, 2012)

Urticaria

- Over-represented breed in a Swiss study of 24 cases
- Females over-represented across all breeds 2.4:1

(Rostaher *et al.*, 2017)

Haematological/immunological conditions

Haemophilia A

- Severe factor VIII deficiency is seen in Vizslas

(Brooks, 1999)

Immune-mediated haemolytic anaemia (IMHA)

- Breed at increased risk in an Australian retrospective study of 110 cases: OR 10.0 (95% CI 1.3–74.7)

(McAlees, 2010)

Musculoskeletal conditions

Hip dysplasia

- In a study of data from the Belgian Kennel club (2002–2006), prevalence in the Vizsla was 38%, compared to an overall prevalence of 20%

(Coopman *et al.*, 2008)

Polymyopathy

- Uncommon condition. Immune-mediated aetiology suspected
- Dogs present with dysphagia, regurgitation and temporal muscle atrophy
- Mean age of onset 2.4 years
- Male dogs slightly over-represented

(Massey *et al.*, 2013; Tauro *et al.*, 2015)

Neoplastic conditions

Lymphoma

- Breed at increased risk in case series: OR 2.7 (95% CI 2.0–3.5) compared with a US referral population

(Villamil *et al.*, 2009)

Mast cell tumour (MCT)

- Breed at increased risk of cutaneous MCTs in a retrospective study of VMDB data, 1964–2002: OR 4.84 (95% CI 3.23–7.25) compared to all other dogs
- Risk higher in neutered dogs

(Villamil *et al.*, 2011; Zink *et al.*, 2014)

Melanoma

- Breed at increased risk of cutaneous melanoma in a retrospective study of VMDB data, 1964–2002: OR 17.34 (95% CI 11.21–26.83) compared to all other dogs

(Villamil *et al.*, 2011)

Neoplasia – overall

- Hungarian Wire-haired Vizsla had the third-highest proportional mortality from cancer

among pedigree breeds in the UK: 46.7% (95% CI 21.4–71.9)

(Adams *et al.*, 2010)

Neurological conditions

Idiopathic epilepsy

- Partial onset seizure disorder seen in the Vizsla
- Inherited as an autosomal recessive trait

(Patterson *et al.*, 2003; Ekenstedt *et al.*, 2011)

Ocular conditions

Glaucoma – primary

- Breed at increased risk in a retrospective Swiss study of 129 cases (1995–2009)
- Mean age of onset in the Vizsla was 10.6 years
- M:F ratio 1:1.7

(Strom *et al.*, 2011a)

HUNGARIAN WATER DOG

See *Hungarian Puli*

HUSKY

See *Alaskan Husky; Siberian Husky*

IRISH RED AND WHITE SETTER

Gastrointestinal conditions

Gastric dilatation/volvulus (bloat, GDV)

- Breed at increased risk in a cross-sectional study of data from a health survey of purebred dogs conducted by questionnaires relating to the 10 years prior to 2004
- Prevalence ratio for GDV mortality was 3.3 (95% CI 2.0–5.5; $p < 0.001$) compared to all other breeds combined

(Evans & Adams, 2010b)

Haematological/immunological conditions

Canine leucocyte adhesion deficiency (CLAD)

- Autosomal recessive inheritance
- 13% of Irish Red and White Setters tested in one study were found to be carriers of the mutation

(Debenham *et al.*, 2002; Foureman *et al.*, 2002)

IRISH SETTER (IRISH RED SETTER)

Cardiovascular conditions

Patent ductus arteriosus

- The Irish Setter is often suggested to be predisposed, but not all studies confirm this
- Females predisposed

(Matic, 1988; Darke, 1989; Oliveira *et al.*, 2011)

Vascular ring anomaly – persistent right aortic arch (PRAA)

- The Irish Setter is often suggested to be predisposed, but not all studies confirm this

See also under *Gastrointestinal conditions*

(Matic, 1988; Krebs *et al.*, 2014)

Dermatological conditions

Anal furunculosis (perianal fistula)

- Breed at increased risk in a number of case series
- Middle-aged dogs are predisposed; mean age in one study was 5.2 years
- In the same study males were over-represented (2:1) and intact dogs of both sexes were at increased risk compared with their neutered counterparts

(Killingsworth *et al.*, 1988; Day & Weaver, 1992)

Atopic dermatitis (atopy)

- Breed at increased risk in a US series of 268 cases (1981–1984)
- Also reported as a breed at increased risk (OR 2.2 compared to the general hospital population) in a US study of 383 cases
- Some studies show no sex predilection, others show females predisposed

(Scott, 1981; Schick & Fadok, 1986)

Cutaneous neoplasia

See under *Neoplastic conditions*

Endocrine conditions

Hypothyroidism

- Breed at increased risk in a North American study of 3206 cases (1964–1978)
- In another large US study the Irish Setter was in the top five breeds affected, with an incidence of 7.69% compared to an incidence of 1.54% in mixed breeds

- May occur at a younger age in breeds at risk (2–3 years)

(Nesbitt *et al.*, 1980; Milne & Hayes, 1981; Bellumori *et al.*, 2013)

Insulinoma

- Uncommon condition
- In a retrospective study of 73 cases, 7 were Irish Setters
- Middle-aged/older dogs affected. Average age across all breeds was 9.1 years in one study

(Kruth *et al.*, 1982; Caywood *et al.*, 1988)

Gastrointestinal conditions

Acquired megaoesophagus

- Breed at increased risk in case series
- Megaoesophagus can be idiopathic or secondary to peripheral neuropathies, myasthenia gravis, oesophagitis and chronic or recurrent gastric dilatation

(Gaynor *et al.*, 1997)

Gastric dilatation/volvulus (bloat, GDV)

- Breed at increased risk in many case series
- In one retrospective study of 1934 cases recorded in the VMDB (1980–1989), OR 3.5 (95% CI 2.4–5.0)
- Risk increases with higher thoracic depth: width ratios
- Risk increases by 33% with each year of age
- In a cross-sectional study of data from a health survey of purebred dogs conducted by questionnaires relating to the 10 years prior to 2004, prevalence ratio for GDV morbidity was 12.6 (95% CI 9.31–17.06; $p < 0.0001$) compared to all other breeds combined, making the Irish Setter one of the four breeds with highest morbidity. Prevalence ratio for GDV mortality was also increased at 2.3 (1.5–3.4; $p < 0.001$) compared to all other breeds combined

(Glickman *et al.*, 1994; Schellenberg *et al.*, 1998; Evans & Adams, 2010b)

Gluten-sensitive enteropathy

- Autosomal recessive inheritance
- Clinical signs develop at 4–7 months

(Batt *et al.*, 1984; Garden *et al.*, 2000)

Vascular ring anomaly – persistent right aortic arch (PRAA)

- Clinical signs appear at the time of weaning
- Not all studies suggest a predisposition
- In one study of 44 cases, 5 were Irish Setters

(Matic, 1988; Buchanan, 2004)

Haematological/immunological conditions

Canine leucocyte adhesion deficiency (CLAD)

- Autosomal recessive inherited mutation
- Frequency of carriers of the mutation in Germany was estimated at 11%

(Kijas *et al.*, 2000; Pfeiffer & Brenig, 2005)

Haemophilia A

- Factor VIII deficiency
- X-linked recessive inheritance

(Brooks, 1999)

Musculoskeletal conditions

Irish Setter hypochondroplasia

- Rare condition
- Inherited as an autosomal recessive trait

(Hanssen *et al.*, 1998)

Metaphyseal osteopathy (hypertrophic osteodystrophy)

- Affects dogs aged 2–6 months
- Males may be predisposed
- OR 14.3 (95% CI 5.6–36.7) compared to mixed-breed dogs in a large retrospective case series based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002; Safra *et al.*, 2016)

Osteosarcoma

See under *Neoplastic conditions*

Neoplastic conditions

Insulinoma

See under *Endocrine conditions*

Melanoma

- Breed at increased risk of cutaneous melanoma in a retrospective study of VMDB data, 1964–2002: OR 2.23 (95% CI 1.47–3.38) compared to all other dogs

(Villamil *et al.*, 2011)

Osteosarcoma

- Breed at increased risk in a number of case series
- OR 3.5 (95% CI 2.5–4.8) compared to German Shepherd Dogs in a retrospective study of VMDB data, 1980–1994
- Across all breeds there was an increased risk with increasing age, plateauing at 10 years

- Across all breeds there was a slight predisposition for males, but an almost twofold increase for neutered dogs of both sexes

(Heyman *et al.*, 1992; Ru *et al.*, 1998)

Neurological conditions

Amblyopia and quadriplegia

- Rare condition – no recent reports in the literature
- Autosomal recessive inheritance
- Congenital paralysis and blindness with no visible ocular cause (amblyopia)

(Palmer *et al.*, 1973; Sakai *et al.*, 1994)

Cerebellar hypoplasia

- Rare congenital condition. The Irish Setter is one of the few breeds in which it is reported
- Seen with lissencephaly in Irish Setters

(Coates *et al.*, 2002; Heckler *et al.*, 2011)

Degenerative myelopathy

- Overall prevalence among all dogs in the VMDB (1990–1999) was 0.19%; prevalence for the Irish Setter over the same period was 0.68%

(Coates *et al.*, 2007)

Globoid cell leucodystrophy (Krabbe disease)

- Rare condition. The Irish Setter is one of the few breeds in which it is reported
- Signs develop by 3 months of age

(McGraw & Carmichael, 2006)

Idiopathic epilepsy

- Irish Setters have been described as being predisposed to both cluster seizures and refractory epilepsy

(Raw & Gaskell, 1985; Forrester *et al.*, 1989)

Lissencephaly

- Rare congenital condition. The Irish Setter is one of the few breeds in which it is reported
- Seen with cerebellar hypoplasia in Irish Setters

(Coates *et al.*, 2002; Heckler *et al.*, 2011)

Ocular conditions

Amblyopia (seen with quadriplegia)

See under *Neurological conditions*

Progressive retinal atrophy (PRA)

- Autosomal recessive inheritance
- Rod–cone dysplasia type I (rcd1)
- Early onset; most dogs are blind at 6 months old
- A second form of PRA, occurring at 4–5 years, may be seen in this breed (late-onset PRA or rcd4)

(Aguirre & Rubin, 1975; Downs *et al.*, 2014a)

Renal and urinary conditions

Urethral sphincter mechanism incompetence

- Breed at increased risk in a case series (3/30 cases were Irish Setters in one study)
- Neutered females predisposed

(Holt & Thrusfield, 1993; Martinoli *et al.*, 2014)

Respiratory conditions

Laryngeal paralysis–polyneuropathy syndrome

- Idiopathic
- Males are more commonly affected, 2.4:1 in one study
- May be inherited by an autosomal dominant mode

(White, 1989; Burbidge, 1995)

IRISH TERRIER

Cardiovascular conditions

Aortic stenosis – subaortic stenosis (SAS)

- Irish terriers were in the top five breeds affected in a large USA-based retrospective case study of 90 004 dogs presented to a university teaching hospital. 3.13% of Irish Terriers were affected, compared to 0.15% of mixed breeds

(Oliveira *et al.*, 2011; Bellumori *et al.*, 2013)

Dermatological conditions

Footpad hyperkeratosis

- Age of onset 6 months
- Autosomal recessive inheritance

(Binder *et al.*, 2000; Drögemüller *et al.*, 2014)

Musculoskeletal conditions

Muscular dystrophy – X-linked

- Rare condition – occurs in Irish Terriers

(Wentink *et al.*, 1972; Shelton, 1999)

Renal and urinary conditions

Familial renal disease (familial nephropathy)

- Irish Terriers have been reported with tubular transport dysfunction

(Picut & Lewis, 1987a)

Urolithiasis – cystine

- Sex-linked inheritance is suggested
- Young dogs are affected (2–5 years)

- Almost all cases are male
- In one study of 1731 calculi in West Germany, 10 Irish Terriers were included; all had cystine calculi and all were male

(Tsan *et al.*, 1972; Lewis & Morris, 1984; Hesse, 1990)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- Breed at increased risk in case series
- Common disease of older entire bitches (mean age 7.25 years)
- Most cases present within 12 weeks of oestrus

(Chastain *et al.*, 1999; Smith, 2006)

IRISH WATER SPANIEL

Dermatological conditions

Pattern baldness (follicular dysplasia)

- Dominant mode of inheritance suggested
- Dietary factors may play a role
- Hair loss begins at 2–4 years of age, and occurs mainly on the flanks
- Hair loss is due to fracture of the hair in Irish Water Spaniels
- Eventually the whole of the trunk is involved

(Cerundolo *et al.*, 2000)

IRISH WOLFHOUND

Cardiovascular conditions

Atrial fibrillation (AF)

- One study suggested 10.5% of the breed are affected
- Often associated with dilated cardiomyopathy (DCM), but in one study rhythm disturbances without evidence of DCM were found in 48/500 Irish Wolfhounds presented for examination at a cardiology practice
- Ventricular premature complexes may also be seen in this breed

(Vollmar, 2000; Menaut *et al.*, 2005)

Dilated cardiomyopathy (DCM)

- Irish wolfhounds were in the top five breeds affected in a large USA-based retrospective case study of 90 004 dogs presented to a university teaching hospital. 6.08% of Irish Wolfhounds were affected, compared to 0.16% of mixed breeds
- Prevalence increases with increasing age
- Approximately twice as common in males as females
- Inheritance does not follow a simple pattern but involves multiple loci

(Vollmar, 2000; Philipp *et al.*, 2012; Bellumori *et al.*, 2013)

Gastrointestinal conditions

Congenital portosystemic shunt

- Breed at increased risk in case series; digenic inheritance suspected
- Clinical signs usually seen in young dogs < 1 year
- Shunts are usually intrahepatic in the Irish Wolfhound
- Irish Wolfhound puppies may have a transient asymptomatic hyperammonaemia at 6–8 weeks in the absence of a portosystemic shunt. Ammonia levels normalize by 4 months

(Hunt, 2004; Zandvliet & Rothuizen, 2007; van Steenbeek *et al.*, 2009)

Gastric dilatation/volvulus (bloat, GDV)

- Breed at increased risk in a cross-sectional study of data from a health survey of purebred dogs conducted by questionnaires relating to the 10 years prior to 2004
- Prevalence ratio for GDV mortality was 4.5 (95% CI 2.6–7.7; $p < 0.001$) compared to all other breeds combined

(Evans & Adams, 2010b)

Haematological/immunological conditions

Immunodeficiency syndrome

See under *Respiratory conditions* (*Rhinitis/bronchopneumonia*)

von Willebrand's disease (vWD)

- Irish Wolfhounds suffer from type I disease, but do not seem to exhibit a clinical bleeding tendency

(Clark & Parry, 1995; Brooks, 1999)

Musculoskeletal conditions

Bone tumour

See under *Neoplastic conditions*

Elbow dysplasia

- Breed at increased risk of fragmentation of the medial coronoid process: OR 93.4 (95% CI 39.6–220.3) compared to mixed-breed dogs in

a large retrospective study based on cases recorded in the VMDB, 1986–1995
(LaFond *et al.*, 2002; Clements *et al.*, 2007)

Hip dysplasia
- Breed incidence of 10% in one study in Norway
- Incidence is affected by growth rate and exercise

(Krontveit & Moe, 2013)

Osteochondrosis – shoulder
- Males predisposed, 2.24:1 in one study
- Age of onset is usually 4–7 months, but can be older
- OR 47.1 (95% CI 26.4–84.0) compared to mixed-breed dogs in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(Rudd *et al.*, 1990; LaFond *et al.*, 2002)

Osteochondrosis – stifle
- Age of onset usually 5–12 months, but may be earlier
- OR 523.5 (95% CI 165.6–1655.0) compared to mixed-breed dogs in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Panosteitis (enostosis, eosinophilic panosteitis)
- Young males predisposed
- OR 2.3 (95% CI 1.2–4.2) compared to mixed-breed dogs in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Neoplastic conditions
Bone tumour
- Irish Wolfhounds had the highest risk of malignant bone tumours in one study of Swedish insurance data (1995–2002). Irish Wolfhounds had an overall incidence of 99 cases (95% CI 59–160) per 10 000 DYAR, compared to 5.5 cases per 10 000 DYAR for all breeds combined
- Males over-represented
- Mean age was 6.6 years in Irish Wolfhounds; the risk increases with increasing age

(Egenvall *et al.*, 2007; Anfinsen *et al.*, 2011; Karlsson *et al.*, 2013)

Neurological conditions
Idiopathic epilepsy
- Suspected to be inherited as an autosomal recessive trait with incomplete penetrance
- One 2006 report suggested that the risk is increasing in Irish Wolfhounds
- In a retrospective study, idiopathic epilepsy was diagnosed in 18.3% of 796 Irish Wolfhounds
- Males were at increased risk (61.6% were male)
- First seizure occurred by 3 years of age in 73% of cases

(Casal *et al.*, 2006)

Ocular conditions
Progressive retinal atrophy (PRA)
- Autosomal recessive inheritance
- Early onset. Blindness at 2–3 years of age

(Gould *et al.*, 1997)

Reproductive conditions
Dystocia
- Breed at increased risk in a retrospective study of Swedish insurance data (195 931 bitches 1995–2002)
- Incidence in Irish Wolfhounds was 16.5 cases per 1000 DYAR, compared to 5.7 cases per 1000 DYAR for the general population

(Bergström *et al.*, 2006)

Low fertility
- High incidence of low libido, small testicles and poor semen quality in Irish Wolfhounds

(Dahlbom *et al.*, 1997)

Respiratory conditions
Aspiration pneumonia
- High incidence noted in Irish Wolfhounds at one referral hospital in Australia
- The overall hospital incidence was 0.5%. Irish Wolfhounds had the highest breed incidence, with 9/25 dogs affected

(Greenwell & Brain, 2014)

Rhinitis/bronchopneumonia syndrome
- Uncommon
- Many but not all cases have been < 1 year old
- Seen in Europe and North America
- Underlying cause is unclear; cell-mediated immunodeficiency, low levels of IgA, and primary ciliary dyskinesia have all been investigated with no conclusion drawn

(Wilkinson, 1969; Leisewitz *et al.*, 1997; Clercx *et al.*, 2003)

ITALIAN GREYHOUND

Dermatological conditions

Colour dilution alopecia

- Affects blue Italian Greyhounds
- Onset at 4–18 months, the condition starts at the dorsal midline

(Jae *et al.*, 2005)

Cutaneous neoplasia

See under *Neoplastic conditions*

Endocrine conditions

Multiple autoimmune diseases syndrome

- Resembles autoimmune polyendocrine syndrome type 2 (APS-2) in humans
- Seen in Italian Greyhounds in the USA
- Affects mainly glandular tissue, e.g. adrenals, thyroid, pancreas, gonads and skin
- Females are over-represented
- Typically occurs in middle age

(Pedersen *et al.*, 2012a, 2015)

Gastrointestinal conditions

Enamel hypoplasia

- Enamel is roughened and thinnish with brownish mottling
- Permanent and deciduous teeth uniformly affected
- Prevalence 14%, familial

(Gandolfi *et al.*, 2013)

Haematological/immunological conditions

Grey eosinophils

- Eosinophils with clear granules
- Detected in 34.5% of Italian Greyhounds in one study
- Some haematology analysers may not count or may underestimate grey eosinophils

(Giori *et al.*, 2011)

Neoplastic conditions

Cutaneous haemangiosarcoma

- Breed at increased risk in a case series of non-visceral haemangiosarcomas
- Mean age 9.7 years

(Schultheiss, 2004)

Ocular conditions

Cataract

- Prevalence of primary cataract 2.42%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005)

Vitreal syneresis

- Breed at increased risk, familial
- May result in anterior displacement of the vitreous, and glaucoma
- May also predispose to retinal detachment

(Papaioannou & Dubielzig, 2013)

Physiological conditions

Alanine aminotransferase (ALT) levels

- Higher in Italian Greyhounds than other sight hounds

(Uhriková *et al.*, 2013)

ITALIAN MASTIFF (CANE CORSO)

Musculoskeletal conditions

Hip dysplasia

- In a French retrospective study over 14 years (1993–2006), of the 31 breeds represented by at least 100 affected dogs, the Italian Mastiff had the highest prevalence (59.7%)

(Genevois *et al.*, 2008)

Ocular conditions

Prolapse of the gland of the nictitating membrane ('cherry eye')

- Breed at increased risk in a retrospective review of 155 cases in Europe, 2001–2008
- 75.4% cases (across all breeds) occurred before 1 year of age
- Italian Mastiffs are at increased risk of bilateral occurrence, with a short interval between prolapses

(Mazzucchelli *et al.*, 2012)

ITALIAN SPINONE (SPINONE ITALIANO)

Neoplastic conditions

Neoplasia – overall

- Italian Spinone had the sixth-highest proportional mortality from cancer among pedigree breeds in the UK: 44.7% (95% CI 30.5–58.9)

(Adams *et al.*, 2010)

Neurological conditions

Idiopathic epilepsy

- Breed at increased risk in case series
- Prevalence of 5.3% (95% CI 4.03–6.57%) among Italian Spinone registered with the UK Kennel Club, compared to an estimated prevalence of 0.6% in the UK general dog population
- Can be severe in this breed. Early and aggressive treatment may improve survival

(Kearsley-Fleet *et al.*, 2013; De Risio *et al.*, 2015)

Spinocerebellar ataxia (hereditary ataxia)

- Autosomal recessive inheritance
- A GAA repeat expansion in intron 35 ITPR1 identified in Italian Spinone in the UK
- Progressive ataxia, tremors and hypermetria seen from 4 months, usually leading to death or euthanasia by 1 year of age due to an inability to walk

(Forman *et al.*, 2015)

JACK RUSSELL TERRIER

Behavioural conditions

Aggression

- Breed scoring highly for aggression towards both people and other dogs in a study based on Canine Behavioural Assessment and Research Questionnaires (C-BARQ) completed by owners in the USA

(Duffy *et al.*, 2008)

Dermatological conditions

Black hair follicular dysplasia

- Thought to be inherited as an autosomal recessive trait
- Changes usually seen by 4 weeks of age

(Schmutz *et al.*, 1998)

Demodicosis

- Jack Russell Terriers are at increased risk of juvenile-onset, generalized demodicosis compared to a control hospital population: OR 1.6 (95% CI 1.019–2.4) based on a large retrospective case–control study of a US practice database
- Juvenile onset was defined as < 18 months old
- Other risk factors associated with demodicosis included pyoderma, short hair and concurrent coccidiosis

(Plant *et al.*, 2011)

Dermatophytosis (ringworm)

- No sex predisposition
- Dogs < 1 year old predisposed

(Sparkes et al., 1993)

Ichthyosis

- Autosomal recessive inheritance
- Causative mutation identified

(Credille *et al.*, 2009; Hartley *et al.*, 2012)

Vasculitis

- Alopecia and ulcers of the extremities and bony prominences resembling dermatomyositis of Collies and Shetland Sheepdogs

(Parker & Foster, 1996)

Drug reactions

Vaccine-associated adverse effect

- In a large retrospective study in the USA (2002–2003) Jack Russell Terriers had a mean rate of 54.4 adverse reactions per 10 000 dogs vaccinated, compared to an overall rate of 38.2 reactions per 10 000 dogs vaccinated
- Risk seemed to decrease with increasing body weight

(Moore *et al.*, 2005)

Endocrine conditions

Hyperadrenocorticism (Cushing's syndrome)

- In a retrospective study of data from UK first-opinion practice (VetCompass) Jack Russell Terriers had an OR of 1.6 (95% CI 1.0–2.5) compared to mixed breeds
- Dogs > 12 years were at higher risk (OR 5.7) compared to dogs aged 6–8.9 years

(O'Neill *et al.*, 2016d)

Gastrointestinal conditions

Chronic hepatitis

- In a UK-based study of 200 post-mortem samples of liver, Jack Russell Terriers were found to have an increased risk ratio of 3.6 (95% CI 1.3–10.1)

(Watson *et al.*, 2010)

Congenital portosystemic shunt

- Breed at increased risk in case series in the UK and Australia
- Clinical signs usually seen in young dogs < 1 year
- Usually extrahepatic in Jack Russell Terriers

(Hunt, 2004; Adam *et al.*, 2012)

Haematological/immunological conditions

Haemophilia B

- Factor IX deficiency
- X-linked recessive inheritance

(Brooks, 1999)

Severe combined immunodeficiency

- Inherited as an autosomal recessive trait

(Meek *et al.*, 2001; Bell *et al.*, 2002)

Musculoskeletal conditions

Congenital myasthenia gravis

See under *Neurological conditions*

Myokymia and neuromyotonia

- Hereditary
- Age of clinical onset reported as 2 months to 3 years
- Myokymia (rippling muscle contractions), neuromyotonia (muscle stiffness) and hyperthermia are seen in affected dogs
- May be associated with hereditary ataxia
- Multiple forms may exist

(Hartley & Palmer, 1973; Vanhaesebrouck *et al.*, 2010; Bhatti *et al.*, 2011; Gilliam *et al.*, 2014)

Neurological conditions

Congenital deafness

- Prevalence in Jack Russell Terriers 3.57% (unilateral) and 0.5% (bilateral) in one study
- Significant association with white coat colour

(Comito *et al.*, 2012)

Congenital myasthenia gravis

- Autosomal recessive inheritance suspected
- Rare
- Age of clinical onset: 2–6 months

(Wallace & Palmer, 1984; Wilkes *et al.*, 1987; Shelton, 1999)

Paroxysmal dyskinesia

- Breed at increased risk in one study
- Median age at onset of 23 Jack Russell Terriers was 4 years and 8 months; 15 of the 23 were male

(Lowrie & Garosi, 2016)

Spinocerebellar ataxia (hereditary ataxia)

- Age of clinical onset reported as 2 months to 3 years
- Symptoms include ataxia, hypermetria and seizures
- Myokymia, neuromyotonia and hyperthermia may be associated with hereditary ataxia (see under *Musculoskeletal conditions*)
- Multiple forms may exist

(Hartley & Palmer, 1973; Wessmann *et al.*, 2004; Vanhaesebrouck *et al.*, 2010; Bhatti *et al.*, 2011; Gilliam *et al.*, 2014)

Steroid-responsive meningitis–arteritis (SRMA)

- Breed at increased risk in case series
- OR 6.91 (95% CI 2.2–22.66; $p = 0.001$) in a retrospective UK-based case–control study
- Age of onset 3 month to 9 years

(Rose *et al.*, 2014)

Ocular conditions

Cataract

- Prevalence of primary cataract 2.26%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005; Oberbauer *et al.*, 2008)

Glaucoma – primary

- Breed at increased risk compared to the overall population of dogs in a retrospective study of 9778 dogs with primary glaucoma from the VMDB, 1964–2002
- Prevalence was 1.37% in Jack Russell Terriers for the years 1994–2002, compared to an overall prevalence in all dogs of 0.89% over the same period
- Prevalence was 1.31% in Jack Russell Terriers for the years 1984–1993, compared to an overall prevalence in all dogs of 0.76% over the same period

(Gelatt & MacKay, 2004a)

Glaucoma – secondary

- Breed at increased risk of glaucoma secondary to lens luxation

(Strom *et al.*, 2011b)

Lens luxation – primary

- Inherited; mutation identified
- Age of onset: 3–6 year

(Oberbauer *et al.*, 2008; Gould *et al.*, 2011)

Renal and urinary conditions

Urolithiasis – calcium oxalate

- Breed at increased risk. OR 2.33 (95% CI 2.05–2.65; $p < 0.0001$) compared to the

national insurance database in a retrospective study of 14 008 uroliths from dogs in the UK (1997–2006)
- Males predisposed

(Roe *et al.*, 2012)

Urolithiasis – cysteine
- Breed at increased risk. OR 2.32 (95% CI 1.59–3.6; $p < 0.0001$) compared to the national insurance database in a retrospective study of 14 008 uroliths from dogs in the UK (1997–2006)

(Roe *et al.*, 2012)

Urolithiasis – struvite (magnesium ammonium phosphate)
- Breed at increased risk. OR 1.84 (95% CI 1.64–2.07; $p < 0.0001$) compared to the national insurance database in a retrospective study of 14 008 uroliths from dogs in the UK (1997–2006)
- Females predisposed

(Roe *et al.*, 2012)

JÄMTHUND

See *Swedish Elkhound*

JAPANESE AKITA INU

Behavioural conditions

Aggression
- Breed scoring highly for aggression towards other dogs in a study based on Canine Behavioural Assessment and Research Questionnaires (C-BARQ) completed by owners in the USA

(Duffy *et al.*, 2008)

Dermatological conditions

Calcinosis cutis
- Breed at increased risk compared to the general population in a USA-based retrospective report of 46 cases
- Median age at diagnosis 7.6 years (across all breeds)
- Male dogs over-represented (across all breeds)
- 78% of all cases were associated with excess exogenous or endogenous steroids

(Doerr *et al.*, 2013)

Sebaceous adenitis
- Autosomal recessive mode of inheritance suspected
- Young to middle-aged dogs affected
- No apparent sex predisposition
- Generalized, greasy changes seen in Akitas
- Some animals may show systemic signs
- Mean age at diagnosis 4.8 years
- 10/104 cases were Akitas in a Swedish study

(Reichler *et al.*, 2001; Tevell *et al.*, 2008; Szczepanik *et al.*, 2012)

Pemphigus foliaceus
- Uncommon
- Breed at increased risk in case series
- OR 37.8 (95% CI 13.1–98.8; $p = 0.0001$) in a histopathological study of 50 cases in the USA, 1986–1991
- No sex predisposition noted
- Mean age of onset 4.2 years

(Kuhl *et al.*, 1994)

Uveodermatologic syndrome (Vogt–Koyanagi–Harada-like syndrome)
- Akitas account for 80% of diagnosed cases

See also under *Ocular conditions*

(Angles *et al.*, 2005)

Gastrointestinal conditions

Exocrine pancreatic insufficiency (EPI)
- Breed at increased risk in a retrospective study of 635 dogs in the USA

(Williams & Minnich, 1990)

Gastric dilatation/volvulus (bloat, GDV)
- Breed at increased in case series

(Glickman *et al.*, 2000a, 2000b)

Haematological/immunological conditions

Haemophilia A
- Factor VIII deficiency
- X-linked recessive inheritance

(Brooks, 1999)

Musculoskeletal conditions

Cranial cruciate ligament (CCL) disease
- Breed at increased risk in a case series
- Neutered dogs predisposed
- Heavier dogs may be predisposed

(Duval *et al.*, 1999)

Panosteitis (enostosis, eosinophilic panosteitis)

- Seen in rapidly growing young dogs
- OR 1.8 (95% CI 1.2–2.7) compared to mixed-breed dogs in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Patellar luxation

- OR 6.7 (95% CI 4–11.3) compared to mixed-breed dogs in a large retrospective study based on cases recorded in the VMDB, 1986–1995
- Males predisposed (1.8:1)
- Mostly affects dogs < 2 years of age

(LaFond *et al.*, 2002; Gibbons *et al.*, 2006)

Polyarthritis

- Seen in young Akitas < 1 year old
- Affected dogs have fever, joint pain, lymphadenopathy and signs of meningeal pain
- The condition seems resistant to immunosuppressive therapy

(Dougherty & Center, 1990)

Neoplastic conditions

Canine acanthomatous ameloblastoma

- Oral tumour most common in the rostral maxilla
- Breed at increased risk in a case series
- Neutered dogs of both sexes at increased risk
- Mean age at presentation 8.8 years

(Fiani *et al.*, 2011)

Neurological conditions

Acquired myasthenia gravis

- Breed at increased risk compared to mixed-breed dogs
- Intact male dogs and dogs < 1 year old had some protection from risk
- Two age peaks, at 2–4 years and 9–12 years, have been observed

(Shelton *et al.*, 1997)

Ocular conditions

Glaucoma – primary

- Breed at increased risk compared to the overall population of dogs in a retrospective study of 9778 dogs with primary glaucoma from the VMDB, 1964–2002
- Prevalence was 1.39% in Akitas for the years 1994–2002, compared to an overall prevalence in all dogs of 0.89% over the same period
- Prevalence was 1.11% in Akitas for the years 1984–1993, compared to an overall prevalence in all dogs of 0.76% over the same period

(Gelatt & MacKay, 2004a)

Glaucoma – secondary

- Akitas have an increased risk of glaucoma secondary to uveitis which occurs with uveodermatologic syndrome

(Gelatt & MacKay, 2004b)

Multiple ocular defects

- Congenital defects; autosomal recessive inheritance suspected
- May include microphthalmia, cataract, posterior lenticonus and retinal dysplasia

(Laratta *et al.*, 1985)

Progressive retinal atrophy (PRA)

- Autosomal recessive inheritance
- Night blindness is present at 1–3 years, complete blindness at 3–5 years

(O'Toole & Roberts, 1984)

Uveodermatologic syndrome (Vogt–Koyanagi–Harada-like syndrome)

- Breed at increased risk
- Ocular signs include uveitis, which can progress to glaucoma, retinal detachment and blindness
- Young adults (1.5–4 years) affected

(Angles *et al.*, 2005; Carter *et al.*, 2005)

Physiological conditions

Pseudohyperkalaemia

- Red blood cells in some Akitas contain more potassium than in other breeds; haemolysis may therefore cause false findings of hyperkalaemia

(Degen, 1987; Conrado *et al.*, 2014)

Red cell microcytosis

- Red blood cells may be small in Akitas without clinical disease
- Mean corpuscular volume (MCV) may be as low as 55–64 fl (normal 85–95)

(Degen, 1987; Fujise *et al.*, 1997; Gookin *et al.*, 1998)

Serum cobalamin levels

- In a retrospective study of 28 675 serum cobalamin tests, Akitas had an increased incidence of values below the lower limit of the reference interval (251 ng/l) OR 2.8 (95% CI 1.9–4.1)

(Grützner *et al.*, 2012)

JAPANESE CHIN

Musculoskeletal conditions

Patellar luxation

- OR 4.8 (95% CI 1.1–20.5) compared to mixed breeds in a large retrospective series based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Neurological conditions

Lysosomal storage disease – GM_2 gangliosidosis

- Rare
- Mutation identified in Japanese Chins

(Sanders *et al.*, 2013)

Ocular conditions

Cataract

- Breed at increased risk in case series
- In a retrospective study of 561 small-breed dogs in Korea, OR 13.1 (95% CI 6.0–28.7) compared to the general hospital population. Female dogs at significantly lower risk than male dogs in the Japanese Chin (OR 0.1)
- Prevalence of primary cataract 4.89%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003). Male predisposition was replicated in this study

(Gelatt & MacKay, 2005; Park *et al.*, 2009)

JAPANESE SHIBA INU

Behavioural conditions

Aggression

- Shiba Inu was reported with high aggression to dogs and snapping at children in Japan
- Polymorphism c.471 T > C associated with some types of aggressive behaviour in the Shiba Inu in the USA

(Takeuchi & Mori, 2006; Takeuchi *et al.*, 2009)

Tail-chasing

- Repetitive behaviour and pathological behaviour
- Dogs originating from pet stores predisposed
- Shiba Inu was significantly predisposed ($p < 0.001$) compared with other breeds in Japan, with 28% of Shiba Inu affected

(Goto *et al.*, 2012)

Musculoskeletal conditions

Patellar luxation

- 6.2% of US Shiba Inu affected
- Mainly medial luxation observed, often bilateral

(Orthopedic Foundation for Animals, 2015)

Neoplastic conditions

Oral epulis

- Shiba Inu accounted for 12.1% of a fibromatous epulis caseload in Japan

(Yoshida *et al.*, 1999)

Neurological conditions

Intervertebral disc disease (IVDD)

- Shiba Inu accounted for 2.3% of a cervical IVDD caseload and 2.4% of a thoracolumbar IVDD caseload at a Japanese referral hospital

(Itoh *et al.*, 2008)

Lysosomal storage disease – GM_1 gangliosidosis

- Inherited as autosomal recessive traits
- Described in Shiba Inu in Japan
- Age at onset of 5–6 months and survival period of 14–15 months

(Yamato *et al.*, 2003)

Ocular conditions

Glaucoma

- 29.0% of Shiba Inu referred for eye or neurological conditions in Japan were affected

(Kato *et al.*, 2006)

Physiological conditions

Litter size

- Smaller litters associated with older bitches and smaller breeds
- Shiba Inu had the eighth smallest mean litter size (3.3 puppies) among registered breeds in Norway

(Borge *et al.*, 2011)

JAPANESE TOSA

Infectious conditions

Babesiosis

- High incidence reported in this breed in Japan (unknown if this is due to a true breed susceptibility or increased risk of exposure via ticks or possibly bites)

- Often subclinical
- Babesiosis is tick-borne but possibly also transmitted by fighting

(Miyama *et al.*, 2005)

JINDO

See *Korean Jindo*

KEESHOND (WOLFSPITZ)

Cardiovascular conditions

Patent ductus arteriosus

- Breed at increased risk
- Females predisposed
- Mode of inheritance is polygenic

(Matic, 1988; Buchanan, 2001; Oliveira *et al.*, 2011)

Tetralogy of Fallot

- Congenital
- One of a group of defects known as conotruncal defects

(Matic, 1988; Patterson, 1989; Werner *et al.*, 2005)

Ventricular septal defect

- Congenital

(Matic, 1988; Patterson, 1989; Werner *et al.*, 2005)

Dermatological conditions

Alopecia X

- Males may be predisposed
- Clinical signs seen at any age but often 1–2 years

(Lothrup, 1988; Chastain & Panciera, 2004; Mausberg *et al.*, 2007)

Endocrine conditions

Diabetes mellitus

- Autosomal recessive inheritance
- Insulin-dependent diabetes mellitus due to hypoplasia of the cells of the Islet of Langerhans
- Onset commonly before 6 months of age
- OR 2.45 (95% CI 1.47–4.12) compared to mixed-breed dogs in a retrospective report of 6860 dogs with diabetes mellitus from the VMDB, 1970–1999. Females predisposed: OR 1.37

(Kramer *et al.*, 1980, 1988; Guptill *et al.*, 2003)

Hypothyroidism

- Keeshonden were in the top five breeds affected in a large USA-based retrospective case study of 90 004 dogs presented to a university teaching hospital. 6.63% of Keeshonden were affected, compared to 1.54% of mixed breeds

(Bellumori *et al.*, 2013)

Primary hyperparathyroidism

- Keeshonden represent at least 25% of dogs diagnosed with primary hyperparathyroidism
- Autosomal dominant inheritance
- Older dogs affected. Mean age 9.8 years

(Berger & Feldman, 1987; Chastain & Panciera, 2007; Goldstein *et al.*, 2007)

Musculoskeletal conditions

Hip dysplasia

- OR 1.8 (95% CI 1.1–2.8) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Patellar luxation

- OR 4.4 (95% CI 2.5–8.0) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Neoplastic conditions

Parathyroid tumours (resulting in primary hyperparathyroidism)

See under *Endocrine conditions*

Neurological conditions

Idiopathic epilepsy

- Inherited
- Bias towards males reported
- Age of onset 6 months to 6 years

(Cunningham & Farnbach, 1988; Hall & Wallace, 1996; Ekenstedt & Oberbauer, 2013)

Ocular conditions

Spontaneous chronic corneal epithelial defects (refractory corneal ulceration, indolent ulcers)

- Persistent corneal erosions with no obvious cause
- Breed at increased risk in case series; 11.1% of 45 dogs were Keeshonden in one US study

(Murphy *et al.*, 2001)

Renal and urinary conditions

Urolithiasis – calcium oxalate

- Breed at increased risk in case series
- OR 4.6 (95% CI 3.5–5.8) compared to mixed-breed dogs in a USA-based retrospective study of 10 673 calcium oxalate cases
- Males at increased risk ($p < 0.001$), representing 69% of submissions across all breeds
- In a Canadian case series of urolith submissions, 1998–2001, the OR was 3.00 (95% CI 1.26–7.17) compared to mixed-breed dogs

(Ling *et al.*, 2003; Low *et al.*, 2010)

KELPIE

See *Australian Kelpie*

KERRY BLUE TERRIER

Dermatological conditions

Cutaneous neoplasia

See under *Neoplastic conditions*

Footpad hyperkeratosis

- Familial
- Develops at 4–6 months

(Duclos, 2013)

Spiculosis

- Rare
- Affects young, entire male Kerry Blues

(McKeever *et al.*, 1992)

Gastrointestinal conditions

Hypodontia

- Condition identified in Kerry Blues in Russia
- Reduced numbers of premolars
- Litter sizes were smaller in those with affected pups
- Inheritance not established

(Aksenovich *et al.*, 2004)

Haematological/immunological conditions

Factor XI deficiency

- Inherited as an autosomal trait with incomplete penetrance
- Affected dogs have mild bleeding tendencies. Some are asymptomatic

(Knowler *et al.*, 1994; Brooks, 1999; Tcherneva & Giger, 2007)

Neoplastic conditions

Pilomatrixoma

- Uncommon (1% of all cutaneous neoplasms in the dog)
- Breed at increased risk in case series
- Mean age 6.6 years

(Scott & Anderson, 1991; Toma & Noli, 2005)

Neurological conditions

Cerebellar degeneration

- Rare
- Signs seen at 9–16 weeks of age and progress until unable to stand at 10–12 months

(de Lahunta & Averill, 1976; Montgomery, 1982)

Canine multiple system degeneration

- Rare
- Presents as a movement disorder
- Autosomal recessive inheritance

(O'Brien *et al.*, 2005)

Ocular conditions

Cataract

- Prevalence of primary cataract 2.58%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005)

KING CHARLES SPANIEL (ENGLISH TOY SPANIEL)

Cardiovascular conditions

Mitral valve disease

- Breed at increased risk: OR 5.36 (95% CI 3.36–8.55) in a UK study

(Thrusfield *et al.*, 1985)

Neurological conditions

Primary brain tumour – oligodendroglioma

- Breed at significantly increased risk compared to the general population in a study of post-mortem results of 435 dogs with intracranial neoplasia

(Song *et al.*, 2013)

Chiari malformation/syringomyelia

- Breed at increased risk in a UK-based retrospective study of VetCompass data, 2009–2014

(Sanchis-Mora *et al.*, 2016)

Ocular conditions

Corneal ulceration (ulcerative keratitis)

- In a UK-based study of first-opinion practice the prevalence in the King Charles was 2.22% (95% CI 1.11–3.93), compared to an overall prevalence of 0.8% (95% CI 0.75–0.86)

(O'Neill *et al.*, 2017b)

KLEE KAI

See *Alaskan Klee Kai*

KOOIKER DOG (KOOIKERHONDJE) (SMALL DUTCH WATERFOWL DOG)

Haematological/immunological conditions

von Willebrand's disease (vWD)

- Inherited as an autosomal recessive trait
- Type III disease is seen in this breed
- Identification of the mutations involved and development of a genetic test have enabled elimination of the mutation from breeding stock approved by the Dutch breeding club

(Slappendel *et al.*, 1998; van Oost *et al.*, 2004)

Musculoskeletal conditions

Patellar luxation

- Patellar luxation was present in 24% of a cohort of 842 screened Dutch Kooikers
- Males and females similarly affected

(Wangdee *et al.*, 2014)

Neurological conditions

Hereditary necrotizing myelopathy

- Clinical signs begin at 3–12 months age
- No sex predisposition

(Mandigers *et al.*, 1993)

Renal and urinary conditions

Renal dysplasia

- Rare condition
- Reported in 3 young adult Dutch Kookier dogs

(Schulze *et al.*, 1998)

KOREAN JINDO

Physiological conditions

Pseudohyperkalaemia

- Korean Jindos may have red blood cells containing high levels of potassium, leading to an increased risk of pseudohyperkalaemia
- In a study of 35 Korean Jindos in Korea, 25.7% were found to be affected

(Yamato *et al.*, 1999)

KROMFOHRLÄNDER

Dermatological conditions

Footpad hyperkeratosis

- Autosomal recessive inheritance
- Age of onset 6 months

(Drögemüller *et al.*, 2014)

KUVASZ

See *Hungarian Kuvasz*

LABRADOR RETRIEVER

Behavioural conditions

Attraction to water

- Labrador Retrievers were found to be more attracted to water than to social stimuli (humans or other dogs) in one study

(Tavares *et al.*, 2015)

Cardiovascular conditions

Accessory pathway arrhythmia

- Presence of abnormal pathways of conduction connecting the atria to the ventricles
- Result most commonly in atrial fibrillation or orthodromic reciprocating tachycardia
- Males predisposed

(Wright *et al.*, 1996; Finster *et al.*, 2008; Santilli, 2010)

Atrioventricular (AV) block

- Breed at increased risk in case series
- Labrador Retrievers have a high risk of both second- and third-degree AV block

(Schrope & Kelch, 2006; Wess *et al.*, 2006)

Pericardial effusion
- Male predisposition suggested
- Studies have demonstrated a predisposition to both idiopathic pericardial effusion and primary cardiac haemangiosarcoma

(MacDonald *et al.*, 2009; Kumar *et al.*, 2011; Yamamoto *et al.*, 2013)

Tricuspid valve dysplasia
- Breed at increased risk in several case series
- OR 13.81 (95% CI 3.89–49.05) compared to the general hospital population, in an Australian retrospective study of 10 dogs with tricuspid valve dysplasia seen between 2001 and 2012
- In an Italian retrospective case series of 976 dogs with congenital heart defects, Labrador Retrievers had an OR of 11.13 ($p < 0.0001$) compared to the general hospital population

(Famula *et al.*, 2002; Oliveira *et al.*, 2011; Aherne & Beijerink, 2013)

Dermatological conditions

Atopic dermatitis (atopy)
- In an Australian retrospective case series, Labradors Retrievers had an OR of 2.2 (95% CI 1.65–3.0) compared to the overall hospital population
- Breed at increased risk in a US series of 268 cases (1981–1984)
- Breed at increased risk in a study of Munich cases: OR 3.7 (95% CI 1.6–8.5) compared to the general hospital population
- Birth in autumn or summer is a predisposing factor
- Dogs between 1 and 2 years of age have the highest probability of an insurance claim for atopy
- Some studies show no sex predilection, others show females predisposed

(Shaw *et al.*, 2004; Nødtvedt *et al.*, 2006; Jaeger *et al.*, 2010; Mazrier *et al.*, 2016)

Blastomycosis
See under *Infectious conditions*

Calcinosis cutis
- Breed at increased risk in case series
- Males over-represented
- Occurs most commonly secondary to excess endogenous or exogenous corticosteroid

(Doerr *et al.*, 2013)

Cutaneous neoplasia
See under *Neoplastic conditions*

Eosinophilic dermatitis and oedema
- Rare
- Hypersensitivity reaction suspected
- 4/9 dogs in a case series were Labrador Retrievers

(Holm *et al.*, 1999; Mauldin *et al.*, 2006)

Hereditary nasal parakeratosis in Labrador Retrievers
- Autosomal recessive inheritance
- Affects Labradors and their crosses
- Age of onset 6–12 months

(Pagé *et al.*, 2003; Jagannathan *et al.*, 2013)

Mural folliculitis and parakeratosis
- Rare condition identified in Labrador Retrievers
- Lesions can be diffuse, starting as comedones and progressing to large dense crusted plaques
- An immune-mediated condition is suspected

(Hargis *et al.*, 2013)

Pemphigus foliaceus
- Predisposed breed in a number of studies
- Males over-represented

(Gomez *et al.*, 2004; Mueller *et al.*, 2006)

Endocrine conditions

Diabetes mellitus
- Breed at increased risk in case series
- Neutered dogs of both sexes at increased risk
- More frequently diagnosed in the winter months

(Chastain *et al.*, 2001; Davison *et al.*, 2005)

Hypothyroidism
- Breed at increased risk
- Predisposition to hyperlipidaemia, atherosclerosis and neurological signs in affected dogs

(Vitale & Olby, 2007)

Gastrointestinal conditions

Acquired megaoesophagus
- Breed at increased risk
- May be secondary to myopathy (see under *Musculoskeletal conditions*)

(Bedu *et al.*, 2012)

Chronic hepatitis

- Breed at increased risk in a UK-based study of 551 cases: OR 2.0 (95% CI 1.6–2.5; $p < 0.001$) compared to a control population. Median age was 8 years 3 months, and females were over-represented across the whole study
- Additionally at increased risk of copper-associated hepatitis due to an inherited defect in copper storage. Middle-aged females predisposed. Higher levels of dietary copper can increase the risk

(Hoffmann *et al.*, 2006; Shih *et al.*, 2007; Bexfield *et al.*, 2012a; Fietan *et al.*, 2014, 2015)

Congenital portosystemic shunt

- Breed at increased risk of intrahepatic shunts in several case series. 28/100 cases were Labrador Retrievers in one retrospective case series
- Clinical signs usually seen in young dogs < 1 year

(Tobias & Rohrbach, 2003; Adam *et al.*, 2012; Weisse *et al.*, 2014)

Spirocercosis

- Oesophageal infection with *Spirocerca lupi*
- Breed at increased risk in a case series in Israel
- Median age was 5 years
- May be associated with oesophageal sarcomas

(Mazaki-Tovi *et al.*, 2002; Ranen *et al.*, 2008)

Haematological/immunological conditions

Haemophilia A

- Factor VIII deficiency
- X-linked recessive inheritance

(Brooks, 1999; Aslanian *et al.*, 2014)

Haemophilia B

- Factor IX deficiency
- X-linked recessive inheritance

(Mischke *et al.*, 2011)

Selective IgA deficiency

- Breed at increased risk in case series
- 12% of 141 Labrador Retrievers were found to have low serum IgA (<0.07 g/l) in one 2014 study
- Immunodeficiency is associated with recurrent infections of mucosal sites and increased susceptibility to immune-mediated disease

(Olsson *et al.*, 2014)

Infectious conditions

Blastomycosis

- Breed at increased risk in case series. 29.6% of 125 cases were Labrador Retrievers in one retrospective study in Minnesota
- Young (2–4 years) entire males predisposed
- Geographic distribution: mainly North America (Mississippi, Missouri, Ohio River valleys, mid-Atlantic States, Quebec, Manitoba and Ontario)
- Proximity to a body of water is a risk factor in endemic areas

(Rudmann *et al.*, 1992; Kerl, 2003; Crews *et al.*, 2008)

Borreliosis (Lyme disease)

- Breed at increased risk of Lyme nephritis

See also under *Renal and urinary conditions*

(Littman, 2013)

Infectious skin diseases

See under *Dermatological conditions*

Spirocercosis

See under *Gastrointestinal conditions*

Metabolic conditions

Overweight/obesity

- In a study of 21 754 dogs carried out in 1995 in the USA, Labrador Retrievers had an OR of 1.6 compared to all other dogs
- Across all breeds, dogs aged 6–10 years and neutered dogs (OR 1.5) were at greatest risk
- A genetic basis is believed to exist in the Labrador Retriever

(Lund *et al.*, 2006; Raffan *et al.*, 2016; Mankowska *et al.*, 2017)

Musculoskeletal conditions

Cranial cruciate ligament (CCL) disease

- Breed at increased risk in case series. 16% of 426 dogs with cranial cruciate disease were Labrador Retrievers in one retrospective study
- OR 2.56 (95% CI 2.47–2.64) compared to all dogs in a separate retrospective study of data from the VMDB, 1964–2003. In this study neutered males, neutered females and dogs > 4 years old of all breeds combined were at increased risk

(Comerford *et al.*, 2006; Witsberger *et al.*, 2008; Guthrie *et al.*, 2012)

Discospondylitis
- Labrador Retrievers were at higher risk in a study of 513 cases in North America: OR 1.5 (95% CI 1.0–2.2) compared to mixed-breed dogs
- Higher risk with increasing age
- Males twice as likely to be affected as females: OR 2.0 (95% CI 1.7–2.4)

(Burkert *et al.*, 2005)

Elbow dysplasia
- Breed at increased risk
- OR 20.5 (95% CI 13.9–30.3) for fragmented coronoid process, OR 109.4 (95% CI 54.4–219.9) for osteochondrosis and OR 8.5 (95% CI 6.5–11.1) for ununited anconeal process, all compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995
- Male dogs were 1.7 times more likely to have osteoarthritis in affected joints in one study
- Polygenic inheritance suspected

(LaFond *et al.*, 2002; Woolliams *et al.*, 2011; Lavrijsen *et al.*, 2012)

Hip dysplasia
- Breed at increased risk in case series
- OR 2.34 (95% CI 2.28–2.41; $p < 0.001$) compared to all dogs in a retrospective study of data from the VMDB, 1964–2003. In this study, neutered males and dogs < 4 years old of all breeds combined were at increased risk
- One study of 1018 Labrador Retrievers estimated the prevalence in the breed as 12.6%

(Witsberger *et al.*, 2008; Sánchez-Molano *et al.*, 2014; Lavrijsen *et al.*, 2014)

Limber tail
- Breed at increased risk in case series
- Swimming (OR 4.7) and being a working dog (OR 5.1) were risk factors
- Affected related dogs more than might be expected purely by chance

(Pugh *et al.*, 2016)

Lumbosacral transitional vertebrae
- Inheritance suspected
- Females more frequently affected

(Morgan *et al.*, 1999; Moeser & Wade, 2017)

Metaphyseal osteopathy (hypertrophic osteodystrophy)
- Affects dogs aged 2–6 months
- Males may be predisposed
- OR 5.9 (95% CI 2.8–12.4) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Muscular stiffness
- A muscular stiffness which persists at rest has been reported in male Labrador Retrievers
- X-linked inheritance suggested
- Onset of clinical signs 2–16 months
- Signs stabilize in adulthood

(Vanhaesebrouck *et al.*, 2011)

Myopathy
- Several different types are inherited in Labrador Retrievers
- Inherited as either an autosomal recessive or an X-linked condition
- Onset at 1–7 months of age
- X-linked myotubular myopathy (XLMTM) and X-linked dystrophin-deficient muscular dystrophy (XLMD) present as severe generalized muscle weakness which is rapidly progressive
- Autosomal recessive centronuclear myopathy is a less severe and less rapidly progressive form
- A mild form of XLMD has been seen in older male dogs which have raised muscle enzymes and histological changes in their muscles but do not have clinical signs of weakness and muscle atrophy
- Sarcolemmal-specific collagen VI deficiency results in progressive gait abnormalities and joint deformity

(Bley *et al.*, 2002; Maurer *et al.*, 2012; Snead *et al.*, 2015; Cerda-Gonzalez *et al.*, 2016)

Oculoskeletal dysplasia
See under *Ocular conditions*

Osteochondrosis – elbow
See *Elbow dysplasia*

Osteochondrosis – shoulder
- Breed at increased risk in case series
- OR 13.1 (95% CI 10.4–16.4) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995
- Males predisposed
- Age of onset usually 4–7 months, but can be older

(Rudd *et al.*, 1990; LaFond *et al.*, 2002; Biezyński *et al.*, 2012)

Osteochondrosis – stifle
- Breed at increased risk in case series
- OR 27.6 (95% CI 13.2–58.0) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995
- Males predisposed
- Age of onset usually 5–12 months

(LaFond *et al.*, 2002)

Osteochondrosis – tarsus
- Breed at increased risk in case series
- OR 45.9 (95% CI 26.8–78.6) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995
- Age at presentation 6 months to 1 year, but some present later

(Montgomery *et al.*, 1994; LaFond *et al.*, 2002)

Osteosarcoma
See under *Neoplastic conditions*

Panosteitis (enostosis, eosinophilic panosteitis)
- Seen in rapidly growing young dogs
- OR 1.6 (95% CI 1.4–1.9) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Patellar luxation
- Breed at increased risk in case series
- In one study of 70 large-breed dogs with patellar luxation, 25 cases were in Labrador Retrievers (RR 3.3)
- Males predisposed
- Mainly medial luxation observed in Labrador Retrievers

(Arthurs & Langley-Hobbs, 2006; Gibbons *et al.*, 2006; Bound *et al.*, 2009)

Polyarthritis
- Breed at increased risk in case series
- Usually affects dogs at 1–3 years, but any age can be affected

(Clements *et al.*, 2004; Stull *et al.*, 2008; Foster *et al.*, 2014)

Neoplastic conditions

Cutaneous haemangioma
- Breed at increased risk in case series

(Schultheiss, 2004)

Haemangiosarcoma
- Breed at increased risk in case series
- At risk of both visceral (including splenic and cardiac) and non-visceral (mostly skin) haemangiosarcomas
- Mean age reported as 10 years

(Schultheiss, 2004; Kim *et al.*, 2007; Yamamoto *et al.*, 2013)

Histiocytic sarcoma complex – histiocytic sarcoma and disseminated histiocytoma
- Breed at increased risk in case series
- Age of onset: > 5 years

See also under *Ocular conditions*

(Schultz *et al.*, 2007; Takahashi *et al.*, 2014; Dervisis *et al.*, 2016)

Lingual neoplasia
- Breed at increased risk in case series
- OR 2.41 (95% CI 1.46–3.98) for lingual squamous cell carcinoma in a retrospective study of 1196 dogs with lingual lesions
- Females at increased risk (OR 2.26)

(Dennis *et al.*, 2006; Culp *et al.*, 2013)

Lipoma
- Breed at increased risk of infiltrative lipoma in a case series
- 8/15 dogs were Labrador Retrievers in this study
- Ratio of female:male (all breeds) was 4:1

(Bergman *et al.*, 1994)

Mast cell tumour (MCT)
- Breed at increased risk in case series
- OR 2.9 (95% CI 2.17–3.89) compared to the general hospital population in a retrospective UK study of 222 cases
- May be seen at any age (from 4 months onwards), but usually seen in older animals
- Predilection sites include hindlimb, perineum and scrotum
- An association with low vitamin D levels noted in this breed

See also under *Ocular conditions*

(Wakshlag *et al.*, 2011; Warland & Dobson, 2013)

Melanoma
- Breed at increased risk of limbal, canine uveal anterior, oral and skin/nail bed melanoma in case series
- Labradors may have a mutation predisposing them to ocular melanomas

- Limbal melanomas are usually benign, oral melanomas highly malignant

(Donaldson *et al.*, 2006; Schultheiss, 2006; Featherstone *et al.*, 2009; Boston *et al.*, 2014; Tuohy *et al.*, 2014; Kawabe *et al.*, 2015)

Osteosarcoma

- Breed at increased risk in case series
- OR 1.3 (95% CI 1.0–1.7) compared to German Shepherd Dogs in a retrospective study of VMDB data, 1980–1994
- Across all breeds there was an increased risk with increasing age, plateauing at 10 years
- Across all breeds there was a slight predisposition for males, but an almost twofold increase for neutered dogs of both sexes

(Ru *et al.*, 1998)

Sarcoma – soft tissue

- 14/87 cases were Labrador Retrievers in a USA-based retrospective case series
- Breed at increased risk of cutaneous soft-tissue sarcoma in a retrospective study of VMDB data, 1964–2002: OR 1.48 (95% CI 1.25–1.74) compared to all other dogs

(Heller *et al.*, 2005; Stefanello *et al.*, 2011; Villamil *et al.*, 2011)

Squamous cell carcinoma – digit

- Breed at increased risk in case series
- Middle-aged to older dogs predisposed
- Labrador Retrievers seem to be at risk of digital tumours generally

(O'Brien *et al.*, 1992; Henry *et al.*, 2005; Capak *et al.*, 2007)

Thymoma

- Uncommon tumour
- Breed at increased risk (30/116 cases were Labrador Retrievers in a USA-based retrospective study)
- Mean age 9.5 years

(Day, 1997a; Robat *et al.*, 2013; Carette *et al.*, 2014)

Neurological conditions

Exercise-induced collapse

- Onset at 7 months to 2 years of age
- Autosomal recessive inheritance, mutation identified
- In one retrospective genetic survey of different populations of Labrador Retrievers in the USA and Canada, 17.9–38.0% of tested dogs were carriers, and 1.8–13.6% were homozygous. Of the latter, 83.6% had collapsed by 4 years of age

(Minor *et al.*, 2011; Furrow *et al.*, 2013)

Idiopathic epilepsy

- Polygenic recessive inheritance suggested
- Age of onset 6 months to 6 years
- 3.1% prevalence in a study of Danish Labrador Retrievers, compared to 1% in the general canine population

(Jaggy *et al.*, 1998; Berendt *et al.*, 2002)

Leucodystrophy

- Rare conditions involving a disorder of myelin synthesis and maintenance
- Labrador Retriever central axonopathy affects spinal cord myelin; pups from 4–6 weeks are unable to walk; autosomal recessive inheritance
- Fibrinoid leucodystrophy affects myelin of the cerebrum and spinal cord; ataxia and weakness seen at 6–9 months of age; similar to Alexander disease in humans
- Spongiform leucodystrophy affects myelin diffusely (cerebellum, cerebrum and spinal cord); ataxia and tremor seen as early as 2 weeks of age; similar to Canavan's disease in humans

(Zachary & O'Brien, 1985; de Lahunta *et al.*, 1994; Sisó *et al.*, 2005)

Narcolepsy–cataplexy

- Rare condition
- Autosomal recessive inheritance, mutation identified
- Age of clinical onset < 1 year

(Hungs *et al.*, 2001; Tonokura *et al.*, 2007)

Paroxysmal dyskinesia

- Breed at increased risk in case series
- Median age at onset in 36 Labrador Retrievers was 2.25 years; 29 of the 36 were male.

(Lowrie & Garosi, 2016)

Ocular conditions

Cataract

- Dominant inheritance with incomplete penetrance suggested
- Age of onset 6–18 months
- Localization: posterior polar subcapsular; slowly progressive; rarely proceeds to blindness

- Other types have been reported less commonly
- In a large-scale retrospective review of ocular examinations of Labrador Retrievers in the Netherlands (1980–2000), the prevalence of cataract was 8%

(Curtis & Barnett, 1989; Kraijer-Huver *et al.*, 2008)

Entropion
- Polygenic inheritance suspected
- Lateral lower lids affected

(Read & Broun, 2007)

Histiocytic sarcoma – ocular
- Breed at increased risk in case series
- Mean age 8.61 years

See also under *Neoplastic conditions*

(Naranjo *et al.*, 2007)

Mast cell tumour (MCT) – conjunctival
- Breed at increased risk of conjunctival mast cell tumours in case series (12/32 dogs were Labrador Retrievers)

See also under *Neoplastic conditions*

(Fife *et al.*, 2011)

Melanoma
See under *Neoplastic conditions*

Oculoskeletal dysplasia
- Dogs may be affected with retinal dysplasias (complete, geographic or multifocal) and varying degrees of developmental skeletal abnormalities (short-limbed dwarfism)
- Autosomal recessive inheritance, mutation identified
- Retinal dysplasia may also be seen without skeletal abnormality in the Labrador Retriever

(Carrig *et al.*, 1988; Pellegrini *et al.*, 2002; Goldstein *et al.*, 2010)

Progressive retinal atrophy (PRA)
- Autosomal recessive inheritance
- Progressive rod–cone degeneration
- Late onset. Night blindness at 4–6 years, severe visual impairment at 6–8 years

(Gentilini *et al.*, 2009)

Retinal pigment epithelial dystrophy (RPED, central progressive retinal atrophy)
- Dominant inheritance with incomplete penetrance has been suggested
- More prevalent in the UK than in the USA. Becoming less prevalent following the introduction of control schemes
- Ophthalmoscopic signs seen at 2–3 years of age; visual problems noticed at 5–7 years

(Barnett, 1988)

Uveal cysts
- Breed at increased risk in a retrospective study of 28 cases (1989–1991)
- Mean age was 9.1 years in Labrador Retrievers

(Corcoran & Koch, 1993)

Physiological conditions
Serum cobalamin levels
- In a retrospective study of 28 675 serum cobalamin tests, Labradors had an increased incidence of values below the lower limit of the reference interval (251 ng/l): OR 1.4 (95% CI 1.3–1.5)

(Grützner *et al.*, 2012)

Vertebral heart score (VHS)
- The healthy Labrador had a higher mean score than other dogs (except the Boxer and Cavalier King Charles Spaniel) in one study

(Lamb *et al.*, 2001)

Renal and urinary conditions
Ectopic ureter
- Breed at increased risk in case series
- Usually presents < 1 year of age
- More commonly diagnosed in females. May present later, and is possibly underdiagnosed in males

(Holt & Moore, 1995; Reichler *et al.*, 2012)

Lyme nephritis
- Breed at increased risk of post-borrelial-infection immune-mediated glomerulonephritis
- Seen in 1–2% of Lyme-seropositive dogs

(Littman, 2013)

Respiratory conditions
Laryngeal paralysis–polyneuropathy syndrome
- Breed at increased risk in many case series
- In a retrospective study in the USA of 232 cases seen at a university hospital, 1987–2012, 107 were Labrador Retrievers. Across all breeds 65% were male
- Middle-aged to older dogs affected

(Burbidge, 1995; Wilson & Monet, 2016)

LAKELAND TERRIER

Ocular conditions

Cataract

- Prevalence of primary cataract 7.46%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005)

LANCASHIRE HEELER

Gastrointestinal conditions

Parvovirus enteritis

See under *Infectious conditions*

Infectious conditions

Parvovirus enteritis

- Breed at increased risk of infection in a study of 15 442 confirmed cases seen in Banfield practices in the USA, 2010/2011
- Females at lower risk than males
- Puppies < 6 months old were 11.40 times more likely to be infected than older dogs

(Lefebvre, 2013)

Ocular conditions

Collie eye anomaly

- Congenital condition
- Incidence of 13.7% demonstrated in Lancashire Heelers in the UK in 1996

(Bedford, 1998; Parker *et al.*, 2007)

Lens luxation – primary

- Mutation identified
- Age of onset: 2–6 years
- Usually progresses to glaucoma in affected dogs

(Sargan *et al.*, 2007)

LAPLAND REINDEER DOG (LAPINPOROKOIRA)

Neurological conditions

Lysosomal enzyme disease – glycogen storage disease type II (Pompe disease)

- Rare condition
- Age of onset from 6 months, death around 2 years

(Walvoort, 1985)

LAPPHUND

See *Finnish Lapphund*; *Swedish Lapphund*

LEONBERGER

Musculoskeletal conditions

Bone tumour

See under *Neoplastic conditions*

Diffuse idiopathic skeletal hyperostosis (DISH)

- Breed at increased risk in retrospective radiographic study of 2041 purebred dogs in the Netherlands, 2003–2008 (OR 9.88; $p < 0.001$)
- Prevalence was 12% (of 25 Leonbergers) compared to an overall prevalence in all dogs in the study of 3.8%

(Kranenburg *et al.*, 2011)

Hip dysplasia

- Incidence of 25% in a prospective study of Norwegian Leonbergers born 1998–2001

(Krontveit *et al.*, 2010)

Neoplastic conditions

Bone tumour

- Breed at high risk of malignant bone tumours in one study of Swedish insurance data (1995–2002). Leonbergers had an overall incidence of 53 cases (95% CI 35–70) per 10 000 DYAR, compared to the risk in all dogs combined of 5.5 cases per 10 000 DYAR
- Males over-represented
- Median age was 7.2 years in Leonbergers; risk increases with increasing age

(Egenvall *et al.*, 2007)

Mammary neoplasia

- 46% of insured Swedish Leonbergers had developed mammary tumours at 10 years of age (ranked first), compared to 13% of the overall population

(Jitpean *et al.*, 2012)

Neurological conditions

Inherited polyneuropathy

- X-linked inheritance suspected
- Age of onset between 1 and 9 years of age

(Shelton *et al.*, 2003; Ekenstedt *et al.*, 2014)

Ocular conditions

Cataract

- In a survey of 365 Leonbergers, 1990–1998, 90 dogs had cataracts
- Localization: posterior polar subcapsular, or nuclear

(Heinrich *et al.*, 2006)

Pectinate ligament dysplasia (PLD)

- 22% of 232 dogs in a retrospective study of UK Leonbergers were affected
- Some cases developed glaucoma
- Females were more commonly affected

(Fricker *et al.*, 2016)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- 61% of insured Swedish Leonbergers had developed pyometra at 10 years of age (ranked third), compared to 19% for the general population

(Chastain *et al.*, 1999; Jitpean *et al.*, 2012)

Respiratory conditions

Laryngeal paralysis–polyneuropathy syndrome

- May be seen in Leonbergers with inherited polyneuropathy
- May be the only symptom in some cases

See also under *Neurological conditions* (*Inherited polyneuropathy*)

(Granger, 2011)

LHASA APSO

Dermatological conditions

Atopic dermatitis (atopy)

- Breed at increased risk in a US series of 268 cases (1981–1984)
- Also reported as a breed at increased risk in another US study of 383 cases: OR 3.4 compared to the general hospital population
- Some studies show no sex predilection, others show females predisposed

(Scott, 1981; Schick & Fadok, 1986)

Cutaneous neoplasia

See under *Neoplastic conditions*

Haematological/immunological conditions

Haemophilia A

- Severe factor VIII deficiency is seen in the Lhasa Apso
- X-linked recessive inheritance

(Brooks, 1999)

Haemophilia B

- Factor IX deficiency
- X-linked recessive inheritance

(Mauser *et al.*, 1996)

Musculoskeletal conditions

Avascular necrosis of the femoral head (Legg–Calvé–Perthes disease)

- Breed at increased risk in case series
- OR 6.7 (95% CI 2.6–17.1) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Patellar luxation

- Breed at increased risk in case series
- OR 3.4 (95% CI 2.5–4.8) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Neoplastic conditions

Sebaceous gland tumours

- Breed at increased risk of sebaceous epithelioma in a case series
- Mean age 10.7 years
- Common site: head and eyelids

(Scott & Anderson, 1990)

Neurological conditions

Hydrocephalus

- Congenital
- Breed at increased risk in a retrospective series of 564 cases
- Onset of clinical signs < 3 months

(Selby *et al.*, 1979)

Intervertebral disc disease (IVDD)

- Breed at significantly increased risk in a study of 8117 cases in North America in 1976
- Peak incidence at 4–6 years of age

(Priester, 1976)

Lissencephaly
- Rare developmental disease
- Age of onset < 1 year

(Saito *et al.*, 2002)

Ocular conditions

Cataract
- Breed at increased risk in two large studies
- OR 5.9 (95% CI 1.2–29.1) compared to the hospital population in a retrospective study of 561 dogs of small breeds in Korea 2002–2007
- Prevalence of primary cataract 4.61%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005; Park *et al.*, 2009)

Corneal ulceration (ulcerative keratitis)
- In a UK-based study of first-opinion practice, the prevalence in the Lhasa Apso was 2.13% (95% CI 1.29–3.31), compared to an overall prevalence of 0.8% (95% CI 0.75–0.86)

(O'Neill *et al.*, 2017b)

Glaucoma – primary
- Breed at increased risk compared to the overall population of dogs in a retrospective study of 9778 dogs with primary glaucoma from the VMDB, 1964–2002
- Prevalence was 1.33% in Lhasas for the years 1994–2002, compared to an overall prevalence in all dogs of 0.89% over the same period
- Prevalence was 1.00% in Lhasas for the years 1984–1993, compared to an overall prevalence in all dogs of 0.76% over the same period

(Gelatt & MacKay, 2004a)

Keratoconjunctivitis sicca
- Breed at increased risk in case series

(Kaswan & Salisbury, 1990; Berdoulay *et al.*, 2005)

Prolapse of the gland of the nictitating membrane ('cherry eye')
- Breed at increased risk in case series. Second most commonly affected breed, representing 11/89 cases
- Usually presents in the first 1–2 years of life

(Morgan *et al.*, 1993)

Proptosis
- Breed at significantly increased risk of ocular proptosis in a study of 66 cases
- Most cases are associated with trauma
- Males are at increased risk

(Gilger *et al.*, 1995)

Renal and urinary conditions

Familial renal disease (familial nephropathy)
- Cases present with chronic renal failure from a few months of age

(O'Brien *et al.*, 1982; Picut & Lewis, 1987b; Nash, 1989)

Urolithiasis – apatite
- Breed at increased risk in a case series: OR 4.1 (95% CI 3.7–4.6) compared to mixed-breed dogs in a retrospective study of 25 499 laboratory stone submissions in the USA, 1985–2006
- Females were at significantly increased risk ($p < 0.001$), representing 77.6% of submissions across all breeds

(Low *et al.*, 2010)

Urolithiasis – calcium oxalate
- Breed at increased risk in case series. OR 10.1 (95% CI 9.2–11.2) compared to mixed-breed dogs in one retrospective study of 25 499 laboratory stone submissions in the USA, 1985–2006. Males were at increased risk ($p < 0.001$), representing 69% of submissions across all breeds
- In a Canadian study of urolith submissions, 1998–2001, OR was 5.19 (95% CI 3.69–7.31) compared to mixed-breed dogs
- In a retrospective study of 14 008 uroliths from dogs in the UK, 1997–2006, OR was 7.2 (95% CI 6.03–8.61; $p < 0.0001$) compared to the national insurance database. Males predisposed

(Ling *et al.*, 2003; Houston *et al.*, 2004; Low *et al.*, 2010; Roe *et al.*, 2012)

Urolithiasis – silica
- Breed at increased risk in case series. OR 6.7 (95% CI 5.3–8.4) compared to mixed-breed dogs in a retrospective study of 25 499 laboratory stone submissions in the USA, 1985–2006
- Males were at significantly increased risk ($p < 0.001$), representing 88.8% of submissions across all breeds

(Low *et al.*, 2010)

Urolithiasis – struvite (magnesium ammonium phosphate)

- Breed at increased risk in a retrospective study of 16 000 laboratory stone submissions, 1998–2003. Average age at diagnosis: males 6.0 years, females 5.7 years. Females predisposed (16:1 in Lhasa Apsos and other predisposed breeds)
- In a retrospective study of 14 008 uroliths from dogs in the UK, 1997–2006, OR was 4.2 (95% CI 3.51–5.02; $p < 0.0001$) compared to the national insurance database. Females predisposed

(Houston *et al.*, 2004; Roe *et al.*, 2012)

LOWCHEN (LITTLE LION DOG)

Ocular conditions

Vitreoretinopathy

- Vitreal liquefaction predisposes to retinal detachment in Lowchens

(Papaioannou & Dubielzig, 2013)

MAH THAI

See *Thai Ridgeback*

MALAMUTE

See *Alaskan Malamute*

MALTESE

Cardiovascular conditions

Mitral valve disease

- Breed at increased risk in case series
- Increased prevalence with increasing age

(Heejin Oui *et al.*, 2015)

Patent ductus arteriosus

- OR 4.14 ($p < 0.0001$) compared to hospital population in a study of 976 cases of congenital heart disease in Italy
- Females predisposed (OR 2.7)

(Oliveira *et al.*, 2011)

Ventricular septal defect

- OR 9.70 (95% CI 2.98–31.57) compared to the general hospital population, in an Australian retrospective study of 13 dogs with ventricular septal defect seen between 2001 and 2012
- Median age at diagnosis 6 months (range 2–60)

(Aherne & Beijerink, 2013)

Drug reactions

Vaccine-associated adverse effect

- In a large retrospective study in the USA (2002–2003), Maltese dogs had a mean rate of 66.8 adverse reactions per 10 000 dogs vaccinated, compared to an overall rate of 38.2 reactions per 10 000 dogs vaccinated
- Risk seemed to decrease with increasing body weight

(Moore *et al.*, 2005)

Endocrine conditions

Hypothyroidism (lymphocytic thyroiditis)

- Breed with an increased prevalence of thyroid hormone autoantibodies (THAA)
- In a cohort study of 287 948 serum samples from dogs in the USA with clinical signs of hypothyroidism, Maltese had an odds ratio of being affected of 2.25 ($p < 0.001$) compared to dogs of all other breeds
- Across the study, females were over-represented and the highest prevalence was in dogs 2–4 years old

(Nachreiner *et al.*, 2002)

Gastrointestinal conditions

Antral pyloric hypertrophy (pyloric stenosis)

- Breed at increased risk in case series
- Mean age at diagnosis 8.2 years
- Males may be predisposed

(Bellenger *et al.*, 1990)

Atresia ani

- Breed at increased risk of this rare disease: OR 13.385 compared to mixed-breed dogs
- Females predisposed: OR 1.796
- Symptoms seen at weaning

(Vianna & Tobias, 2005)

Congenital portosystemic shunt

- Maltese were in the top five breeds affected in a large USA-based retrospective study of 90 004 dogs presented to a university teaching hospital. 5.87% were affected, compared to 0.35% of mixed breeds
- Clinical signs usually seen in young dogs < 1 year

- Usually extrahepatic in the Maltese

(Tobias & Rohrbach, 2003; Hunt, 2004; Bellumori *et al.*, 2013; O'Leary *et al.*, 2014)

Haemorrhagic gastroenteritis

- Breed at increased risk in case series
- In a study of 108 dogs in Germany, 2006–2009, Maltese represented 4.6% of the affected dogs, but only 1.3% of the general hospital population
- Increased incidence in the winter months

(Mortier *et al.*, 2015)

Haematological/immunological conditions

Haemophilia B

- Severe factor IX deficiency in the Maltese
- X-linked recessive inheritance

(Brooks, 1999)

Immune-mediated haemolytic anaemia (IMHA)

- Breed at increased risk in case series
- OR 2.8 (95% CI 1.5–4.9) in a study of 110 cases in Australia
- Median age was 6 years

(McAlees, 2010)

Musculoskeletal conditions

Patellar luxation

- Mainly medial luxation observed in the Maltese
- Breed at increased risk in case series
- OR 6.5 (95% CI 4.1–10.2) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002; Alam *et al.*, 2007)

Neoplastic conditions

Mammary neoplasia

- Breed at increased risk in case series in Japan
- 28/101 dogs in the study were Maltese (higher than the breed prevalence in the area)

(Itoh *et al.*, 2005)

Testicular neoplasia

See under *Reproductive conditions*

Neurological conditions

Granulomatous meningoencephalitis

- Breed at increased risk
- Dogs over 8 years less likely to be diagnosed than younger dogs

(Granger *et al.*, 2010; Wouda, 2015)

Hydrocephalus

- Congenital
- Breed at increased risk in a retrospective series of 564 cases
- Onset of clinical signs < 3 months

(Selby *et al.*, 1979)

Necrotizing meningoencephalitis

- Breed at increased risk
- Genetic risk loci identified

(Granger *et al.*, 2010; Schrauwen *et al.*, 2014)

Shaker dog disease

- Uncommon
- Age of clinical onset < 2 years

(Bagley *et al.*, 1993)

Ocular conditions

Cataract

- Prevalence of primary cataract 3.21%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)
- However, at lower risk (OR 0.7) compared to the hospital population in a retrospective study of 561 dogs of small breeds in Korea, 2002–2007

(Gelatt & MacKay, 2005; Park *et al.*, 2009)

Renal and urinary conditions

Urolithiasis – calcium oxalate

- Breed at increased risk in case series. OR 5.2 (95% CI 4.4–6.0) compared to mixed-breed dogs, in one retrospective case series of 25 499 laboratory stone submissions in the USA, 1985–2006
- Males at increased risk ($p < 0.001$), representing 69% of submissions across all breeds
- In a Canadian case series of urolith submissions, 1998–2001, OR was 6.77 (95% CI 3.63–12.62) compared to mixed-breed dogs

(Ling *et al.*, 2003; Low *et al.*, 2010)

Reproductive conditions

Cryptorchidism

- Breed at increased risk in case series
- Congenital defect believed to be inherited as a sex-limited, autosomal recessive trait
- Retained testicles are at a higher risk of neoplasia

(Hayes *et al.*, 1985; Romagnoli, 1991)

Dystocia
- Breed at increased risk in a retrospective study of Swedish insurance data (including 195 931 bitches, 1995–2002)
- Incidence in Maltese was 11.5 cases per 1000 DYAR, compared to 5.7 cases per 1000 DYAR for the general population

(Bergström *et al.*, 2006)

Testicular neoplasia
- Breed at increased risk in case series
- May be associated with high risk of cryptorchidism

(Liao *et al.*, 2009)

MANCHESTER TERRIER

Cardiovascular conditions

Dilated cardiomyopathy (DCM)
- Rapidly progressive form identified in juvenile Toy Manchester terriers
- Affected dogs are 10–58 weeks old
- May die suddenly without prior clinical signs

(Legge *et al.*, 2013)

Haematological/immunological conditions

Haemophilia A
- Factor VIII deficiency
- X-linked recessive inheritance

(Brooks, 1999)

von Willebrand's disease (vWD)
- Possibly inherited as an autosomal recessive trait
- Mainly type I disease seen in the Manchester Terrier

(Brooks, 1999)

Musculoskeletal conditions

Avascular necrosis of the femoral head (Legg–Calvé–Perthes disease)
- Test matings have shown that this condition is inherited with high heritability in the Manchester Terrier

(Vasseur *et al.*, 1989)

Ocular conditions

Cataract
- Prevalence of primary cataract 3.81%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005)

Glaucoma – primary
- Breed at increased risk compared to overall population of dogs in a retrospective study of 9778 dogs with primary glaucoma from the VMDB, 1964–2002
- Prevalence of 2.63% in Manchester Terriers for the years 1984–1993 compared to an overall prevalence in all dogs of 0.76% in the same period

(Gelatt & MacKay, 2004a)

Glaucoma – secondary
- Breed at increased risk in case series of 217 cases in Switzerland 1995–2009

(Strom *et al.*, 2011b)

MASTIFF

See *Dogue de Bordeaux*; *Italian Mastiff*; *Neapolitan Mastiff*; *Old English Mastiff*; *Savoy Sheepdog*

MASTIFF (UNSPECIFIED)

Cardiovascular conditions

Atrial fibrillation (AF)
- Breed at increased risk in two case series
- In a retrospective report of cases from the VMDB, 1969–2007, OR was 8.34 compared to all breeds
- Males were significantly over-represented across all breeds in the series (2549 vs. 977 females)

(Menaut *et al.*, 2005; Westling *et al.*, 2008)

Drug reactions

Vaccine-associated adverse effect
- In a large retrospective study in the USA (June 2012 to March 2013), Mastiffs had a rate of 83 reactions per 10 000 dogs vaccinated, compared to an overall rate of 26.3 reactions per 10 000 dogs vaccinated

(Peng *et al.*, 2015)

Gastrointestinal conditions

Gastric dilatation/volvulus (bloat, GDV)
- Breed at increased risk in a cross-sectional study of data from a health survey of purebred

dogs conducted by questionnaires relating to the 10 years prior to 2004
- Prevalence ratio for GDV mortality was 6.8 (95% CI 4.1–11.3; $p < 0.001$) compared to all other breeds combined

(Evans & Adams, 2010b)

Musculoskeletal conditions

Cranial cruciate ligament (CCL) disease
- Breed at increased risk in a study of 201 dogs < 2 years of age

(Duval *et al.*, 1999)

Elbow dysplasia
- Breed at increased risk in case series
- Fragmented coronoid process: OR 48.4 (95% CI 26.3–89.1) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995
- Ununited anconeal process: OR 20.2 (95% CI 8.9–45.9) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Hip dysplasia
- Neutered male dogs predisposed
- OR 3.5 (95% CI 2.2–5.6) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Osteochondrosis – shoulder
- Males predisposed
- Age of onset usually 4–7 months, but can be older
- OR 11.9 (95% CI 6.1–23.2) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Osteochondrosis – stifle
- Males predisposed
- Age of onset usually 5–12 months, but may be earlier
- OR 1006.9 (95% CI 339.1–2989.5) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Osteosarcoma
See under *Neoplastic conditions*

Panosteitis (enostosis, eosinophilic panosteitis)
- Seen in rapidly growing young dogs
- OR 3.5 (95% CI 2.2–5.6) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Neoplastic conditions

Osteosarcoma
- OR 5.1 (95% CI 1.8–14.5) compared to a control population in a case–control study of 3062 cases from the VMDB, 1980–1994
- Across all breeds there was an increased incidence with age, plateauing at 10 years
- Across all breeds there was a slight predisposition for males, but an almost twofold increase for neutered dogs of both sexes

(Ru *et al.*, 1998)

Ocular conditions

Progressive retinal atrophy (PRA)
- Autosomal dominant inheritance

(Kijas *et al.*, 2003)

Renal and urinary conditions

Urolithiasis – cystine
- Breed at increased risk in case series
- Young dogs affected (2–5 years)
- Almost all cases are male

(Case *et al.*, 1992)

Reproductive conditions

Delivery by caesarean section
- In the top 10 breeds in a cross-sectional study conducted by the Kennel Club in the UK. The study found a caesarean rate of 64.9% in 79 litters of Mastiffs born over a 10-year period

(Evans & Adams, 2010a)

MCNAB SHEPHERD

Drug reactions

Ivermectin and milbemycin
- High doses can cause tremors, ataxia, coma and death
- Associated with the mutant *MDR1* allele

(Dowling, 2006)

MEXICAN HAIRLESS

Dermatological conditions

Acne

- Comedones commonly occur spontaneously in this breed

(Kimura & Doi, 1996)

Canine ectodermal dysplasia (hairlessness)

- Monogenic, autosomal semi-dominant inheritance

(Drögemüller *et al.*, 2008b)

Reproductive conditions

High perinatal mortality

- Hairless pups have a markedly lower survival rate than haired pups
- Raising the temperature of cages to a minimum of 25 °C improved survival rates

(Kimura *et al.*, 1993)

MINIATURE BULL TERRIER

Ocular conditions

Lens luxation – primary

- Estimated prevalence 7.3–15.2%
- Mutation identified
- Age of onset > 3 years

(Curtis *et al.*, 1983; Gould *et al.*, 2011; Gharahkhani *et al.*, 2012)

Reproductive conditions

Delivery by caesarean section

- In the top 10 breeds in a cross-sectional study conducted by the Kennel Club in the UK. The study found a caesarean rate of 52.4% in 42 litters of Miniature Bull Terriers born over a 10-year period

(Evans & Adams, 2010a)

MINIATURE PINSCHER

Cardiovascular conditions

Mitral valve disease

- Breed at increased risk: OR 8.75 (95% CI 3.29–23.28) in a UK study

(Thrusfield *et al.*, 1985)

Dermatological conditions

Colour dilution alopecia

- Reported in blue or fawn Dobermanns and Miniature Pinschers
- Frequency of the disease may be as high as 93% in blues and 75% in fawns
- Coat-colour genes play a role in the inheritance of this condition

(Miller, 1990a)

Demodicosis

- Miniature Pinschers are at increased risk of juvenile-onset, generalized demodicosis compared to a control hospital population, OR 2.0 (95% CI 1.3–3.1) based on a large retrospective case–control study of a US practice database
- Juvenile onset was defined as < 18 months old
- Other risk factors associated with demodicosis included pyoderma, short hair and concurrent coccidiosis

(Plant *et al.*, 2011)

Drug reactions

Vaccine-associated adverse effect

- In a large retrospective study in the USA (2002–2003), Miniature Pinschers had a mean rate of 74.6 adverse reactions per 10 000 dogs vaccinated, compared to an overall rate of 38.2 reactions per 10 000 dogs vaccinated. The risk seemed to decrease with increasing body weight
- In a second large retrospective study in the USA (June 2012 to March 2013), Miniature Pinschers had a rate of 50.8 reactions per 10 000 dogs vaccinated, compared to an overall rate of 26.3 reactions per 10 000 dogs vaccinated

(Moore *et al.*, 2005; Peng *et al.*, 2015)

Gastrointestinal conditions

Congenital portosystemic shunt

- Breed at increased risk in a retrospective case study of 2400 cases from VMDB data, 1980–2002
- OR 7.0 (95% CI 1.2–22.7) compared to mixed-breed dogs
- Female:male ratio was 1.14:1 across all breeds
- Clinical signs usually seen in young dogs < 1 year

(Tobias & Rohrbach, 2003)

Haemorrhagic gastroenteritis

- Breed at increased risk in a case–control study of 108 cases
- More cases seen in the winter months

(Mortier *et al.*, 2015)

Haematological/immunological conditions

Immune-mediated haemolytic anaemia (IMHA)

- Breed at increased risk in a study of 33 cases: OR 7.4 (95% CI 1.2–47.1) compared to control population
- Usually affects young adult and middle-aged dogs
- Females at increased risk: OR 2.1 in this study

(Miller *et al.*, 2004)

Musculoskeletal conditions

Avascular necrosis of the femoral head (Legg–Calvé–Perthes disease)

- Breed at increased risk in case series
- OR 71.5 (95% CI 31.1–164.4) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Patellar luxation

- Breed at increased risk in case series
- OR 14.4 (95% CI 5.8–35.9) compared to mixed breeds in a large retrospective series based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Ocular conditions

Cataract

- Prevalence of primary cataract 4.58%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005)

Renal and urinary conditions

Urolithiasis – calcium oxalate

- Breed at increased risk in a Canadian study of urolith submissions, 1998–2001: OR 5.03 (95% CI 2.12–11.93) compared to mixed-breed dogs

(Ling *et al.*, 2003)

Urolithiasis – cystine

- Autosomal dominant inheritance, mutation identified
- Breed at increased risk in case series. OR 9.3 (95% CI 4.0–22.0) compared to mixed-breed dogs in one retrospective case series of 25 499 laboratory stone submissions in the USA, 1985–2006. Males at increased risk ($p < 0.001$), representing 97.8% of submissions across all breeds

(Case *et al.*, 1992; Low *et al.*, 2010; Brons *et al.*, 2013)

Reproductive conditions

Eclampsia (puerperal tetany)

- Breed at increased risk in case series
- Usually seen in the first 6 weeks postpartum

(Chastain *et al.*, 2001)

MOUNTAIN DOG

See *Entlebucher Mountain Dog*; *Estrela Mountain Dog*; *Swiss Mountain Dog*

MÜNSTERLÄNDER – POINTER

Dermatological conditions

Black hair follicular dysplasia

- Seen in large Münsterländers
- Autosomal recessive inheritance
- Grey and white fur is noted at birth
- Grey hair falls out over first few months of life

(Philipp *et al.*, 2005; Von Bomhard *et al.*, 2006)

Musculoskeletal conditions

Osteochondrosis – shoulder

- OR 83.1 (95% CI 28.2–245.0) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995
- Males predisposed
- Age of onset usually 4–7 months, but can be older

(LaFond *et al.*, 2002)

Renal and urinary conditions

Urolithiasis – cystine

- Mutation identified

(Karmi *et al.*, 2010a)

NEAPOLITAN MASTIFF

Cardiovascular conditions

Dilated cardiomyopathy (DCM)

- Neapolitan Mastiffs were in the top five breeds affected in a large USA-based retrospective

case study of 90 004 dogs presented to a university teaching hospital. 6.52% were affected, compared to 0.16% of mixed breeds
(Bellumori *et al.*, 2013)

Gastrointestinal conditions

Gastric dilatation/volvulus (bloat, GDV)

- Breed at increased risk in a cross-sectional study of data from a health survey of purebred dogs conducted by questionnaire, relating to the 10 years prior to 2004
- Prevalence ratio for GDV mortality was 11.7 (95% CI 3.6–38; p 0.0012) compared to all other breeds combined

(Evans & Adams, 2010b)

Musculoskeletal conditions

Cranial cruciate ligament (CCL) disease

- Breed at increased risk in a study of 201 dogs < 2 years of age
- Neutered individuals are predisposed

(Duval *et al.*, 1999)

Hip dysplasia

- OR 4.7 (95% CI 1.7–13.2) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995
- Neutered male dogs predisposed

(LaFond *et al.*, 2002)

Panosteitis (enostosis, eosinophilic panosteitis)

- Seen in rapidly growing young dogs
- OR 2.0 (95% CI 1.2–3.5) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Ocular conditions

Ectropion

- High prevalence seen in an Italian study
- Associated with macroblepharon

(Guandalini *et al.*, 2016)

Entropion

- High prevalence seen in an Italian study
- Associated with macroblepharon

(Guandalini *et al.*, 2016)

Macroblepharon (diamond eye)

- High prevalence seen in an Italian study

(Guandalini *et al.*, 2016)

Prolapse of the gland of the nictitating membrane ('cherry eye')

- Breed at increased risk in case series

(Prémont *et al.*, 2012; Guandalini *et al.*, 2016)

NEW ZEALAND HUNTAWAY

Cardiovascular conditions

Dilated cardiomyopathy (DCM)

- In one study, a statistically significant predisposition to this disease was observed; however, only small numbers were involved
- All the Huntaway cases in this study were male
- Average age at diagnosis was 4 years

(Munday *et al.*, 2006)

Neurological conditions

Mucopolysaccharidosis IIIA

- Autosomal recessive inheritance
- Causes severe progressive CNS disease

(Yogalingam *et al.*, 2002)

NEWFOUNDLAND

Cardiovascular conditions

Aortic stenosis – subaortic stenosis (SAS)

- Breed at increased risk (OR 7.0; $p < 0.0001$) compared to the general hospital population in a retrospective study of the medical records of 976 dogs diagnosed with congenital heart disease at a cardiology clinic in Italy
- This study found a male predisposition (OR 1.7). Previous studies have found no gender difference
- In a separate retrospective review of 195 cases (1967–1991), the OR was 88.1 (95% CI 59.7–130) for the Newfoundland compared to the hospital population
- Autosomal dominant inheritance, mutation identified

(Kienle *et al.*, 1994; Oliveira *et al.*, 2011; Stern *et al.*, 2014)

Atrial fibrillation (AF)

- Breed at increased risk in a series of cases of atrial fibrillation without cardiac disease or failure
- In a separate retrospective study of VMDB data, 1969–2007, Newfoundlands had an OR

of 11.60 compared to all dogs. Male dogs were over-represented
(Menaut *et al.*, 2005; Westling *et al.*, 2008)

Dilated cardiomyopathy (DCM)
- Autosomal dominant inheritance with late onset
- Males predisposed
- Median age of onset 5 years

(Tidholm & Jonsson, 1996, 1997; Wiersma *et al.*, 2008)

Patent ductus arteriosus
- Breed at increased risk in case series
- OR 4.65 ($p < 0.001$) compared to the general hospital population in a retrospective study of the medical records of 976 dogs diagnosed with congenital heart disease at a cardiology clinic in Italy

(Oliveira *et al.*, 2011)

Dermatological conditions
Atopic dermatitis (atopy)
- In a study of insured Swedish dogs (1995–2002), Newfoundlands had an incidence of 3.8 cases per 1000 DYAR, compared to 1.7 cases per 1000 DYAR for all dogs in the study
- Birth in autumn or summer is a predisposing factor
- Dogs between 1 and 2 years of age have the highest probability of an insurance claim for atopy
- Some studies show no sex predilection, others show females predisposed

(Nødtvedt *et al.*, 2006)

Pemphigus foliaceus
- Breed at increased risk in case series
- Mean age of onset 4.2 years

(Ihrke *et al.*, 1985)

Gastrointestinal conditions
Acquired megaoesophagus
- May be seen secondary to myasthenia gravis and inflammatory myopathy in Newfoundlands

(Evans *et al.*, 2004)

Exocrine pancreatic insufficiency (EPI)
- Breed at increased risk in case series

(Williams & Minnich, 1990)

Gastric dilatation/volvulus (bloat, GDV)
- Breed at increased risk in a cross-sectional study of data from a health survey of purebred dogs conducted by questionnaire, relating to the 10 years prior to 2004
- Prevalence ratio for GDV mortality was 2.3 (95% CI 1.4–3.8; $p = 0.0016$) compared to all other breeds combined

(Evans & Adams, 2010b)

Musculoskeletal conditions
Acquired myasthenia gravis
See under *Neurological conditions*

Bone tumour
See under *Neoplastic conditions*

Cranial cruciate ligament (CCL) disease
- Breed at increased risk in a study of 201 dogs < 2 years of age
- Breed at highest risk in a separate retrospective study of VMDB cases, 1964–2003: OR 3.77 (95% CI 3.4–4.18; $p < 0.001$) compared to all other dogs. Neutered dogs of both sexes and dogs > 4 years old of all breeds combined were found to be at increased risk
- Newfoundlands were also found to be at highest risk of having both cranial cruciate disease and hip dysplasia: OR 10.01 (95% CI 8.33–12.02)
- An autosomal recessive mode of inheritance with 51% penetrance has been suggested

(Duval *et al.*, 1999; Wilke *et al.*, 2006; Witsberger *et al.*, 2008)

Elbow dysplasia
- Increased risk of osteochondrosis of the elbow: OR 261 (95% CI 107.1–635.8) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995
- Increased risk of fragmented coronoid process: OR 10.9 (95% CI 5.0–24.0) compared to mixed breeds in the same study
- Increased risk of ununited anconeal process: OR 13.8 (95% CI 7.1–26.8) compared to mixed breeds in the same study

(LaFond *et al.*, 2002)

Hip dysplasia
- Breed at highest risk in case series: OR 5.77 (95% CI 5.35–6.21; $p < 0.001$) compared to all

other dogs in a retrospective study of VMDB cases 1964–2003. Neutered male dogs and dogs < 4 years of age of all breeds combined were found to be at increased risk
- Newfoundlands were also found to be at the highest risk of having both cranial cruciate disease and hip dysplasia: OR 10.01 (95% CI 8.33–12.02)

(Witsberger *et al.*, 2008; Krontveit *et al.*, 2010)

Myopathy – inflammatory
- Significantly over-represented in a study of 200 cases in the USA. Newfoundlands represented 9.5% of the cases but only 0.26% of AKC registrations
- Mean age at diagnosis 2.1 years

(Evans *et al.*, 2004)

Osteochondrosis – shoulder
- Breed at increased risk in case series: OR 18.7 (95% CI 12–29.2) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995
- Young males predisposed

(LaFond *et al.*, 2002)

Panosteitis (enostosis, eosinophilic panosteitis)
- Seen in rapidly growing young dogs
- Breed at increased risk in case series: OR 1.9 (95% CI 1.3–2.8) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Neoplastic conditions

Bone tumour
- Breed at high risk of malignant bone tumours in one study of Swedish insurance data (1995–2002). Newfoundlands had an overall incidence of 22 cases (95% CI 11–32) per 10 000 DYAR, compared to the risk in all dogs combined of 5.5 cases per 10 000 DYAR
- Males over-represented
- Median age was 8.2 years in Newfoundlands; risk increases with increasing age

(Egenvall *et al.*, 2007)

Neurological conditions

Acquired myasthenia gravis
- Familial predisposition

(Lipsitz *et al.*, 1999)

Ocular conditions

Eversion of the cartilage of the nictitating membrane
- Inheritance suspected
- Usually occurs in young dogs

(Allbaugh & Stuhr, 2013)

Glaucoma – primary
- Breed at increased risk in a retrospective study of 123 cases in Switzerland, 1995–2009
- Age at presentation 6.8 ± 2.5 years

(Strom *et al.*, 2011a)

Renal and urinary conditions

Ectopic ureter
- Breed at increased risk in a case series: OR 12.6 (95% CI 5.0–29.6) compared to a control population in a retrospective study of cases in North American teaching hospitals, 1964–1981
- Usually presents < 1 year of age
- More commonly diagnosed in females

(Hayes, 1984)

Urolithiasis – cystine
- Breed at increased risk in case series: OR 12.6 (95% CI 6.9–22.6) compared to mixed-breed dogs in a retrospective case series of 25 499 uroliths in the USA, 1985–2006
- Presents earlier in Newfoundlands than in other breeds (from 6 months to 1 year)
- Males and females are both affected in this breed, but only males are seen with urinary obstruction

(Case *et al.*, 1992; Casal *et al.*, 1995; Low *et al.*, 2010)

NORFOLK TERRIER

Cardiovascular conditions

Mitral valve disease
- In a study of 48 apparently healthy Norfolk Terriers 6 years and older, 48% had a heart murmur and 85% had echocardiographic evidence of degenerative mitral valve disease

(Trafny *et al.*, 2012)

Dermatological conditions

Epidermal hyperkeratosis
- Autosomal recessive mode of inheritance
- Clinical signs noted at birth

(Barnhart *et al.*, 2004)

Renal and urinary conditions

Urolithiasis – calcium oxalate

- Breed at increased risk. OR 9.69 (95% CI 7.02–13.37; $p < 0.0001$) compared to the national insurance database in a retrospective study of 14 008 uroliths from dogs in the UK, 1997–2006
- Males predisposed

(Roe *et al.*, 2012)

Urolithiasis – struvite (magnesium ammonium phosphate)

- Breed at increased risk. OR 2.39 (95% CI 1.55–3.69; $p < 0.0001$) compared to the national insurance database in a retrospective study of 14 008 uroliths from dogs in the UK, 1997–2006
- Females predisposed

(Roe *et al.*, 2012)

Reproductive conditions

Dystocia

- Breed at increased risk in a retrospective study of Swedish insurance data including 195 931 bitches, 1995–2002
- Incidence in Norfolk Terriers was 13.6 cases per 1000 DYAR, compared to 5.7 cases per 1000 DYAR for the general population

(Bergström *et al.*, 2006)

NORWEGIAN BUHUND

Behavioural conditions

Noise sensitivity

- Highest frequency of noise sensitivity of 17 breeds in a web-based survey of owners in Norway
- Fearfulness increased with age, and was greater in females (OR 1.3) and in neutered dogs (OR 1.73)

(Storengen & Lingaas, 2015)

Ocular conditions

Cataract

- Autosomal dominant inheritance
- In studies, approximately 50% of the breed have been found to be affected
- Age of onset 6 weeks. Rate of progression varies
- Localization: starts as small dots and progresses to involve the whole fetal nucleus at 4–5 years. Pulverulant ('candyfloss') appearance
- Norwegian Sheepdogs also suffer with posterior polar and cortical cataracts

(Bjerkås & Haaland, 1995; Kristiansen *et al.*, 2017)

NORWEGIAN ELKHOUND

Endocrine conditions

Diabetes mellitus

- Breed at increased risk of diabetes in dioestrus and pregnancy
- Almost all cases in the Norwegian Elkhound are female

(Fall *et al.*, 2007)

Gastrointestinal conditions

Gastric carcinoma

See under *Neoplastic conditions*

Haematological/immunological conditions

Selective IgA deficiency

- Breed at increased risk in case series
- 21% of 14 Norwegian Elkhounds were found to have low serum IgA (<0.07 g/l) in one 2014 study
- Immunodeficiency is associated with recurrent infections of mucosal sites and increased susceptibility to immune-mediated disease

(Olsson *et al.*, 2014)

Musculoskeletal conditions

Hip dysplasia

- Breed at increased risk in case series: OR 2.3 (95% CI 1.5–3.6) compared to mixed-breed dogs in a large retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002)

Norwegian Elkhound chondrodysplasia

- Inherited as an autosomal recessive trait
- Shortened body and disproportionately short limbs

(Bingel & Sande, 1982; Kyöstilä *et al.*, 2013)

Neoplastic conditions

Gastric carcinoma

- Breed at increased risk in a retrospective study of data from the Norwegian Canine Cancer Register, 1998–2009
- Males at increased risk: OR 2.3 (all breeds combined)
- Median age 10 years (all breeds combined)

(Seim-Wikse *et al.*, 2013)

Intracutaneous cornifying epithelioma (keratoacanthoma)
- Predisposed to the generalized form (up to 40 growths)
- Mean age 7.3 years

(Stannard & Pulley, 1975)

Ocular conditions

Glaucoma – primary
- Inheritance suspected, mutation identified
- Most primary cases appear to be open-angle
- Lens luxation may occur secondary to glaucoma
- Often only diagnosed in middle-aged and older dogs
- Breed at increased risk compared to overall population of dogs in a retrospective study of 9778 dogs with primary glaucoma from the VMDB, 1964–2002
- Prevalence was 1.98% in Norwegian Elkhounds for the years 1994–2002, compared to an overall prevalence in all dogs of 0.89% over the same period
- Prevalence was 2.34% in Norwegian Elkhounds for the years 1984–1993, compared to an overall prevalence in all dogs of 0.76% over the same period

(Gelatt & MacKay, 2004a, Oshima *et al.*, 2004; Ahonen *et al.*, 2014)

Lens luxation – secondary
- Occurs secondary to glaucoma

(Ahonen *et al.*, 2014)

Progressive retinal atrophy (PRA)
- Autosomal recessive inheritance
- Early retinal degeneration
- Night blindness at 6 weeks followed by total vision loss at 12–18 months

(Acland & Aguirre, 1987)

Renal and urinary conditions

Familial renal disease (familial nephropathy)
- Mode of inheritance unknown
- Norwegian Elkhounds suffer with periglomerular and interstitial fibrosis. Dogs may present in renal failure from a few months to 5 years of age. Primary renal glycosuria is present in some cases

(Finco *et al.*, 1977; Wiersma *et al.*, 2005)

NORWEGIAN LUNDEHUND

Dermatological conditions

Alopecia
- A non-infectious spontaneous multifocal alopecia has been seen in approximately 11.7% of Norwegian Lundehund in Sweden
- Median age of onset 1.5 years

(Bergvall & Shokrai, 2014)

Gastrointestinal conditions

Chronic atrophic gastritis
- Associated with gastric neoplasia and lymphangiectasia (see below)

(Qvigstad *et al.*, 2008)

Gastric neoplasia
- Breed at increased risk of gastric neuroendocrine carcinoma
- Seen associated with chronic atrophic gastritis and lymphangiectasia (see below)

(Qvigstad *et al.*, 2008)

Inflammatory bowel disease
- Associated with lymphangiectasia (see below)

(Landsverk & Gamlem, 1984; Kolbjørnsen *et al.*, 1994)

Lymphangiectasia (resulting in protein-losing enteropathy)
- Breed at increased risk
- Specific syndrome in this breed associated with chronic atrophic gastritis, gastric neoplasia and lymphocytic-plasmacytic enteritis

(Landsverk & Gamlem, 1984; Kolbjørnsen *et al.*, 1994)

Musculoskeletal conditions

Joint flexibility
- Extreme flexibility seen in all joints (including the spine)

(Pfahler & Distl, 2015)

Polydactyly
- Affects all four limbs. Often six toes per foot

(Pfahler & Distl, 2015)

NORWEGIAN SHEEPDOG

See *Norwegian Buhund*.

NORWICH TERRIER

Gastrointestinal conditions

Congenital portosystemic shunt

- Norwich Terriers were among the top five breeds affected in a large USA-based retrospective study of 90 004 dogs presented to a university teaching hospital. 7.4% of Norwich Terriers were affected, compared to 0.35% of mixed breeds

(Bellumori *et al.*, 2013)

Musculoskeletal conditions

Paroxysmal dyskinesia

- In a study of 195 Norwich Terriers, 13% were affected
- Mean age at first episode was 3 years

(De Risio *et al.*, 2016a)

Ocular conditions

Cataract

- Prevalence of primary cataract 4.02%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005)

Respiratory conditions

Brachycephalic obstructive airway syndrome (BOAS)

- Breed at increased risk
- In a prospective study of 16 dogs, 12 had upper respiratory symptoms, and 11 of these were found to have abnormalities of the laryngeal opening including everted laryngeal saccules, laryngeal collapse and narrow laryngeal opening

(Johnson *et al.*, 2013)

NOVA SCOTIA DUCK TOLLING RETRIEVER

Endocrine conditions

Hypoadrenocorticism (Addison's disease)

- Autosomal recessive inheritance
- Autoimmune basis suspected
- Early onset (median age 3 years) in this breed
- Females may be predisposed

(Hughes *et al.*, 2007, 2010)

Haematological/immunological conditions

Selective IgA deficiency

- Breed at increased risk in case series
- 20% of 11 Nova Scotia Duck Tolling Retrievers were found to have a low serum IgA (<0.07 g/l) in one 2014 study
- Immunodeficiency is associated with recurrent infections of mucosal sites and increased susceptibility to immune-mediated disease

(Olsson *et al.*, 2014)

Musculoskeletal conditions

Immune-mediated rheumatic disease (IMRD)

- Breed at increased risk. In a study of Swedish insurance data, 1995–2006 this breed was 18 times more likely to suffer with IMRD than all other breeds combined
- Incidence 6.8 cases per 10 000 DYAR
- In one study, 70% of cases were antinuclear antibody (ANA)-positive, and some showed immune-mediated skin changes
- Dogs were mostly middle-aged

(Hansson-Hamlin & Lilliehöök, 2009; Bremer *et al.*, 2015)

Neoplastic conditions

Lymphoma

- Breed at increased risk. In a study of Swedish insurance data, 1995–2006, this breed was 2.8 times more likely to suffer with lymphoma than all other breeds combined
- Incidence 15 cases per 10 000 DYAR

(Bremer *et al.*, 2015)

Neurological conditions

Degenerative encephalopathy

- Autosomal recessive inheritance suspected
- Symptoms are present at 2 months to 5 years, are progressive, and include movement during sleep, increased anxiety, noise phobia and gait abnormalities

(Barker *et al.*, 2016)

Steroid-responsive meningitis–arteritis (SRMA)

- Breed at increased risk. In a study of Swedish insurance data, 1995–2006, this breed was 12 times more likely to suffer with steroid-responsive meningitis-arteritis than all other breeds combined

- Incidence 20 cases per 10 000 DYAR
- Dogs were mostly young

(Hansson-Hamlin & Lilliehöök, 2013; Bremer *et al.*, 2015)

OGAR POLSKI

See *Polish Hound*

OLD ENGLISH MASTIFF

Neurological conditions

Primary brain tumour – oligodendroglioma

- Breed at significantly increased risk compared to the general population in a study of post-mortem results of 435 dogs with intracranial neoplasia

(Song *et al.*, 2013)

Ocular conditions

Progressive retinal atrophy (PRA)

- Autosomal dominant inheritance

(Vilboux *et al.*, 2008)

OLD ENGLISH SHEEPDOG (OESD)

Cardiovascular conditions

Atrial fibrillation (AF)

- Breed at increased risk: OR 3.0 in a review of VMDB data, 1969–2007, compared to all dogs
- Males were significantly over-represented across all breeds

(O'Grady *et al.*, 2008; Westling *et al.*, 2008)

Dermatological conditions

Demodicosis

- Breed at increased risk: RR 28.9 in a Canadian study, 1987–1988, compared to hospital population
- Lesions may be confined to the paws in OESDs

(Scott & Paradis, 1990)

Drug reactions

Ivermectin and milbemycin

- In a UK study, 11% of OESDs were found to have the *MDR1* mutation which has been associated with multiple drug sensitivity

(Tappin *et al.*, 2012)

Endocrine conditions

Hypothyroidism (lymphocytic thyroiditis)

- Breed with a higher prevalence of thyroid hormone autoantibodies (THAA)
- In a cohort study of 287 948 serum samples from dogs in the USA with clinical signs of hypothyroidism, OESD had an OR of 2.65 ($p < 0.001$) of being affected compared to dogs of all other breeds

(Nachreiner *et al.*, 2002)

Haematological/immunological conditions

Immune-mediated haemolytic anaemia (IMHA)

- Breed at increased risk. In a study of 24 cases, 33% were OESDs (however other studies have failed to confirm a predisposition in this breed)
- Most cases were ANA-positive, suggesting a multi-system autoimmune syndrome
- Usually affects young adult and middle-aged animals
- May be more common in bitches

(Mills *et al.*, 1985)

Musculoskeletal conditions

Hip dysplasia

- Breed at increased risk in case series
- OR 3.46 (95% CI 3.21–3.74) compared to all other dogs in a large retrospective study of VMDB cases, 1964–2003. Male neutered dogs and dogs < 4 years of age of all breeds combined were found to be at increased risk
- OR 7.1 (95% CI 4.1–12.4) compared to mixed breeds in a separate retrospective study based on cases recorded in the VMDB, 1986–1995

(LaFond *et al.*, 2002; Witsberger *et al.*, 2008)

Osteochondrosis – shoulder

- Breed at increased risk in case series. OR 7.1 (95% CI 4.1–12.4) compared to mixed breeds in a large retrospective study based on cases recorded in the VMDB, 1986–1995
- Young males predisposed

(LaFond *et al.*, 2002)

Neoplastic conditions

Oral neoplasia

- Breed at increased risk (compared to the hospital population) in a retrospective case series in the USA, 1980–1987
- Median age across all breeds was 10 years

- 62% of all affected dogs were > 20 kg, and 54% of all affected dogs were female

(Schwarz *et al.*, 1991)

Thyroid neoplasia

- Breed affected more frequently than expected in a series of 30 cases in the UK

(Sullivan *et al.*, 1987a)

Primary brain tumour

See under *Neurological conditions*

Neurological conditions

Cerebellar degeneration

- Autosomal recessive inheritance
- Late onset
- Slowly progressive

(Steinberg *et al.*, 2000)

Primary brain tumour

- Breed at increased risk in case series. In a USA retrospective study of 86 cases, 1983–1988, OESDs accounted for 4% of cases but < 1% of the hospital population. In more recent studies of 173 cases and 435 cases, an increased risk was not observed
- Older dogs affected; median age 9 years

(Heidner *et al.*, 1991; Snyder *et al.*, 2006; Song *et al.*, 2013)

Ocular conditions

Cataract

- Breed at increased risk in case series
- Prevalence of primary cataract 2.61%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Koch, 1972; Gelatt & MacKay, 2005)

Renal and urinary conditions

Urethral sphincter mechanism incompetence

- Breed at increased risk in case series; OESDs were the most commonly affected breed (8/60) in a retrospective review in the UK 1973–1983
- Spayed females predisposed

(Holt, 1985; Holt & Thrusfield, 1993)

Urolithiasis – silica

- Breed at increased risk in case series
- Males significantly over-represented

(Aldrich *et al.*, 1997)

Reproductive conditions

Cryptorchidism

- Congenital defect believed to be inherited as a sex-limited, autosomal recessive trait
- Breed at increased risk in case series

(Hayes *et al.*, 1985; Romagnoli, 1991)

Respiratory conditions

Primary ciliary dyskinesia

- Recessively inherited, mutation identified
- One study of 578 OESDs including 28 affected dogs suggested a carrier frequency of 19% in European dogs and 7% in non-European dogs

(Merveille *et al.*, 2014)

OTTERHOUND

Gastrointestinal conditions

Gastric dilatation/volvulus (bloat, GDV)

- Breed at increased risk in a cross-sectional study of data from a health survey of purebred dogs conducted by questionnaire, relating to the 10 years prior to 2004
- Prevalence ratio for GDV morbidity was 13.1 (95% CI 5.601–30.40; $p < 0.0001$) compared to all other breeds combined, making it one of the four breeds with highest morbidity

(Evans & Adams, 2010b)

Haematological/immunological conditions

Hereditary thrombopathy

- A genetic platelet defect inherited as an autosomal recessive trait. Mutation identified
- Similar to Glanzmann's thrombasthenia in humans

(Boudreaux & Lipscomb, 2001)

PAPILLON

Musculoskeletal conditions

Patellar luxation

- Mainly medial luxation observed, often bilateral
- 3.1% of US referred Papillons affected
- Papillon has an OR of 8.4 (95% CI 3.4–20.7) in the USA and is over-represented in Korea

(LaFond *et al.*, 2002; Alam *et al.*, 2007; Orthopedic Foundation for Animals, 2015)

Neoplastic conditions

Mammary neoplasia

- Papillon had an incidence of 158 cases 10 000 DYAR compared with 116 per 10 000 DYAR in crossbreeds among insured entire bitches in Sweden

(Egenvall *et al.*, 2005)

Neurological conditions

Idiopathic epilepsy

- Hereditary basis established in several breeds
- Papillon had an incidence of 23.4 per 10 000 DYAR (95% CI 17.8–29.0) among insured dogs in Sweden, compared with 16.1 (95% CI 14.7–17.4) for crossbreeds
- Papillon had 3.40% prevalence, compared with 0.91% for crossbreeds in a US referral study

(Bellumori *et al.*, 2013; Heske *et al.*, 2014)

Intervertebral disc disease (IVDD)

- Males and older dogs predisposed
- Papillon had an incidence rate of 39.5 per 10 000 DYAR (95% CI 32.2–46.9), compared with 27.8 for an overall population of insured dogs in Sweden

(Bergknut *et al.*, 2012)

Necrotizing meningoencephalitis

- Identified in a US Papillon

(Cooper *et al.*, 2014b)

Neuroaxonal dystrophy

- Group of neurodegenerative disorders characterized by severe degeneration of neuronal cells and their processes; can be familial
- Onset from 8 weeks, with euthanasia or death before 12 months
- Several reports in Papillons

(Franklin *et al.*, 1995; Diaz *et al.*, 2007; Nibe *et al.*, 2007, 2009)

Ocular conditions

Progressive retinal atrophy (PRA)

- Autosomal recessive disease in Papillons
- Late onset reported in Papillons in Sweden
- Frameshift mutation identified in the Papillon and its Phalene variant
- 17.8% of Papillons affected in a Swedish study

(Narfström & Ekesten, 1998; Narfström & Wrigstad, 1999; Ahonen *et al.*, 2013; Winkler *et al.*, 2013)

Physiological conditions

Litter size

- Smaller litters associated with older bitches and smaller breeds
- Papillon had the eleventh smallest mean litter size (3.3 puppies) among registered breeds in Norway

(Borge *et al.*, 2011)

Renal and urinary conditions

Urolithiasis – calcium oxalate

- Small breeds and males are predisposed
- Papillon had OR 9.85 compared to crossbreeds in the USA

(Lekcharoensuk *et al.*, 2000a)

Kidney disease

- Papillon had an incidence of 28 (95% CI 22–34) cases per 10 000 DYAR, compared with 15.8 overall among insured dogs in Sweden

(Pelander *et al.*, 2015)

PARSON RUSSELL TERRIER

Neoplastic conditions

Mast cell tumour (MCT)

- Parson Russell Terrier had the highest breed RR (15.29) using laboratory records in the USA
- Parson Russell Terrier had an OR significantly above 1.0 ($p < 0.05$) compared with crossbreeds from a cancer registry in Switzerland

(Grüntzig *et al.*, 2016; Mochizuki *et al.*, 2016)

Neurological conditions

Spinocerebellar ataxia (hereditary ataxia)

- Incoordination noticed from 2–9 months of age
- Progressive and often leads to euthanasia
- Missense mutation in the *CAPN1* gene, and mutation in *KCNJ10*, identified in the Parson Russell Terrier

(Forman *et al.*, 2013; Rohdin *et al.*, 2015)

Ocular conditions

Glaucoma – secondary

- High intraocular pressure due to primary intraocular diseases that impede aqueous humor flow

- Parson Russell Terrier has the highest standardized morbidity ratio (7.1) compared with an overall referral population in the USA

(Johnsen *et al.*, 2006)

Lens luxation – primary

- *ADAMTS17* mutation has been identified: 24.53% of UK and 22.40% of US Parson Russell Terriers were carriers

(Gould *et al.*, 2011)

Renal and urinary conditions

Hyperuricosuria

- Parson Russell Terrier has 7.75% prevalence of carriers for the mutation in the USA

(Karmi *et al.*, 2010a)

PEKINGESE

Behavioural conditions

Aggression

- Pekingese had 1.56 times the risk of attacking children in Austria compared with the overall population

(Schalamon *et al.*, 2006)

Dental conditions

Abnormal dentition

- The most common specific problems among affected dogs overall were polyodontia (33.2%), retained deciduous teeth (19.7%) and prognathism (10.0%)
- Pekingese comprised the third-highest proportion (15.4%) of an affected caseload aged 7–18 months in Bulgaria

(Borissov *et al.*, 2004)

Gastrointestinal conditions

Congenital portosystemic shunt

- Referred Pekingese (0.36% prevalence) had an OR of 7.1 (95% CI 3.7–13.8) compared with an overall US referral population

(Tobias & Rohrbach, 2003)

Metabolic conditions

Overweight/obesity

- 51.9% of Pekingese attending veterinary clinics in China were obese

(Courcier *et al.*, 2010; Mao *et al.*, 2013; Raffan *et al.*, 2016)

Musculoskeletal conditions

Chondrodysplasia (short-limbed or disproportional dwarfism)

- Defining Pekingese breed characteristic
- An *fgf4* retrogene identified as a cause of chondrodysplasia

(Israel *et al.*, 2009; Parker *et al.*, 2009)

Patellar luxation

- Mainly medial luxation observed, often bilateral
- OR 3.4 (95% CI 2.7–5.9) in the USA compared with crossbreeds

(LaFond *et al.*, 2002; Orthopedic Foundation for Animals, 2015)

Neurological conditions

Atlantoaxial subluxation/instability

- Congenital or developmental condition
- Young small-breed dogs affected
- Pekingese comprised 10.5% and 8.7% of two US case-study populations

(Beaver *et al.*, 2000; Platt *et al.*, 2004)

Hemivertebrae (wedge-shaped vertebrae)

- Assumed to be highly heritable
- 100% of Pekingese affected

(Schlensker & Distl, 2013)

Intervertebral disc disease (IVDD)

- Pekingese had 20.59% prevalence, compared with 4.43% for crossbreeds in a US referral caseload
- Pekingese comprised 3.8% of a cervical IVDD caseload and 3.6% of a thoracolumbar IVDD caseload at a Japanese referral hospital
- Pekingese comprised 3.8% and 2.9% of two US referral IVDD caseloads, and 31.9% of a referral population in Turkey
- Pekingese had RR 3.5 ($p < 0.01$) compared with an overall referral population in the USA
- Pekingese was significantly ($p < 0.01$) over-represented, comprising 4.67% of referral cases, in the Czech Republic

(Priester, 1976; Nečas, 1999; Bartels *et al.*, 2003; Besalti *et al.*, 2006; Itoh *et al.*, 2008; Israel *et al.*, 2009; Bellumori *et al.*, 2013)

Ocular conditions

Bacterial keratitis

- Pekingese had OR 122.4 (95% CI 24.1–620.5) compared with a US referral population, and comprised 13.2% of referral cases in Serbia

(Tolar *et al.*, 2006; Hadži-Milić *et al.*, 2013)

Cataract
- 28% of cataracts reported as breed-related in France
- Prevalence of primary cataract 2.14%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005; Donzel *et al.*, 2016)

Corneal ulceration (ulcerative keratitis)
- Pekingese showed 19.3% prevalence of corneal ulceration among ophthalmic referrals in South Africa
- Pekingese was the second commonest breed, comprising 25% of a referral caseload, in South Korea

(Petrick, 1996; Kim *et al.*, 2009)

Epiphora
- Associated with anatomical features such as medial canthal entropion, trichiasis, tight medial palpebral ligament and close apposition of the eyelids to the globe
- Pekingese comprised 17.4% of a surgical referral caseload in Korea

(Yi *et al.*, 2006)

Glaucoma – primary
- Pekingese had 1.22% prevalence in a US referral population, 1994–2002

(Gelatt & MacKay, 2004a)

Renal and urinary conditions

Renal calculi
- May be associated with urinary tract infections
- OR 8.27 ($p < 0.001$) in females and OR 3.97 ($p = 0.054$) in males compared with crossbred dogs in a US referral study

(Ling *et al.*, 1998c)

Urolithiasis – apatite
- OR 5.5 (95% CI 4.6–6.5) compared with crossbred dogs in the USA
- Females are predisposed

(Low *et al.*, 2010)

Urolithiasis – silica
- OR 4.4 (95% CI 2.8–7.0) compared with crossbred dogs in the USA, and OR 3.3 ($p < 0.001$) compared with all dogs in another US study

(Aldrich *et al.*, 1997; Low *et al.*, 2010)

Urolithiasis – struvite (magnesium ammonium phosphate)
- OR 5.3 (95% CI 4.5–6.1) compared with crossbred dogs in the USA, and OR 12.3 (95% CI 8.8–17.2) compared with all dogs in the UK
- Small breeds and males are predisposed

(Low *et al.*, 2010; Roe *et al.*, 2012)

Urolithiasis – urate
- OR 7.2 (95% CI 5.8–9.0) compared with crossbred dogs in the USA
- Younger and female animals predisposed

(Low *et al.*, 2010)

Reproductive conditions

Cryptorchidism
- Pekingese had RR 1.9 (95% CI 1.5–2.5) compared with an overall US referral population

(Hayes *et al.*, 1985)

Dystocia
- 43.8% of Pekingese litters born by caesarean section in the UK

(Evans & Adams, 2010a)

Respiratory conditions

Brachycephalic obstructive airway syndrome (BOAS)
- Pekingese had a prevalence of 20.0% among referral dogs in Belgium

(Njikam Nsangou *et al.*, 2009; Roedler *et al.*, 2013; Marchant *et al.*, 2017)

Tracheal collapse
- Common cause of cough in mature, small-breed dogs
- Pekingese comprised 15.5% of a referral caseload in Korea

(Eom *et al.*, 2008)

Soft-tissue conditions

Perineal herniation
- Pekingese comprised 10.0% of referral cases in Croatia

(Vnuk *et al.*, 2008)

PETIT BASSET GRIFFON VENDEEN

Endocrine conditions

Hypothyroidism
- Females and younger dogs are predisposed to having serum thyroid hormone autoantibodies (THAA) that are associated with hypothyroidism

- Petit Basset Griffon Vendeen had OR 2.16 ($p = 0.036$) for THAA compared with all other breeds in the USA

(Nachreiner *et al.*, 2002)

Neoplastic conditions

Mast cell tumour (MCT)

- Mean age at presentation 7.5–9 years, but can occur at any age
- OR 5.1 (95% CI 1.4–18.1) compared with crossbred dogs in the USA

(Goldschmidt & Mcmanus, 2000)

Ocular conditions

Glaucoma – primary

- Prevalence of 10.4% among Petit Basset Griffon Vendeen formally screened in the UK
- Presents from 3 years of age onwards
- Considered to be genetically determined in this breed

(Bedford, 2017)

Neurological conditions

Idiopathic epilepsy

- Prevalence of 8.9% (95% CI 6.3–11.5) in Petit Basset Griffon Vendeen registered with Danish Kennel Club
- Median age at onset of 24 months in this breed
- Hereditary component supported in this breed

(Gulløv *et al.*, 2011)

Physiological conditions

High prevalence of electrocardiographic J waves

- The J wave is a positive deflection at the J point in the ECG and can be classified as notched, slurred or undetermined
- J waves may be considered a normal variant on the canine ECG and should not be interpreted as cardiac disease
- The overall prevalence of J waves in Petit Basset Griffon Vendeen was 91% was significantly higher ($p < 0.05$) than the 43% in other breeds in Denmark

(Rudling *et al.*, 2016)

PHU QUOC RIDGEBACK

Physiological conditions

Webbed feet

- Breed comes from Phu Quoc Island in Vietnam's southern Kien Giang Province
- Has webbing between all main digits
- May be an adaptation for an aquatic environment

(Dang *et al.*, 2017)

PINSCHER – MINIATURE

See *Miniature Pinscher*

POINTER (INCLUDING GERMAN SHORT-HAIRED, GERMAN WIRE-HAIRED, ENGLISH)

Dermatological conditions

Blastomycosis

See under *Infectious conditions*

Cutaneous neoplasia

See under *Neoplastic conditions*

Exfoliative cutaneous lupus erythematosus (ECLE)

- Age of onset from 6 months to 2.75 years
- The prognosis is poor because of failure to respond or complications associated with treatment
- Characterized in German Short-haired Pointers from primary and referral veterinary practices in the USA, UK and Australia

(Bryden *et al.*, 2005)

Familial cutaneous lupus erythematosus (CLE)

- Typically presents before 10 months of age
- Therapy is rarely rewarding and cases often lead to euthanasia
- Simple autosomal recessive mode of inheritance identified
- 8.5% of a US targeted sample of German Short-haired Pointers were affected

(Wang *et al.*, 2011)

Hereditary lupoid dermatosis (exfoliative cutaneous lupus erythematosus)

- Autosomal recessive or polygenic recessive inheritance suggested
- Characterized in German Short-haired Pointer across several countries

(Bryden *et al.*, 2005)

Junctional epidermolysis bullosa (JEB)

- Recessive inherited blistering disorder of the skin and mucous membranes

- Genetic basis identified in the German Shorthaired Pointer

(Capt *et al.*, 2005)

Malassezia dermatitis

- German Short-haired Pointer had the seventh-highest prevalence (4.1%) in a dermatology referral caseload in Romania

(Mircean *et al.*, 2010)

Drug reactions

Anaesthetic-related complications

- German Short-haired Pointer had 5% incidence among general small animal practices in Canada

(Dyson *et al.*, 1998)

Endocrine conditions

Hypothyroidism

- Females and younger dogs are predisposed to having serum thyroid hormone autoantibodies (THAA) that are associated with hypothyroidism
- Pointer (unspecified) had OR 3.61 ($p=0.001$), English Pointer OR 3.31 ($p=0.01$), and German Wire-haired Pointer OR 2.72 ($p=0.01$) for THAA compared with all other breeds in the USA

(Nachreiner *et al.*, 2002)

Gastrointestinal conditions

Primary hepatitis

- Multiple causes including microorganisms, toxins and drugs, immune-mediated reactions and breed-associated metabolic errors
- Females predisposed ($p<0.01$)
- German Pointer was over-represented in a referral population in the Netherlands

(Poldervaart *et al.*, 2009)

Haematological/immunological conditions

von Willebrand's disease (vWD)

- German Short-haired and German Wire-haired Pointers affected by type II disease
- Polymerase chain reaction (PCR) test developed

(Kramer *et al.*, 2004)

Infectious conditions

Blastomycosis

- Young, large-breed dogs predisposed
- Pointer (unspecified) was at increased risk compared with referral crossbred dogs in the USA

(Rudmann *et al.*, 1992; Arceneaux *et al.*, 1998)

Musculoskeletal conditions

Cranial cruciate ligament (CCL) disease

- Estimated heritability of 0.48 and a highly polygenic complex trait
- German Short-haired Pointer had an OR of 1.20 (95% CI 1.06–1.35) compared with an overall referral population in the USA
- German Short-haired Pointer had 5.63% prevalence, compared with 1.58% overall in referred dogs in the Czech Republic

(Nečas *et al.*, 2000; Witsberger *et al.*, 2008; Baker *et al.*, 2017)

Enchondrodystrophy

- Inherited dwarfism in English Pointers
- 3.3% of English Pointers affected in an older UK study

(Whitbread *et al.*, 1983)

Hip dysplasia

- German Wire-haired Pointer had 9.2% prevalence in the USA
- German Wire-haired Pointer had OR 7.1 (95% CI 3.3–15.1) and Pointer (unspecified) OR 2.4 (95% CI 1.4–4.2) compared with crossbred dogs in the USA

(LaFond *et al.*, 2002; Ginja *et al.*, 2010; Orthopedic Foundation for Animals, 2016)

Osteochondrosis – shoulder

- The coefficient of heritability varies from 0.25 to 0.45
- Age of onset usually 4–7 months, the period of rapid growth
- Males predisposed
- German Short-haired Pointer had OR 5.5 (95% CI 3.0–10.3) and German Wire-haired Pointer OR 38.8 (95% CI 16.7–90.3) compared to crossbred dogs in the USA

(Rudd *et al.*, 1990; Nečas *et al.*, 1999; LaFond *et al.*, 2002)

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- German Short-haired Pointer had an OR of 1.6 (95% CI 1.1–2.4) compared with crossbred dogs in the USA

(LaFond *et al.*, 2002)

Neoplastic conditions

Cutaneous haemangiosarcoma

- English Pointer had an OR of 2.3 (95% CI 1.3–3.9) compared to a US referral population

(Villamil *et al.*, 2011)

Cutaneous neoplasia
- Median age of 9 years
- English Pointer comprised 7.5% of purebred cases in a referral hospital in Greece

(Kaldrymidou *et al.*, 2002)

Haemangiosarcoma
- English Pointer had OR 9.03 (95% CI 1.38–59.10) of haemangiosarcoma compared with crossbred dogs in the USA
- Two studies showed English Pointer had OR 2.25 (95% CI 1.30–3.90) and OR 3.65 (95% CI 1.50–8.86) of cutaneous haemangiosarcoma compared with crossbred dogs in the USA

(Hargis *et al.*, 1992; Goldschmidt & Mcmanus, 2000; Villamil *et al.*, 2011)

Mammary neoplasia
- Pointer (unspecified) had an incidence of 18.4 benign mammary cases and 12.9 malignant mammary cases per 1000 dogs in the USA, significantly higher than the general population ($p < 0.05$)

(MacVean *et al.*, 1978)

Mast cell tumour (MCT)
- Mean age at presentation 7.5–9 years, but can occur at any age
- Two US studies showed Pointer had OR 1.7 (95% CI 1.1–2.6) and English Pointer OR 1.84 (95% CI 1.31–2.60) compared with crossbred dogs

(Goldschmidt & Mcmanus, 2000; Villamil *et al.*, 2011)

Prostate neoplasia
- Neutering associated with 3.56 times increased odds
- German Short-haired Pointer had OR 1.89 ($p = 0.01$) compared with an overall referral population in the USA
- German Pointer had OR 2.19 (95% CI 1.16–4.06) compared with an overall referral population in the Netherlands

(Teske *et al.*, 2002; Bryan *et al.*, 2007)

Neurological conditions

Acquired myasthenia gravis
- German Short-haired Pointers had significantly higher risk than crossbred dogs in the USA

(Shelton *et al.*, 1997)

Discospondylitis
- Males and older dogs predisposed
- Pointer (unspecified) had OR 6.2 (95% CI 2.4–15.9) compared with referral crossbred dogs in the USA

(Burkert *et al.*, 2005)

Hemivertebrae (wedge-shaped vertebrae)
- Assumed to be highly heritable
- 34.5% of German Short-haired Pointers affected

(Kramer *et al.*, 1982)

Idiopathic epilepsy
- Hereditary basis established in several breeds
- German Smooth and Wire-haired Pointer had an incidence of 17.7 cases per 10 000 DYAR (95% CI 12.8–22.7) among insured dogs in Sweden, compared with 16.1 (95% CI 14.7–17.4) for crossbreeds

(Heske *et al.*, 2014)

Lipoidystrophy (amaurotic idiocy)
- Affects young males from 10–18 months
- Generally leads to euthanasia
- Recessive sex-linked mode of transmission suspected in male German Short-haired Pointers in the USA

(Karbe & Schiefer, 1967)

Sensory neuropathy (acral mutilation syndrome)
- Affects English Pointer and German Short-haired Pointer
- Presents at about 4 months, when affected pups suddenly begin to self-mutilate their paws

(Cummings *et al.*, 1983, 1984)

Ocular conditions

Cone degeneration (hemeralopia or day blindness)
- Autosomal recessive inheritance
- A missense mutation in exon 6 (D262N, nucleotide 784) identified in German Short-haired Pointers

(Sidjanin *et al.*, 2002)

Eversion of the cartilage of the nictitating membrane
- Described in a line of German Short-haired Pointers
- Recessive inheritance suggested

(Martin & Leach, 1970)

Physiological conditions

Litter size

- Larger litters associated with younger bitches and larger breeds
- German Short-haired Pointer had the fourth largest mean litter size (8.3 puppies) and the German Wire-haired Pointer had the thirteenth largest mean litter size (7.3 puppies) among registered breeds in Norway

(Borge *et al.*, 2011)

Reproductive conditions

Dystocia

- 26% of Pointer (unspecified) litters born by caesarean section in the UK

(Evans & Adams, 2010a)

XX Sex reversal

- Highly likely to be inherited disorder in German Short-haired Pointers

(Meyers-Wallen *et al.*, 1995)

Respiratory conditions

Primary ciliary dyskinesia

- Clinical signs are apparent early in life
- Described in related English Pointers in the USA

(Morrison *et al.*, 1987)

POLISH HOUND (POLISH OGAR DOG, OGAR POLSKI)

Musculoskeletal conditions

Elbow dysplasia

- Polish hound had 3.6% prevalence among radiographed dogs in Poland, compared with 0.7% in the overall population

(Narojek *et al.*, 2008; Michelsen, 2013)

Ocular conditions

Distichiasis

- Prevalence of 40.5% in Polish Hounds in Poland

(Ksiazek *et al.*, 2014)

Entropion

- Prevalence of 23.0% in Polish Hounds in Poland

(Ksiazek *et al.*, 2014)

Physiological conditions

Low thrombocyte count (physiological thrombocytopenia)

- Mean platelet count in normal Polish Hounds ($167 \pm 11.6 \times 10^9$/l) was lower than in other breeds combined (344.4 ± 6.85 G/l)
- Associated with genetic bottleneck after the Second World War

(Micun *et al.*, 2009)

POLISH LOWLAND SHEEPDOG (POLSKI OWCZAREK NIZINNY)

Cardiovascular conditions

Atrioventricular (AV) block

- Polish Lowland Sheepdog had the highest prevalence (35.7%) of first-degree atrioventricular blocks among referred cardiology cases in Poland

(Noszczyk-Nowak *et al.*, 2017)

Patent ductus arteriosus

- Polish Lowland Sheepdog comprised 30.8% of a referral caseload in Germany
- Median age at presentation was 5.7 months

(Schneider *et al.*, 2001)

Musculoskeletal conditions

Short tail (bobtail)

- 64.3% of Polish Lowland Sheepdogs tested in Finland affected

(Hytönen *et al.*, 2009)

Neurological conditions

Neuronal ceroid lipofuscinosis

- Described in related Polish Lowland Sheepdogs in Sweden
- Appeared normal at birth, with progressive neurological signs developing from 6 months

(Narfström *et al.*, 2007)

Ocular conditions

Progressive retinal atrophy (PRA)

- The rcd4 mutation in the *C2ORF71* gene was associated with the majority of PRA in the Polish Lowland Sheepdog in Sweden

(Svensson *et al.*, 2016)

POMERANIAN

Cardiovascular conditions

Patent ductus arteriosus

- Small breeds (median body weight 5 kg) and females predisposed
- Median age was 4 months

- Pomeranian comprised 7.3% and 7.7% of two US referral caseloads

(Bureau *et al.*, 2005; Goodrich *et al.*, 2007)

Dermatological conditions

Alopecia X

- Pomeranian comprised 79.3% of a referral caseload in Japan
- Pomeranian was the most commonly affected breed, comprising 26.5% of an endocrine alopecia caseload of neutered dogs in the USA

(Takada *et al.*, 2002; Frank *et al.*, 2003, 2004)

Demodicosis

- An inheritance pathway has been described
- Short-haired breeds and dogs aged < 1 year predisposed
- Pomeranian had a 26.19% prevalence among dermatitis cases that were skin scraped in India

(Solanki *et al.*, 2007; It *et al.*, 2010)

Drug reactions

Anaesthetic-related complications

- Pomeranian had 4% incidence among general small animal practices in Canada

(Dyson *et al.*, 1998)

Endocrine conditions

Hypothyroidism

- Pomeranian was at increased risk in a US referral study

(Milne & Hayes, 1981)

Gastrointestinal conditions

Congenital portosystemic shunt

- Referred Pomeranians (0.29% prevalence) had an OR of 5.6 (95% CI 2.7–11.6) compared with an overall US referral population

(Tobias & Rohrbach, 2003)

Gallbladder mucocoele

- Associated with hyperlipidaemia
- Older dogs predisposed
- Pomeranian had an OR of 7.74 (95% CI 5.43–21.03) compared with an overall referral population in Japan

(Kutsunai *et al.*, 2014)

Infectious conditions

Salmonellosis

- 7.7% of dogs may harbour *Salmonella* when apparently healthy, subclinically affected, as latent infection or as carriers
- Pomeranians had 45.56% seroprevalence among apparently healthy dogs in India

(Verma *et al.*, 2011)

Metabolic conditions

Overweight/obesity

- 54.6% of Pomeranians attending veterinary clinics in China were obese

(Courcier *et al.*, 2010; Mao *et al.*, 2013; Raffan *et al.*, 2016)

Musculoskeletal conditions

Elbow dysplasia

- OR 3.7 (95% CI 1.7–8.1) for ununited anconeal process compared to crossbred dogs in the USA

(LaFond *et al.*, 2002; Michelsen, 2013)

Patellar luxation

- Genetic mechanism suggested
- 6.5% of Pomeranians affected in the UK
- Mainly medial luxation observed, often bilateral
- OR 6.5 (95% CI 4.0–10.7) in the UK and OR 18.6 (95% CI 13.1–26.4) in the USA, compared to crossbreeds
- Pomeranian was over-represented in Korea and comprised 28.9% of a caseload in Thailand and 9.3% of a US caseload
- Pomeranian had a 75% prevalence in Thailand

(LaFond *et al.*, 2002; Alam *et al.*, 2007; Campbell *et al.*, 2010; Nganvongpanit & Yano, 2011; Soontornvipart *et al.*, 2013; Orthopedic Foundation for Animals, 2015; O'Neill *et al.*, 2016c)

Neurological conditions

Atlantoaxial subluxation/instability

- Congenital or developmental condition
- Young small-breed dogs affected
- In case studies, Pomeranian comprised 10.6% in Japan, 46.7% in the UK, and 10.5% and 6.5% of two US populations

(Denny *et al.*, 1988; Beaver *et al.*, 2000; Platt *et al.*, 2004; Aikawa *et al.*, 2013)

Intervertebral disc disease (IVDD)

- Pomeranian comprised 6.1% of a cervical IVDD caseload and 1.2% of a thoracolumbar IVDD caseload at a Japanese referral hospital

(Itoh *et al.*, 2008)

Physiological conditions

Litter size

- Smaller litters associated with older bitches and smaller breeds
- Pomeranians had the second smallest mean litter size (2.4 puppies) among registered breeds in Norway

(Borge *et al.*, 2011)

Vertebral heart score (VHS)

- Pomeranians from US referral practices had significantly greater ($p = 0.0014$) radiographic vertebral heart score (size) than a previously established average of 9.7 ± 0.5

(Buchanan & Bücheler, 1995; Jepsen-Grant *et al.*, 2013)

Renal and urinary conditions

Hyperuricosuria

- Pomeranian had 1.13% prevalence of carriers for the mutation in the USA

(Karmi *et al.*, 2010a)

Urolithiasis – calcium oxalate

- OR 7.2 (95% CI 6.3–8.2) compared with crossbred dogs in the USA
- OR 9.85 compared with crossbred dogs in the USA

(Lekcharoensuk *et al.*, 2000a; Low *et al.*, 2010; Okafor *et al.*, 2014)

Reproductive conditions

Cryptorchidism

- Pomeranian had RR 3.1 (95% CI 2.3–4.0) and OR 2.9 (1.94–4.36) compared with overall referral populations in two US studies

(Pendergrass & Hayes, 1975; Hayes *et al.*, 1985)

Dystocia

- Pomeranian had the fourth-highest incidence (29.5 per 1000 DYAR), compared with 5.7 per 1000 DYAR in the overall population of insured bitches in Sweden

(Bergström *et al.*, 2006)

Eclampsia (puerperal tetany)

- Small-sized bitches predisposed
- Pomeranian was over-represented and comprised 6% of a US referral caseload

(Drobatz & Casey, 2000)

Respiratory conditions

Tracheal collapse

- Common cause of cough in mature small-breed dogs
- Pomeranian comprised 6%, 13.5% and 16.7% of three US referral caseloads, and 11.9% of a referral caseload in Korea
- Pomeranian had a 9.3% prevalence in a referral population in Australia

(Amis, 1974; Johnson & Fales, 2001; Macready *et al.*, 2007; Marolf *et al.*, 2007; Eom *et al.*, 2008)

POODLE (UNSPECIFIED VARIANT)

Behavioural conditions

Aggression

- Poodle (unspecified) was significantly over-represented ($p < 0.01$), comprising 5.7% of cases compared with 2.9% of an underlying hospital population in Australia

(Blackshaw, 1991)

Anxiety

- Poodle (unspecified) had a significantly higher risk than other breeds in Denmark

(Lund *et al.*, 1996)

Victim of dog-to-dog aggression

- Poodle (unspecified) was over-represented as the victim in dog–dog conflict in Germany, representing 6.8% of victims and 2.8% of the general population

(Roll & Unshelm, 1997)

Cardiovascular conditions

Left systolic apical murmur

- Poodle (unspecified) had 22.7% (±6.2) prevalence compared with 14.4% (±2.2) in an overall population of small-sized breeds in France

(Serfass *et al.*, 2006)

Mitral valve disease

- Poodle (unspecified) had OR 3.9 (95% CI 1.9–8.1) compared with crossbred dogs in UK primary-care veterinary population
- Poodle (unspecified) comprised 18% of an affected caseload, compared with 8% of healthy controls, from a general population in France

(Serres *et al.*, 2008; Parker & Kilroy-Glynn, 2012; Mattin *et al.*, 2015a, 2015b)

Ruptured chordae tendineae

- Recorded among dogs diagnosed with mitral valve disease
- Poodle (unspecified) comprised 34.2% of a referral caseload in France

(Serres *et al.*, 2007)

Dental conditions

Abnormal dentition

- The most common specific problems among affected dogs overall were polyodontia (33.2%), retained deciduous teeth (19.7%) and prognathism (10.0%)
- Poodle (unspecified) comprised the second-highest proportion (21.2%) of an affected caseload aged 7–18 months in Bulgaria

(Borissov *et al.*, 2004)

Periodontal disease

- Poodle (unspecified) had the most severe periodontal destruction of breeds necropsied from general practice in Sweden

(Hamp *et al.*, 1997)

Dermatological conditions

Atopic dermatitis (atopy)

- Poodles (unspecified) were over-represented in Hungary

(Tarpataki *et al.*, 2006)

Endocrine alopecia

- Poodle (unspecified) was the most second commonly affected breed, comprising 6.3% of an endocrine alopecia caseload of neutered dogs in the USA

(Frank *et al.*, 2003)

Endocrine conditions

Diabetes mellitus

- Poodle (unspecified) had an OR of 2.80 ($p < 0.001$) compared with a referral population in Italy

(Fracassi *et al.*, 2004)

Gastrointestinal conditions

Colitis

- Poodle (unspecified) was the third most commonly affected breed (7.5% of cases) in a referral caseload in the Netherlands

(van der Gaag, 1988)

Sialocoele

- Poodle (unspecified) was over-represented ($p < 0.01$), comprising 18.3% of cases compared with 3.1% of a referral population in Australia

(Bellenger & Simpson, 1992)

Haematological/immunological conditions

Immune-mediated thrombocytopenia (IMTP)

- Poodles (unspecified) comprised 21% of the caseload and had RR 4.0 ($p < 0.001$) compared to a US referral hospital population

(Grindem *et al.*, 1991)

Musculoskeletal conditions

Lumbosacral transitional vertebrae

- Poodle (unspecified) had 19.0% prevalence, compared with an overall 10.0% prevalence, among dogs screened for pelvic problems in the Czech Republic

(Fialová *et al.*, 2014)

Patellar luxation

- Mainly medial luxation observed, often bilateral
- Poodle (unspecified) was over-represented in Korea
- Poodle (unspecified) comprised 34.3% of a caseload in Thailand
- Poodle (unspecified) comprised 44.4% of a medial patellar luxation caseload in Brazil

(Alam *et al.*, 2007; Mortari *et al.*, 2009; Nganvongpanit & Yano, 2011)

Neoplastic conditions

Adenoma/adenocarcinoma

- Poodle (unspecified) had an OR significantly above 1.0 ($p < 0.05$) compared with cross-breeds from a cancer registry in Switzerland

(Grüntzig *et al.*, 2016)

Haemangiosarcoma

- Poodle (unspecified) was the second most commonly affected breed in the USA

(Brown *et al.*, 1985)

Mammary neoplasia

- Poodle (unspecified) had OR 2.5 for mammary gland tumour and OR 2.7 for malignant mammary gland tumour compared with an overall referral population in the Czech Republic ($p < 0.01$)

(Zatloukal *et al.*, 2005)

Mast cell tumour (MCT)
- Median age 9 years
- Poodle (unspecified) comprised 7% of a US referral caseload of cutaneous MCT

(Patnaik *et al.*, 1984a)

Melanoma
- Poodle (unspecified) had an OR significantly above 1.0 ($p < 0.05$) compared with crossbreeds from a cancer registry in Switzerland

(Grüntzig *et al.*, 2016)

Squamous cell carcinoma – lingual
- Females predisposed (OR 2.26; 95% CI 1.45–3.54)
- Poodle (unspecified) had 4.61 (95% CI 1.91–11.13) OR compared with other breeds with lingual neoplasia at a US diagnostic laboratory

(Dennis *et al.*, 2006)

Neurological conditions

Atlantoaxial subluxation/instability
- Congenital or developmental condition
- Young small-breed dogs affected
- Poodle (unspecified) comprised 26.1% of a US caseload

(Beaver *et al.*, 2000)

Discospondylitis
- Males and older dogs predisposed
- Poodle (unspecified) had OR 6.7 (95% CI 2.1–21.4) compared with referral crossbreeds in the USA

(Burkert *et al.*, 2005)

Intervertebral disc disease (IVDD)
- Poodle (unspecified) was significantly over-represented ($p < 0.01$), comprising 1.67% of referral cases in the Czech Republic

(Nečas, 1999)

Ocular conditions

Cataract
- Poodles (unspecified) showed 41.3% prevalence of cataract among ophthalmic referrals in South Africa

(Petrick, 1996)

Glaucoma – secondary
- High intraocular pressure due to primary intraocular diseases that impede aqueous humor flow
- Poodle (unspecified) had the second-highest standardized morbidity ratio (4.7) compared with an overall referral population in the USA

(Johnsen *et al.*, 2006)

Myopia (short-sightedness)
- Poodle (unspecified) had a low mean refractive error (–0.38) in the USA

(Murphy *et al.*, 1992)

Renal and urinary conditions

Urolithiasis
- Poodle (unspecified) was the third most common breed submitted for urolith analysis overall in Germany (9.1%) and the fourth most common breed from Spain and Portugal (5.1%)

(Hesse, 1990; Vrabelova *et al.*, 2011)

POODLE – MINIATURE

Cardiovascular conditions

Mitral valve disease
- Miniature Poodle comprised 9.0% of a referral caseload in Italy

(Borgarelli *et al.*, 2008)

Patent ductus arteriosus
- Median age at presentation was 4 months
- Small breeds and females appear predisposed
- Miniature Poodle comprised 8.6% of a US referral caseload
- Miniature and Toy Poodle comprised 5.4% of a US referral caseload

(Goodrich *et al.*, 2007; Selmic *et al.*, 2013)

Endocrine conditions

Diabetes mellitus
- Familial and inherited
- Older entire females are predisposed
- Miniature Poodle showed OR 1.79 (95% CI 1.55–2.06) compared with crossbred dogs in the USA
- Miniature Poodle had OR 4.0 (95% CI 2.1–7.1) compared with crossbred dogs in a US referral study
- Miniature and Toy Poodle had 11th-highest breed incidence in Sweden: 24 cases per 10 000 DYAR (95% CI 16–32)

(Hess *et al.*, 2000; Guptill *et al.*, 2003; Fall *et al.*, 2007; Catchpole *et al.*, 2008)

Hyperadrenocorticism (Cushing's syndrome)

- Miniature Poodle comprised 15.9% of a referral caseload of pituitary-dependent hyperadrenocorticism in Spain

(Alenza *et al.*, 2006)

Gastrointestinal conditions

Cleft lip and/or palate

- Birth defect, small breeds predisposed
- Miniature and Toy Poodle had RR 1.3 compared with all referral dogs in the USA

(Mulvihill *et al.*, 1980)

Portal vein hypoplasia

- May occur in conjunction with portosystemic shunt (PSS)
- Cases present from 6 months to 6 years
- Miniature and Toy Poodle comprised 10.7% of a US referral caseload

(Christiansen *et al.*, 2000)

Musculoskeletal conditions

Avascular necrosis of the femoral head (Legg–Calvé–Perthes disease)

- Inherited as an autosomal recessive trait
- Miniature Poodle had an OR of 12.1 (95% CI 6.5–22.4) compared to crossbreeds in the USA in the USA

(Brenig *et al.*, 1999; LaFond *et al.*, 2002)

Cranial cruciate ligament (CCL) disease

- Estimated heritability of 0.48 and is a highly polygenic complex trait
- Miniature Poodle had an OR of 1.17 (95% CI 1.11–1.24) compared with an overall referral population in the USA

(Witsberger *et al.*, 2008; Baker *et al.*, 2017)

Patellar luxation

- Mainly medial luxation observed, often bilateral
- Miniature Poodle had OR 4.1 (95% CI 3.3–5.5) in the USA
- Miniature and Toy Poodles had OR 5.62 (95% CI 1.93–16.41) compared with all other small breeds in Austria

(LaFond *et al.*, 2002; Vidoni *et al.*, 2006)

Neoplastic conditions

Cutaneous neoplasia

- Median age 9 years
- Miniature Poodle comprised 19.4% of purebred cases in a referral hospital in Greece

(Kaldrymidou *et al.*, 2002)

Mammary neoplasia

- Miniature Poodle had OR 2.5 (95% CI 2.3–2.9) for mammary gland carcinoma compared with an overall US referral population

(Langenbach *et al.*, 1998)

Neurological conditions

Atlantoaxial subluxation/instability

- Congenital or developmental condition
- Young small-breed dogs affected
- Miniature Poodle comprised 25% of a US referral caseload

(Sanders *et al.*, 2004)

Idiopathic epilepsy

- Hereditary basis established in several breeds
- Medium and Miniature Poodle had an incidence of 23.3 per 10 000 DYAR (95% CI 23.3–31.7) among insured dogs in Sweden, compared with 16.1 (95% CI 14.7–17.4) for crossbreeds

(Heske *et al.*, 2014)

Intervertebral disc disease (IVDD)

- Miniature Poodle comprised 26.1% of a referral population in Turkey

(Besalti *et al.*, 2006)

Mucopolysaccharidosis IV

- Autosomal recessive inheritance suspected
- Congenital disorder, and many malformed pups may be euthanized without investigation
- Described in a Miniature Poodle in the USA

(Jolly *et al.*, 2012)

Ocular conditions

Cataract

- Prevalence 10.79%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)
- Prevalence of primary cataract 13.8% in Brazil
- Miniature/Toy Poodles had OR 2.6 (95% CI 2.1–3.2) for cataract compared to a hospital population in Korea
- Miniature Poodle had 21.49% prevalence, compared with 4.04% for crossbreeds, in a US referral study
- Miniature Poodles had OR 4.3 compared with an overall referral population in the USA

(Adkins & Hendrix, 2005; Gelatt & MacKay, 2005; Baumworcel *et al.*, 2009; Park *et al.*, 2009; Bellumori *et al.*, 2013)

Distichiasis
- Heritability of 0.043
- Miniature Poodle comprised 20% of a distichiasis caseload in France

(Ketteritzsch *et al.*, 2004; Raymond-Letron *et al.*, 2012)

Glaucoma – primary
- Miniature Poodle had 1.68% prevalence in a US referral population, 1994–2002

(Gelatt & MacKay, 2004a)

Keratoconjunctivitis sicca
- Miniature Poodle was the third most common breed in a European multicentre study, accounting for 11% of cases

(Ofri *et al.*, 2009)

Lens luxation – primary
- Miniature Poodle had RR 4.51 (95% CI 3.67–5.55) compared with overall referral dogs in the USA

(Sargan *et al.*, 2007)

Optic nerve hypoplasia
- Described in related Miniature Poodles
- Congenital, inheritance suspected

(Kern & Riis, 1981)

Progressive retinal atrophy (PRA)
- Genetic mechanism identified in Miniature Poodle
- PRA mutation identified in Miniature Poodle in the UK

(Goldstein *et al.*, 2006; Downs *et al.*, 2014a)

Progressive rod–cone degeneration (PRCD)
- PRCD gene mapped to the centromeric region of canine chromosome 9 (CFA9)
- Miniature Poodle has 0.45 allele frequency of the disease-causing mutation

(Dostal *et al.*, 2011)

Physiological conditions

Litter size
- Smaller litters associated with older bitches and smaller breeds
- Miniature Poodle had the fourth smallest mean litter size (3.0 puppies) among registered breeds in Norway

(Borge *et al.*, 2011)

Renal and urinary conditions

Ectopic ureter
- Miniature/Toy Poodle bitches had RR 3.6 (95% CI 2.5–4.8) and RR 3.26 (95% CI 2.26–7.93) compared with overall referral populations in two US studies

(Hayes, 1974b, 1984)

Urinary tract infections (UTI)
- Miniature and Toy Poodle (7.8%) was the second most commonly affected breed among referral dogs in the USA for recurrent or persistent UTI

(Norris *et al.*, 2000)

Urolithiasis – calcium oxalate
- Small breeds and males predisposed
- Miniature Poodle had OR 15.2 (95% CI 10.7–21.6) compared with all dogs in the UK
- Miniature and Toy Poodle had OR 3.32 in the USA

(Lekcharoensuk *et al.*, 2000a; Houston *et al.*, 2004; Roe *et al.*, 2012)

Urolithiasis – struvite (magnesium ammonium phosphate)
- Smaller breeds and females are predisposed
- Miniature Poodle had OR 12.7 (95% CI 9.2–17.8) compared with all dogs in the UK

(Houston & Moore, 2009; Roe *et al.*, 2012)

Reproductive conditions

Cryptorchidism
- Miniature Poodle had RR 1.8 (95% CI 1.5–2.1) compared with an overall US referral population
- Miniature and Toy Poodles had OR 2.8 (95% CI 2.43–3.23) compared with an overall US referral population
- Miniature Poodle had a 9.0% prevalence in the UK, which was significantly higher than for crossbred dogs ($p = 0.024$)

(Pendergrass & Hayes, 1975; Hayes *et al.*, 1985; Yates *et al.*, 2003)

Testicular neoplasia
- Miniature and Toy Poodle had a proportional morbidity ratio of 1.9 (95% CI 1.1–3.2) compared with all other dogs in a Norwegian cancer registry

(Nødtvedt *et al.*, 2011)

Eclampsia (puerperal tetany)
- Small-sized bitches predisposed
- Miniature Poodle was over-represented and comprised 6% of a US referral caseload

(Drobatz & Casey, 2000)

Respiratory conditions

Bronchiectasis
- Miniature Poodle had OR 2.88 (95% CI 1.71–4.84) compared with an overall US referral population

(Hawkins *et al.*, 2003)

Tracheal collapse
- Miniature Poodles comprised 8.1% of a US referral caseload and 14.3% of a referral caseload in Korea

(Johnson & Fales, 2001; Eom *et al.*, 2008)

POODLE – STANDARD

Cardiovascular conditions

Dilated cardiomyopathy (DCM)
- Males predisposed
- Standard Poodle was over-represented

(Tidholm & Jonsson, 1997)

Dermatological conditions

Sebaceous adenitis
- Autosomal recessive inheritance with variable expression
- Median age at diagnosis 5 years
- Standard Poodle had the third-highest breed-relative risk in Sweden and comprised 20.2% of a general veterinary caseload

(Tevell *et al.*, 2008; Pedersen *et al.*, 2012b)

Endocrine conditions

Hypoadrenocorticism (Addison's disease)
- Complex inheritance pattern likely: estimated heritability 0.75 in Standard Poodle
- Females predisposed
- Standard Poodle had OR 8.90 (95% CI 4.43–17.32) compared with an overall US referral population
- Standard Poodle comprised 9.8% of a US referral caseload
- Standard Poodle had second-highest breed incidence rate in insured dogs in Sweden: 33.4 (95% CI 26.6–41.9) cases per 10 000 DYAR, compared with 2.26 (95% CI 2.07–2.46) across all dogs

(Melián & Peterson, 1996; Peterson *et al.*, 1996; Famula *et al.*, 2003; Oberbauer *et al.*, 2006; Hanson *et al.*, 2016)

Gastrointestinal conditions

Congenital portosystemic shunt
- Referred Standard Poodles (0.17% prevalence) had OR 3.4 (95% CI 1.6–7.5) compared with an overall US referral population

(Tobias & Rohrbach, 2003)

Gastric dilatation/volvulus (bloat, GDV)
- Pedigree Standard Poodles had 3.1% prevalence in the UK
- Standard Poodle had an incidence of 24 cases per 1000 DYAR (95% CI 6–42) in the USA, with 2.4% of dogs affected per year
- Standard Poodles represented 7.8% of US referral caseloads in two studies and were over-represented in two other US studies

(Glickman *et al.*, 2000a; Beck *et al.*, 2006; Evans & Adams, 2010b; Mackenzie *et al.*, 2010; Green *et al.*, 2012; Sartor *et al.*, 2013)

Musculoskeletal conditions

Osteochondrosis – shoulder
- The coefficient of heritability varies from 0.25 to 0.45
- Age of onset usually 4–7 months, the period of rapid growth
- Males predisposed
- Standard Poodle had an OR of 2.6 (95% CI 1.3–5.3) compared to crossbreeds in the USA

(Rudd *et al.*, 1990; Nečas *et al.*, 1999; LaFond *et al.*, 2002)

Patellar luxation
- Mainly medial luxation observed, often bilateral
- Standard Poodle had OR 3.2 (95% CI 2.2–4.7) compared to crossbreeds in the USA

(LaFond *et al.*, 2002; Alam *et al.*, 2007)

Neoplastic conditions

Gastric carcinoma
- Median age at diagnosis of 10 years
- Standard Poodle had a proportional morbidity ratio of 7.6 (95% CI 2.3–25.0) compared with all breeds in a Norwegian cancer registry

(Seim-Wikse *et al.*, 2013)

Squamous cell carcinoma – digit
- Middle-aged to older dogs and dogs with black coats predisposed
- Standard Poodle comprised 9.1% and 14.3% of two US affected caseloads

(O'Brien *et al.*, 1992; Henry *et al.*, 2005)

Vertebral tumours
- Mean age of 7 years at diagnosis
- Standard Poodles were heavily represented

(Morgan *et al.*, 1980)

Neurological conditions

Idiopathic epilepsy
- Hereditary basis established in several breeds
- Standard Poodle had an incidence of 20.9 per 10 000 DYAR (95% CI 15.2–26.6) among insured dogs in Sweden, compared with 16.1 (95% CI 14.7–17.4) for crossbreeds
- Standard Poodle had 3.19% prevalence compared with 0.91% for crossbreeds in a US referral study

(Bellumori *et al.*, 2013; Heske *et al.*, 2014)

Neonatal encephalopathy with seizures (NEWS)
- Autosomal recessive inheritance
- NEWS locus mapped to a 2.87 Mb segment of CFA36 containing the canine ortholog of ATF2 in the Standard Poodle in the USA

(Chen *et al.*, 2008)

Ocular conditions

Cataract
- 28% of cataracts reported as breed-related in France
- Prevalence of primary cataract 7.00%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005; Donzel *et al.*, 2016)

Progressive retinal atrophy (PRA)
- PRA mutation identified in Standard Poodle in the UK

(Downs *et al.*, 2014a)

Renal and urinary conditions

Kidney disease
- Standard Poodle had an incidence of 28 (95% CI 21–35) cases per 10 000 DYAR, compared with 15.8 per 10 000 DYAR overall, among insured dogs in Sweden

(Pelander *et al.*, 2015)

Reproductive conditions

Cryptorchidism
- Standard Poodle had RR 1.6 (95% CI 1.1–2.3) compared with an overall US referral population

(Pendergrass & Hayes, 1975)

POODLE – TOY

Cardiovascular conditions

Patent ductus arteriosus
- Small breeds and females appear predisposed
- Median age at presentation was 4 months
- Toy Poodle was the second most common breed, comprising 9.6% of a US referral caseload
- Toy and Miniature Poodle comprised 5.4% of a US referral caseload

(Bureau *et al.*, 2005; Goodrich *et al.*, 2007)

Endocrine conditions

Diabetes mellitus
- Familial and inherited
- Peak incidence age 7–9 years
- Older entire females are predisposed
- Toy Poodle had OR 3.3 (95% CI 1.4–6.7) compared with crossbreeds in a US referral study
- Miniature and Toy Poodle had 11th-highest breed incidence in Sweden: 24 cases per 10 000 DYAR (95% CI 16–32)

(Guptill *et al.*, 2003; Hess *et al.*, 2003; Fall *et al.*, 2007; Catchpole *et al.*, 2008)

Primary hypoparathyroidism
- Toy Poodles comprised 17.9% of a US referral case series

(Bruyette & Feldman, 1988)

Gastrointestinal conditions

Cleft lip and/or palate
- Birth defect, small breeds predisposed
- Toy and Miniature Poodle had RR 1.3 compared with all referral dogs in the USA

(Mulvihill *et al.*, 1980)

Congenital portosystemic shunt
- Referred Toy Poodles (0.16% prevalence) had OR 3.1 (95% CI 1.6–6.0) compared with an overall US referral population

(Tobias & Rohrbach, 2003)

Portal vein hypoplasia

- May occur in conjunction with portosystemic shunt (PSS)
- Cases present from 6 months to 6 years
- Toy and Miniature Poodle comprised 10.7% of a US referral caseload

(Christiansen *et al.*, 2000)

Musculoskeletal conditions

Avascular necrosis of the femoral head (Legg–Calvé–Perthes disease)

- Inherited as an autosomal recessive trait
- Toy Poodle had OR 22.4 (95% CI 11.7–42.8) compared to crossbreeds in the USA in the USA

(Pidduck & Webbon, 1978; Brenig *et al.*, 1999; LaFond *et al.*, 2002)

Patellar luxation

- Mainly medial luxation observed, often bilateral
- Toy and Miniature Poodles had OR 5.62 (95% CI 1.93–16.41) compared with all other small breeds in Austria
- Toy Poodle had OR 9.7 (95% CI 7.6–12.3) in the USA and was over-represented in Korea

(LaFond *et al.*, 2002; Vidoni *et al.*, 2006; Alam *et al.*, 2007)

Neurological conditions

Atlantoaxial subluxation/instability

- Congenital or developmental condition
- Young small-breed dogs affected
- Toy Poodle comprised 12.8% of a Japanese caseload

(Aikawa *et al.*, 2013)

Idiopathic epilepsy

- Hereditary basis established in several breeds
- Toy Poodles comprised 6.4% of epilepsy cases and 7.6% of idiopathic epilepsy cases among referred dogs in Japan

(Hamamoto *et al.*, 2016)

Intervertebral disc disease (IVDD)

- Toy Poodles comprised 1.5% of a cervical IVDD caseload and 1.2% of a thoracolumbar IVDD caseload at a Japanese referral hospital

(Itoh *et al.*, 2008)

Lysosomal storage disease – GM_2 gangliosidosis

- Inherited as an autosomal recessive trait
- Described in related Toy Poodles in Japan

(Tamura *et al.*, 2010)

Ocular conditions

Cataract

- 28% of cataracts reported as breed-related in France
- Prevalence of primary cataract 10.21%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)
- Toy/Miniature Poodle had OR 2.6 (95% CI 2.1–3.2) for cataract compared to a hospital population in Korea
- Toy Poodle had OR 6.1 compared with an overall referral population in the USA

(Adkins & Hendrix, 2005; Gelatt & MacKay, 2005; Baumworcel *et al.*, 2009; Park *et al.*, 2009; Donzel *et al.*, 2016)

Glaucoma

- Toy Poodle had 1.20% prevalence in a US referral population, 1994–2002
- 12.9% of Toy Poodles referred for eye or neurological conditions in Japan were affected

(Gelatt & MacKay, 2004a; Kato *et al.*, 2006)

Lens luxation – primary

- Toy Poodle had RR 3.10 (95% CI 2.37–4.06) compared with overall referral dogs in the USA

(Sargan *et al.*, 2007)

Myopia (short-sightedness)

- The Toy Poodle had the highest mean myopic refractive error of all breeds tested ($p < 0.001$), with a 76.6% prevalence among privately owned dogs in the USA

(Kubai *et al.*, 2008)

Progressive retinal atrophy (PRA)

- Genetic mechanism identified in Toy Poodle

(Goldstein *et al.*, 2006)

Progressive rod–cone degeneration (PRCD)

- PRCD gene mapped to the centromeric region of canine chromosome 9 (CFA9)
- Toy Poodle has 0.45 allele frequency of the disease-causing mutation

(Dostal *et al.*, 2011)

Physiological conditions

Litter size

- Smaller litters are associated with older bitches and smaller breeds

- Toy Poodle had the smallest mean litter size (2.4 puppies) among registered breeds in Norway

(Borge *et al.*, 2011)

Renal and urinary conditions

Ectopic ureter

- Toy/Miniature Poodle bitches had RR 3.6 (95% CI 2.5–4.8) and RR 3.26 (95% CI 2.26–7.93) compared with overall referral populations in two US studies

(Hayes, 1974b, 1984)

Urinary tract infections (UTI)

- Toy and Miniature Poodle (7.8%) was the second most commonly affected breed among referral dogs in the USA for recurrent or persistent UTI

(Norris *et al.*, 2000)

Urolithiasis – calcium oxalate

- Small breeds and males are predisposed
- Toy and Miniature Poodle had OR 3.32 in the USA

(Lekcharoensuk *et al.*, 2000a)

Reproductive conditions

Cryptorchidism

- Toy Poodle had RR 6.0 (95% CI 5.1–7.0) compared with an overall US referral population
- Toy and Miniature Poodles had OR 2.8 (95% CI 2.43–3.23) compared with an overall US referral population

(Pendergrass & Hayes, 1975; Hayes *et al.*, 1985)

Testicular neoplasia

- Toy and Miniature Poodle had a proportional morbidity ratio of 1.9 (95% CI 1.1–3.2) compared with all other dogs in a Norwegian cancer registry

(Nødtvedt *et al.*, 2011)

PORTUGUESE PODENGO PEQUENO (SMALL PORTUGUESE PODENGO)

Musculoskeletal conditions

Patellar luxation

- 7.2% of US Portuguese Podengo Pequeno affected
- Mainly medial luxation observed, often bilateral

(Orthopedic Foundation for Animals, 2015)

Neurological conditions

Cerebellar degeneration

- Born normal but then develop cerebellar deficits from 2 weeks of age
- Autosomal recessive inheritance suspected
- Described in Portuguese Podengo Pequeno in the Netherlands

(van Tongeren *et al.*, 2000)

PORTUGUESE WATER DOG (PORTIE CÃO DE AGUA)

Cardiovascular conditions

Dilated cardiomyopathy (DCM)

- Early onset and no sex predisposition in Portuguese Water Dog
- Often causes sudden death or is rapidly fatal
- Autosomal recessive inheritance suspected
- May be associated with taurine deficiency

(Dambach *et al.*, 1999; Alroy *et al.*, 2000, 2005)

Dermatological conditions

Canine follicular dysplasia (seasonal flank alopecia)

- Familial tendency with early age of onset suggests an inherited basis
- Portuguese Water Dog comprised 28.6% of a US referral population

(Miller & Scott, 1995; Rothstein *et al.*, 1998)

Improper coat

- Does not meet the American Kennel Club breed standard for having 'a profuse thickly planted coat of strong healthy hair, which covers the body evenly'
- Causal allelic variation at R-spondin 2 (*RSPO2*) gene identified
- 4.7% of Portuguese Water Dogs in the USA affected

(Parker *et al.*, 2010)

Endocrine conditions

Hypoadrenocorticism (Addison's disease)

- Complex inheritance pattern likely: estimated heritability 0.49 (±0.16)
- Prevalence of 1.5% in Portuguese Water Dog
- OR 46.66 (95% CI 3.73–245.9) compared with an overall US referral population
- Portuguese Water Dog had highest breed incidence rate in insured dogs in Sweden: 64.5

(95% CI 34.4–122.0) cases per 10 000 DYAR, compared with 2.26 (95% CI 2.07–2.46) across all dogs

(Peterson *et al.*, 1996; Chase, 2006; Oberbauer *et al.*, 2006; Mitchell & Pearce, 2012; Hanson *et al.*, 2016)

Musculoskeletal conditions

Hip dysplasia

- Portuguese Water Dog prevalence was 13.2% in the USA
- OR 3.1 (95% CI 1.3–7.4) compared to cross-breeds in the USA

(LaFond *et al.*, 2002; Ginja *et al.*, 2010; Orthopedic Foundation for Animals, 2016)

Neurological conditions

Lysosomal storage disease – GM_1 gangliosidosis

- Autosomal recessive inheritance
- Signs seen at 5–6 months and usually fatal
- Reported in Portuguese Water Dogs in the USA

(Saunders *et al.*, 1988; Shell *et al.*, 1989)

Ocular conditions

Progressive retinal atrophy (PRA)

- Genetic mechanism identified in Portuguese Water Dog

(Goldstein *et al.*, 2006)

Progressive rod–cone degeneration (PRCD)

- PRCD gene mapped to the centromeric region of canine chromosome 9 (CFA9)
- Portuguese Water Dog has 0.33 allele frequency of the disease-causing mutation

(Dostal *et al.*, 2011)

PRESA CANARIO (PERRO DE PRESA CANARIO, DOGO CANARIO, CANARY DOG)

Behavioural conditions

Aggression

- Presa Canario had higher levels of territorial aggression in Spain

(Perez-Guisado & Munoz-Serrano, 2009)

Cardiovascular conditions

Dilated cardiomyopathy (DCM)

- Males of large and giant breeds predisposed
- Generally occurs from 5–8 years
- Median survival of 19 weeks
- High prevalence in the Presa Canario reported in Gran Canaria

(Morales *et al.*, 2001)

Infectious conditions

Dirofilariasis

- Large breeds and dogs living outdoors predisposed
- Among dogs attending first-opinion veterinary clinics in the Canaries, Presa Canario had 76% prevalence compared with 58.9% prevalence across all breeds on Gran Canaria, and 34% prevalence compared with 21% prevalence across all breeds on Tenerife

(Montoya *et al.*, 1998, 2006)

PUG

Dental conditions

Dentigerous cyst

- Brachycephalic breeds over-represented
- Pug comprised 17.2% of a US referral caseload and was significantly ($p<0.001$) over-represented compared with the overall hospital population

(Verstraete *et al.*, 2011)

Dermatological conditions

Canine pigmented epidermal naevus

- Characterized in Pugs in Japan

(Narama *et al.*, 2005)

Demodicosis

- An inheritance pathway has been described
- Short-haired breeds predisposed
- OR 1.5 (95% CI 1.0–2.1) compared with an overall US first-opinion population
- Pugs were the most commonly affected breed (16.7%) in a pan-European study
- Pugs were significantly over-represented in Russia ($p<0.001$)

(Mueller *et al.*, 2009; It *et al.*, 2010; Plant *et al.*, 2011; Kuznetsova *et al.*, 2012)

Drug reactions

Vaccine-associated adverse effect

- Smaller breeds predisposed
- Pug had the second-highest incidence (93.0 cases per 10 000 dogs within 3 days of vaccine administration; 95% CI 80.2–107.2), compared with 38.2 per 10 000 (95% CI 37.1–39.3) overall in a US primary-care population

(Moore *et al.*, 2005)

Endocrine conditions

Diabetes mellitus

- Familial and inherited
- Older entire females are predisposed
- OR 3.9 (95% CI 1.2–9.7) compared with crossbreeds in a US referral study

(Hess *et al.*, 2000)

Gastrointestinal conditions

Congenital portosystemic shunt

- Smaller breeds predisposed
- Pug had 5.88% prevalence for portosystemic shunt, compared with 0.35% for crossbreeds, in a US referral study, and comprised 9.4% of another US caseload
- Referred Pugs (1.3% prevalence) had OR 26.2 (95% CI 15.7–42.5) compared with an overall US referral population

(Tobias & Rohrbach, 2003; Winkler *et al.*, 2003; Bellumori *et al.*, 2013)

Metabolic conditions

Overweight/obesity

- 70.7% of Pugs attending veterinary clinics in China were obese
- Overweight/obesity was the most common disorder in UK Pugs (prevalence 13.2%, 95% CI 11.1–15.4)
- The Pug had significantly higher body condition score (6.00) than other show dogs in Holland

(Courcier *et al.*, 2010; Corbee, 2013; Mao *et al.*, 2013; O'Neill *et al.*, 2016a; Raffan *et al.*, 2016)

Musculoskeletal conditions

Avascular necrosis of the femoral head (Legg–Calvé–Perthes disease)

- Inherited as an autosomal recessive trait
- OR 65.6 (95% CI 28.1–152.9) compared to crossbreeds in the USA in the USA

(Brenig *et al.*, 1999; LaFond *et al.*, 2002)

Hip dysplasia

- Pug had second-highest prevalence in a US study: 61%

(Ginja *et al.*, 2010; Orthopedic Foundation for Animals, 2016)

Patellar luxation

- 3.5% of UK Pugs affected, and 5.4% of US referred Pugs affected
- Mainly medial luxation observed, often bilateral
- OR 3.7 (95% CI 2.3–5.8) compared to crossbreeds under UK primary veterinary care
- OR 3.3 (95% CI 1.9–5.6) compared to crossbreeds in the USA

(LaFond *et al.*, 2002; Alam *et al.*, 2007; Orthopedic Foundation for Animals, 2015; O'Neill *et al.*, 2016c)

Spina bifida

- 38.2% of clinically normal Pugs affected in a UK referral study, and Pugs were significantly more likely to be affected ($p < 0.0001$) than French Bulldogs or British Bulldogs

(Ryan *et al.*, 2017)

Thoracic vertebral malformations

- 73.5% of clinically normal Pugs affected with at least one thoracic vertebral malformation in a UK referral study: 25% had no lumbar vertebrae and 17.6% had hemivertebrae

(Ryan *et al.*, 2017)

Neoplastic conditions

Mast cell tumour (MCT)

- Multiple cutaneous tumours were recorded in 56% of Pug cases
- Mean age at presentation 7.5–9 years, but can occur at any age
- OR 10.0 (95% CI 1.5–64.5) compared with crossbreeds in the UK
- OR 5.2 (95% CI 4.3–6.3) and OR 3.17 (95% CI 1.47–6.82) compared with crossbreeds in two US studies
- OR 2.28 (95% CI 1.81–2.86) compared with an overall referral population in the USA
- RR 4.38 compared with all breeds in laboratory records in the USA, but these tended to be low-grade tumours

(Goldschmidt & Mcmanus, 2000; McNie *et al.*, 2006; White *et al.*, 2011; Shoop *et al.*, 2015; Mochizuki *et al.*, 2016)

Squamous cell carcinoma – cornea

- Rare tumour type
- Brachycephalic breeds and animals with keratoconjunctivitis predisposed
- Pug was over-represented and comprised 36.6% of US referral cases

(Dreyfus *et al.*, 2011)

Neurological conditions

Hemivertebrae (wedge-shaped vertebrae)

- Assumed to be highly heritable
- 100% of Pugs affected

(Schlensker & Distl, 2013)

Intervertebral disc disease (IVDD)
- Pugs comprised 0.8% of a cervical IVDD caseload and 2.4% of a thoracolumbar IVDD caseload at a Japanese referral hospital

(Itoh *et al.*, 2008)

Necrotizing meningoencephalitis
- Strong heritability in Pugs
- Genetic mechanism via dog leucocyte antigen (DLA) system reported in Pugs in the USA
- Pugs comprised 90.9% of a US caseload, and were predisposed in Switzerland
- Median age of onset 18 months

(Tipold, 1995; Suzuki *et al.*, 2003; Schatzberg *et al.*, 2005; Levine *et al.*, 2008; Greer *et al.*, 2009, 2010; Safra *et al.*, 2011)

Ocular conditions

Bacterial keratitis
- OR 45.9 (95% CI 7.1–302.3) compared with a US referral population

(Tolar *et al.*, 2006)

Cataract
- 28% of cataracts reported as breed-related in France
- Prevalence of primary cataract 2.28%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005; Donzel *et al.*, 2016)

Conjunctivitis
- 43.1% of a Pug referral ophthalmology caseload in Austria affected

(Krecny *et al.*, 2015)

Corneal pigmentation
- A local biological response to various irritating stimuli
- Detected in at least one eye of 82.4% (95% CI 77.6–86.3%) of Pugs from the general population in the USA
- 68.5% of a Pug referral ophthalmology caseload in Austria affected

(Labelle *et al.*, 2013; Krecny *et al.*, 2015)

Corneal ulceration (ulcerative keratitis)
- Pug showed 23.8% prevalence of corneal ulceration among ophthalmic referrals in South Africa
- Pug had the highest primary-care veterinary predisposition, with OR 19.05 (95% CI 13.45–26.97) compared with crossbreeds in the UK

(Petrick, 1996; O'Neill *et al.*, 2017b)

Distichiasis
- Heritability of 0.043
- 26.9% of a Pug referral ophthalmology caseload in Austria affected

(Ketteritzsch *et al.*, 2004; Krecny *et al.*, 2015)

Ectopic cilia
- 4.6% of a Pug referral ophthalmology caseload in Austria affected

(Krecny *et al.*, 2015)

Entropion
- 100% of a Pug referral ophthalmology caseload in Austria affected

(Krecny *et al.*, 2015)

Iris hypoplasia
- Recorded in 71.0% (95% CI 65.3–76.0%) of left eyes and 72.1% (95% CI 66.5–77.1%) of right eyes of Pugs from the general population in the USA

(Labelle *et al.*, 2013)

Keratoconjunctivitis sicca
- 30% of a Pug referral ophthalmology caseload in Austria affected
- 1.9% of UK general Pug population affected

(Krecny *et al.*, 2015; O'Neill *et al.*, 2016a)

Macroblepharon (diamond eye)
- 100% of a Pug referral ophthalmology caseload in Austria affected

(Krecny *et al.*, 2015)

Persistent pupillary membranes
- Recorded in 83.8% (95% CI 78.9–87.7%) of left eyes and 85.3% (95% CI 80.6–89.0%) of right eyes of Pugs from the general population in the USA

(Labelle *et al.*, 2013)

Sudden acquired retinal degeneration (SARD, amaurosis)
- Small breeds predisposed
- Median age 8.1 years
- Pug comprised 5% of one US caseload, and 8.9% of a separate US referred caseload

(Montgomery *et al.*, 2008; Heller *et al.*, 2017)

Physiological conditions

Vertebral heart score (VHS)

- Pugs from referral US practice had significantly greater ($p < 0.00001$) radiographic vertebral heart score (size) than a previously established average of 9.7 ± 0.5

(Buchanan & Bücheler, 1995; Jepsen-Grant *et al.*, 2013)

Renal and urinary conditions

Renal calculi

- May be associated with urinary tract infections
- OR 9.01 ($p < 0.001$) in female Pugs compared with crossbreeds in a US referral study

(Ling *et al.*, 1998c)

Urolithiasis – struvite (magnesium ammonium phosphate)

- Small breeds and males are predisposed
- OR 4.7 (95% CI 3.3–6.8) compared with all dogs in the UK

(Roe *et al.*, 2012)

Reproductive conditions

Dystocia

- 27.4% of Pug litters born by caesarean section in the UK
- Pug had the fifth-highest incidence (24.1 per 1000 DYAR) among insured bitches in Sweden, compared with 5.7 per 1000 DYAR overall
- OR 11.3 (95% CI 7.1–17.9) compared with first-opinion emergency-care crossbred bitches in the UK

(Bergström *et al.*, 2006; Evans & Adams, 2010a; O'Neill *et al.*, 2017c)

High perinatal mortality

- Older dams and increasing litter size associated with increased perinatal mortality
- Overall perinatal mortality risk in Norway was 8.0%
- Pug had the fourth-highest perinatal mortality (16.9%) among registered purebred litters in Norway

(Tønnessen *et al.*, 2012)

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- 48% of insured Pug bitches develop the condition by 10 years of age, compared with 19% for bitches overall

(Jitpean *et al.*, 2012)

Respiratory conditions

Aspiration pneumonia

- Pugs comprised 4.4% of cases but only 1.6% of the underlying referral population in the USA

(Kogan *et al.*, 2008)

Brachycephalic obstructive airway syndrome (BOAS)

- Pugs comprised 17.9% and 26% of two UK BOAS caseloads, and 21% and 50% of two US BOAS caseloads
- Pugs had the highest breed prevalence (60.0%) among referral dogs in Belgium

(Torrez & Hunt, 2006; Riecks *et al.*, 2007; De Lorenzi *et al.*, 2009; Njikam Nsangou *et al.*, 2009; Fonfara *et al.*, 2011; Roedler *et al.*, 2013; Marchant *et al.*, 2017)

Lung lobe torsion

- Pugs comprised 30.4% of all referral cases in Canada and had a breed prevalence of 2.6%

(Murphy & Brisson, 2006)

Nasopharyngeal turbinates

- Associated with brachycephalic obstructive airway syndrome (BOAS)
- 53% of Pugs affected in a US study

(Ginn *et al.*, 2008)

Tracheal collapse

- Small dog breeds predisposed
- Pug comprised 7.1% of a referral caseload in Korea

(Eom *et al.*, 2008)

PULI

See *Hungarian Puli*

PYRENEAN MOUNTAIN DOG (GREAT PYRENEES)

Cardiovascular conditions

Myocardial infarction (MI)

- Pyrenean Mountain Dogs (9%) were over-represented among MI cases compared with an overall US referral caseload (0.1%)

(Driehuys *et al.*, 1998)

Haematological/immunological conditions

Hereditary thrombopathy

- Inherited intrinsic platelet function defect causing excessive bleeding
- Described in Pyrenean Mountain Dogs in the USA

(Boudreaux *et al.*, 1996; Boudreaux & Lipscomb, 2001)

Musculoskeletal conditions

Chondrodysplasia (short-limbed or disproportional dwarfism)

- Described in related Pyrenean Mountain Dogs in the USA
- Simple autosomal recessive inheritance
- Radiographic abnormalities restricted to the metaphyses of long bones and vertebrae in Pyrenean Mountain Dog

(Bingel & Sande, 1994)

Hip dysplasia

- Pyrenean Mountain Dog prevalence was 9.6% in the USA and 23% in Belgium
- OR 3.3 (95% CI 1.9–5.9) compared to crossbreeds in a US study

(LaFond *et al.*, 2002; Coopman *et al.*, 2008; Ginja *et al.*, 2010; Orthopedic Foundation for Animals, 2016)

Osteochondrosis – shoulder

- The coefficient of heritability varies from 0.25 to 0.45
- Age of onset usually 4–7 months, the period of rapid growth
- Males predisposed
- OR 42.7 (95% CI 24.4–74.8) compared to crossbreeds in the USA

(Rudd *et al.*, 1990; Nečas *et al.*, 1999; LaFond *et al.*, 2002)

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- OR 5.3 (95% CI 3.5–8.0) compared to crossbreeds in the USA

(LaFond *et al.*, 2002)

Patellar luxation

- OR 64.0 (95% CI 22.0–185.9) compared to crossbreeds in the USA

(LaFond *et al.*, 2002)

Ocular conditions

Multifocal retinopathy

- Two spontaneous mutations in the canine *VMD2* gene identified in Pyrenean Mountain Dogs
- Autosomal recessive inheritance
- Pyrenean Mountain Dogs had 43.2% prevalence in Canada

(Grahn *et al.*, 1998; Grahn & Cullen, 2001; Guziewicz *et al.*, 2007)

Physiological conditions

Hypercholesterolaemia

- Healthy Pyrenean Mountain Dogs had high plasma cholesterol compared with other breeds tested in Italy

(Pasquini *et al.*, 2008)

Reproductive conditions

Dystocia

- 28.9% of Pyrenean Mountain Dog litters born by caesarean section in the UK

(Evans & Adams, 2010a)

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- 43% of insured Pyrenean Mountain Dog bitches develop the condition by 10 years of age, compared with 19% for bitches overall

(Jitpean *et al.*, 2012)

Respiratory conditions

Laryngeal paralysis–polyneuropathy syndrome

- Autosomal recessive mode of inheritance suspected
- Described in a family of Pyrenean Mountain Dogs

(Gabriel *et al.*, 2006)

PYRENEAN SHEPHERD (BERGER DES PYRÉNÉES, PASTOR DE LOS PIRINEOS, LABRIT, PETIT BERGER)

Gastrointestinal conditions

Cleft lip and/or palate

- Monogenic autosomal recessive inheritance in Pyrenean Shepherds
- Pyrenean Shepherd had 28.8% prevalence in Germany

(Kemp *et al.*, 2009)

Musculoskeletal conditions

Short tail (bobtail)

- 10.9% of Pyrenean Shepherds tested in Finland affected

(Hytönen *et al.*, 2009)

RAT TERRIER

Endocrine conditions

Congenital hypothyroidism

- Simple autosomal recessive inheritance in Rat Terriers
- Associated with central nervous system hypomyelination
- A homozygous nonsense mutation in the thyroid peroxidase gene identified in Rat Terriers in the USA

(Pettigrew *et al.*, 2007)

Neurological conditions

Primary brain tumour

- Rat Terrier had a significantly increased risk ($p = 0.047$) compared with an overall referral post-mortem population in the USA

(Song *et al.*, 2013)

Ocular conditions

Lens luxation – primary

- *ADAMTS17* mutation has been identified: 37.65% of US Rat Terriers were carriers
- RR 4.83 (95% CI 2.69–8.68) and RR 17.80 (95% CI 2.53–125.10) compared with overall referral dogs in the USA

(Sargan *et al.*, 2007; Gould *et al.*, 2011)

RED AND WHITE SETTER

See *Irish Red and White Setter*

RED KELPIE

See *Australian Kelpie*

RED SETTER

See *Irish Setter*

RETRIEVER

See *Flat-coated Retriever*; *Golden Retriever*; *Labrador Retriever*

RHODESIAN RIDGEBACK

Dermatological conditions

Atopic dermatitis (atopy)

- Rhodesian Ridgeback had the eighth-highest incidence in insured dogs in Sweden (5.0 cases per 1000 DYAR; 95% CI 3.8–6.2) and was over-represented in Switzerland

(Nødtvedt *et al.*, 2006; Picco *et al.*, 2008)

Endocrine conditions

Hypothyroidism

- Females and younger dogs are predisposed to having serum thyroid hormone autoantibodies (THAA) that are associated with hypothyroidism
- Novel genes and pathways reported for Rhodesian Ridgebacks from the USA
- OR 1.72 ($p = 0.001$) for THAA compared with all other breeds in the USA
- Rhodesian Ridgeback was strongly over-represented in the UK

(Nachreiner *et al.*, 2002; Kennedy *et al.*, 2006b; Bianchi *et al.*, 2015)

Musculoskeletal conditions

Elbow dysplasia

- Rhodesian Ridgeback had 14.3% prevalence in the UK, 6.3% in the USA, 21.1% in South Africa and 8% in Belgium

(Kirberger & Stander, 2007; Coopman *et al.*, 2008; Michelsen, 2013; Kennel Club, 2016; Orthopedic Foundation for Animals, 2016)

Lumbosacral transitional vertebrae

- Large breeds predisposed
- Rhodesian Ridgeback had 15.7% prevalence, compared with an overall 10.0% prevalence among dogs screened for pelvic problems, in the Czech Republic

(Fialová *et al.*, 2014)

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- OR 2.0 (95% CI 1.1–3.4) compared to crossbreeds in the USA

(LaFond *et al.*, 2002; Trostel *et al.*, 2003)

Neoplastic conditions

Cutaneous soft-tissue sarcoma

- Rhodesian Ridgeback had OR 4.8 (95% CI 2.7–8.7) compared with a US referral population

and was significantly over-represented ($p=0.016$) in another US referral study

(Baker-Gabb *et al.*, 2003; Villamil *et al.*, 2011)

Mammary neoplasia

- 26% of insured Rhodesian Ridgeback bitches in Sweden developed the condition by 10 years of age, compared with 13% for bitches overall

(Jitpean *et al.*, 2012)

Mast cell tumour (MCT)

- Mean age at presentation between 7.5 and 9 years, but can occur at any age
- Three US studies showed OR 34.44 (95% CI 5.17–229.23), OR 3.6 (95% CI 2.8–4.7) and OR 5.07 (95% CI 3.22–7.98) compared with crossbreeds

(Goldschmidt & Mcmanus, 2000; Villamil *et al.*, 2011; White *et al.*, 2011)

Neurological conditions

Cerebellar Purkinje cell degeneration and coat colour dilution

- Clinical signs evident by 2 weeks of age and generally fatal
- Autosomal recessive inheritance suspected
- Reported in related Rhodesian Ridgebacks in the USA

(Chieffo *et al.*, 1994)

Degenerative myelopathy

- Insidious, progressive ataxia and paresis of the hindlimbs that ultimately leads to paraplegia and euthanasia
- Rhodesian Ridgeback had 0.74% prevalence, compared with 0.15% in referral crossbreeds in the USA
- Homozygosity for the A allele of the canine *SOD1* gene associated with degenerative myelopathy in Rhodesian Ridgeback

(Coates *et al.*, 2007; Awano *et al.*, 2009)

Dermoid sinus

- Prevalence of 8–10% in Rhodesian Ridgebacks in Sweden
- Complex dihybrid mode of inheritance suggested
- Causative mutation is a duplication of *FGF3*, *FGF4*, *FGF19* and *ORAOV1* genes that cause hair ridge and predisposition to dermoid sinus in Rhodesian Ridgeback dogs

(Hillbertz, 2005; Salmon Hillbertz *et al.*, 2007)

Ocular conditions

Glaucoma – secondary

- High intraocular pressure due to primary intraocular diseases that impede aqueous humor flow
- Rhodesian Ridgeback had the third-highest standardized morbidity ratio (4.1) compared with an overall referral population in the USA

(Johnsen *et al.*, 2006)

Physiological conditions

Dorsal ridge

- Breed-defining ridge of Rhodesian Ridgebacks comes from a duplication of a specific region on chromosome 18 called the Ridge allele
- Dominant inheritance
- Homozygosity for the Ridge allele predisposes to dermoid sinus (see under *Neurological conditions*)
- Polymerase chain reaction (PCR) test now developed to accurately determining the copy number genotype for the Ridge allele of Rhodesian Ridgebacks

(Waldo & Diaz, 2015)

Litter size

- Larger litters associated with younger bitches and larger breeds
- Rhodesian Ridgeback had the largest mean litter size (8.9 puppies) among registered breeds in Norway

(Borge *et al.*, 2011)

Reproductive conditions

Dystocia

- Rhodesian Ridgeback had an incidence of 14.1 per 1000 DYAR among insured bitches in Sweden, compared with 5.7 per 1000 DYAR overall

(Bergström *et al.*, 2006)

High perinatal mortality

- Older dams and increasing litter size associated with increased perinatal mortality
- Overall perinatal mortality risk in Norway was 8.0%
- Rhodesian Ridgeback had the third-highest perinatal mortality (17.9%) among registered purebred litters in Norway

(Tønnessen *et al.*, 2012)

Respiratory conditions

Laryngeal paralysis–polyneuropathy syndrome

- Larger breeds and overweight individuals predisposed
- Rhodesian Ridgeback comprised 6% of an Australian caseload

(Snelling & Edwards, 2003)

ROTTWEILER

Behavioural conditions

Aggression

- A genetic basis for aggression has been described
- Rottweiler reported with higher risk of aggression in Denmark, Italy, UK and Spain
- Rottweilers were the commonly reported breed involved in fatal human attacks in the USA
- Rottweiler was over-represented as the aggressor in dog–dog conflict in Germany, representing 3.4% of aggressors and 2.8% of the general population
- Rottweiler had a bite-risk index of 3.9 ($p < 0.001$) compared with an overall general population of dogs in the Netherlands

(Bradshaw *et al.*, 1996; Lund *et al.*, 1996; Roll & Unshelm, 1997; Bradshaw & Goodwin, 1999; Sacks *et al.*, 2000; Notari & Goodwin, 2007; Perez-Guisado & Munoz-Serrano, 2009; Cornelissen & Hopster, 2010; Zapata *et al.*, 2016)

Cardiovascular conditions

Aortic or cardiac mineralization

- Condition had a prevalence of 0.61% in an overall referral population in the UK
- Older dogs predisposed
- Rottweilers were significantly ($p = 0.003$) among a UK referral caseload

(Schwarz *et al.*, 2002)

Aortic stenosis – subaortic stenosis (SAS)

- Rottweilers was significantly over-represented, comprising 17.4% of a US referral caseload

(Kienle *et al.*, 1994)

Atrial fibrillation (AF)

- Large and giant breeds predisposed
- Rottweiler comprised 4% of the caseload and was significantly over-represented ($p < 0.01$) in the US and Canada among AF cases without structural and functional disease

(Menaut *et al.*, 2005)

Dental conditions

Abnormal dentition

- The most common specific problems among affected dogs overall were polyodontia (33.2%), retained deciduous teeth (19.7%) and prognathism (10.0%)
- Rottweiler was the most commonly affected large breed, comprising 5.3% of an overall affected caseload aged 7–18 months in Bulgaria

(Borissov *et al.*, 2004)

Dermatological conditions

Pyotraumatic folliculitis (acute moist dermatitis, hot spot, wet eczema)

- Breeds (and males) with a heavy pelage and dense undercoat predisposed
- Associated with hot weather
- Rottweiler had the highest breed relative risk (3.38) compared with a hospital population in Sweden

(Holm *et al.*, 2004)

Endocrine conditions

Diabetic ketoacidosis

- Rottweiler comprised 12.9% of a referral caseload in Belgium

(De Causmaecker *et al.*, 2009)

Hypoadrenocorticism (Addison's disease)

- Complex inheritance pattern likely
- Females predisposed
- OR 2.60 (95% CI 1.22–5.05) compared with an overall US referral population

(Peterson *et al.*, 1996)

Gastrointestinal conditions

Gastroduodenal perforation

- Large breeds are predisposed
- Rottweilers were over-represented and younger in a US referral study, comprising 26.7% of the caseload

(Hinton *et al.*, 2002)

Inflammatory bowel disease

- Mode of inheritance is incompletely understood and may differ between breeds
- OR 2.97 (95% CI 1.76–5.02) compared with referred crossbreeds in the UK

(Kathrani *et al.*, 2011)

Haematological/immunological conditions

Eosinophilia

- Rottweiler had the highest incidence and the highest median eosinophil count among laboratory submissions in Sweden but is only the seventh most common breed in Sweden

(Lilliehöök *et al.*, 2000)

Immunodeficiency syndrome

- Described in related Rottweiler puppies in the UK
- Complex inheritance suggested

(Day, 1999)

Infectious conditions

Giardiasis

- Dogs aged < 1 year significantly predisposed ($p < 0.0001$)
- OR 2.12 (95% CI 1.03–4.34) compared with an overall rescue population in the UK

(Upjohn *et al.*, 2010)

Leishmaniasis

- Rottweiler was significantly over-represented ($p < 0.001$) among referral animals in Spain, representing 13.1% of affected dogs and 3.8% of the referral population

(Miranda *et al.*, 2008)

Parvovirus enteritis

- Rottweiler had an OR of 6.0 (95% CI 1.4–25.3) compared with an overall referral US population in one study, and was at significantly increased risk in another US study
- Suggested due to defective immune system in Rottweilers

(Glickman *et al.*, 1985; Seton & Seton, 1990; Houston *et al.*, 1996)

Musculoskeletal conditions

Cranial cruciate ligament (CCL) disease

- Estimated heritability of 0.48 and is a highly polygenic complex trait
- Rottweiler had 5.63% prevalence, compared with 1.58% overall in referred dogs, in the Czech Republic, and was the most commonly affected breed in a UK referral caseload, comprising 12.6% of the total
- OR 3.58 (95% CI 3.40–3.78) compared with an overall US referral population, and OR 5.12 (95% CI 2.28–11.49) compared with an overall UK referral population
- Referral Rottweilers in the UK had significantly increased incidence of bilateral CCL disease ($p = 0.05$) and were significantly younger (median 977 days; $p < 0.0001$) compared with other breeds studied

(Bennett *et al.*, 1988; Nečas *et al.*, 2000; Witsberger *et al.*, 2008; Adams *et al.*, 2011; Guthrie *et al.*, 2012; Baker *et al.*, 2017)

Distal tibial valgus deformity

- Median age at presentation 9 months
- RR 12.2 (95% CI 1.5–30.4) compared with an overall referral population in the USA

(Jaeger *et al.*, 2007)

Elbow dysplasia

- Rottweiler had 0.34 ± 0.02 heritability in Sweden
- Rottweiler had 54.9% prevalence in the UK, 39.1% in the USA, 54.7% in South Africa, 54.2% in Germany and 33% in Belgium
- Rottweiler had 6.31% prevalence, versus 0.16% prevalence in crossbreeds, in a US referral caseload
- OR 36.1 (95% CI 23.6–55.2) for fragmented coronoid process, OR 174.0 (95% CI 78.2–387.1) for osteochondrosis of the elbow, and OR 27.4 (95% CI 20.5–36.6) for ununited anconeal process compared to crossbreeds in the USA
- Rottweiler had 2.0% prevalence, compared with 0.7% in the overall population, among radiographed dogs in Poland
- Rottweiler comprised 17.5% of a referral caseload in Germany and 12.25 of a UK referral caseload

(Beuing *et al.*, 2000; LaFond *et al.*, 2002; Meyer-Lindenberg *et al.*, 2002; Kirberger & Stander, 2007; Coopman *et al.*, 2008; Malm *et al.*, 2008; Narojek *et al.*, 2008; Fitzpatrick *et al.*, 2009; Bellumori *et al.*, 2013; Michelsen, 2013; Kennel Club, 2016; Orthopedic Foundation for Animals, 2016)

Hip dysplasia

- Rottweiler had 0.38 ± 0.02 heritability in Sweden
- Rottweiler prevalence was 21.3% and 35.4% among officially submitted radiographs in the USA, and ranged from 41% to 69% among client-owned dogs in the USA

- Two studies reported Rottweiler with OR 6.5 (95% CI 5.5–7.5) and OR 3.33 (95% CI 3.18–3.49) compared to crossbreeds in the USA

(LaFond *et al.*, 2002; Rettenmaier *et al.*, 2002; Paster, 2005; Malm *et al.*, 2008; Witsberger *et al.*, 2008; Ginja *et al.*, 2010; Orthopedic Foundation for Animals, 2016)

Juvenile-onset distal myopathy

- Considered as a type of muscular dystrophy
- Described in related Rottweiler puppies in the USA

(Hanson *et al.*, 1998)

Osteochondrosis – hock

- Males predisposed
- Age of onset usually 5–12 months, but may be earlier
- OR 206.2 (95% CI 108.2–393.2) compared to crossbreeds in the USA

(Nečas *et al.*, 1999; LaFond *et al.*, 2002)

Osteochondrosis – shoulder

- The coefficient of heritability varies from 0.25 to 0.45
- Age of onset usually 4–7 months, the period of rapid growth
- Males predisposed
- OR 22.8 (95% CI 17.4–29.9) compared to crossbreeds in the USA

(Rudd *et al.*, 1990; Nečas *et al.*, 1999; LaFond *et al.*, 2002)

Osteochondrosis – stifle

- Males predisposed
- Age of onset usually 5–12 months, but may be earlier
- OR 66.3 (95% CI 29.4–149.6) compared to crossbreeds in the USA

(Nečas *et al.*, 1999; LaFond *et al.*, 2002)

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- OR 1.4 (95% CI 1.2–1.6) compared to crossbreeds in the USA
- Rottweiler comprised 9.74% of a referral caseload in Romania

(LaFond *et al.*, 2002; Trostel *et al.*, 2003; Igna *et al.*, 2016)

Sacroiliac joint biomechanics

- Rottweiler had the highest sacroiliac joint (SIJ) loading forces among breeds tested in Austria

(Breit & Künzel, 2001)

Sesamoid disease

- Rottweilers showed a radiographic prevalence of 73% but an attributable lameness prevalence of 21.8%

(Read *et al.*, 1992)

Neoplastic conditions

Bone tumour

- The majority of bone tumours are thought to be osteosarcoma
- Rottweiler had the fifth-highest incidence rate (36 per 10 000 DYAR; 95% CI 29–44) among insured dogs in Sweden

(Egenvall *et al.*, 2007)

Canine cutaneous histiocytoma

- OR 1.79 (95% CI 1.60–2.01) compared with crossbreeds in the USA

(Goldschmidt & Mcmanus, 2000; Fulmer & Mauldin, 2007)

Fibroma/fibrosarcoma

- Rottweiler had an OR significantly above 1.0 ($p < 0.05$) compared with crossbreeds from a cancer registry in Switzerland

(Grüntzig *et al.*, 2016)

Histiocytic sarcoma complex – histiocytic sarcoma and disseminated histiocytoma

- Median age at diagnosis 10 years
- Rottweilers were highly represented, comprising 28.2% of a US referral caseload
- Rottweiler was the most commonly affected breed with disseminated histiocytoma, comprising 33.3% of a US referral caseload

(Affolter & Moore, 2002; Schultz *et al.*, 2007)

Lymphoma

- Odds ratios 2.7 (95% CI 2.4–3.0) in the USA, 6.0 (95% CI 2.2–9.9) in Poland and 4.52 (2.09–9.73) in Australia compared with overall referral populations
- RR 2.14 (95% CI 1.65–4.31) compared with an overall referral population in the Netherlands and RR 2.81 in France
- Rottweiler comprised 7.4% of a referral caseload in Brazil and was over-represented in a UK referral caseload

- Rottweiler had an OR significantly above 1.0 ($p < 0.05$) compared with crossbreeds from a cancer registry in Switzerland

(Teske *et al.*, 1994; Jagielski *et al.*, 2002; Sueiro *et al.*, 2004; Pastor *et al.*, 2009; Villamil *et al.*, 2009; Di Bella *et al.*, 2013; Grüntzig *et al.*, 2016; Yau *et al.*, 2017)

Melanoma

- Rottweiler had an OR significantly above 1.0 ($p < 0.05$) compared with crossbreeds from a cancer registry in Switzerland

(Grüntzig *et al.*, 2016)

Mast cell tumour (MCT)

- Rottweiler had OR 2.46 for high-grade MCT tumours compared with all breeds, and showed approximately twofold increase in proportion of high-grade MCT tumours compared with all breeds (19.6 vs. 8.2%)

(Mochizuki *et al.*, 2016)

Neoplasia – overall

- Rottweiler had the fifth-highest proportional mortality from cancer among pedigree breeds in the UK: 45.3% (95% CI 36.9–53.6)

(Adams *et al.*, 2010)

Osteosarcoma

- Highly heritable
- Rottweilers neutered before 1 year old had RR 3.8 (95% CI 1.5–9.2) in males and 3.1 (95% CI 1.1–8.3) in females in the USA
- Rottweiler showed 5.3% prevalence in the USA
- Two US studies reported OR 3.9 (95% CI 2.6–6.0) and 14.6 (95% CI 8.9–24.0) compared to crossbreeds
- OR 4.6 (95% CI 3.6–5.8) for skeletal osteosarcoma compared with an overall US referral population
- Rottweiler had an OR significantly above 1.0 ($p < 0.05$) compared with crossbreeds from a cancer registry in Switzerland
- Increased incidence reported in Rottweilers in Romania, comprising 19.2% of a general caseload

(Langenbach *et al.*, 1998; Ru *et al.*, 1998; Cooley *et al.*, 2002; Rosenberger *et al.*, 2007; Muste *et al.*, 2010; Karlsson *et al.*, 2013; Grüntzig *et al.*, 2016)

Osteosarcoma – soft-tissue

- A malignant, osteoid-producing, mesenchymal neoplasm without primary periosteal or bone involvement
- Median survival time across all breeds was 26 days
- Rottweiler had OR 2.6 (95% CI 1.1–11.7) compared with an overall US referral population

(Langenbach *et al.*, 1998)

Squamous cell carcinoma – digit

- Middle-aged to older dogs and dogs with black coats predisposed
- Rottweiler comprised 9.1% of a US referral caseload

(Henry *et al.*, 2005)

Neurological conditions

Discospondylitis

- Males and older dogs predisposed
- OR 3.1 (95% CI 2.1–4.7) compared with referral crossbreeds in the USA

(Burkert *et al.*, 2005)

Idiopathic epilepsy

- Hereditary basis established in several breeds
- Rottweiler had an incidence of 24.3 cases per 10 000 DYAR (95% CI 19.5–29.1) among insured dogs in Sweden, compared with 16.1 (95% CI 14.7–17.4) for crossbreeds
- Median age at onset of seizures was 36 months (range 8–84 months) in Rottweilers in Sweden and Norway

(Heske *et al.*, 2014, 2015)

Intervertebral disc disease (IVDD)

- Males and older dogs predisposed
- Rottweiler had an incidence rate of 38.3 (95% CI 32.3–44.4), compared with 27.8 for an overall population of insured dogs in Sweden

(Bergknut *et al.*, 2012)

Leucoencephalomyelopathy

- Described in adult Rottweilers in Australia
- Autosomal recessive inheritance suspected

(Slocombe *et al.*, 1989; Davies & Irwin, 2003)

Neuroaxonal dystrophy

- Group of neurodegenerative disorders characterized by severe degeneration of neuronal cells and their processes; can be familial
- Onset from 8 weeks, with euthanasia or death before 12 months

- Several reports in Rottweilers in the Netherlands, Brazil and the USA

(Chrisman, 1992; Kortz *et al.*, 1997; van den Ingh *et al.*, 1998; Jardim *et al.*, 1999; Davies & Irwin, 2003)

Progressive degenerative polyneuropathy

- Described in Rottweilers in France

(Braund *et al.*, 1994b)

Spinal arachnoid pseudocysts

- Described in Rottweilers in Germany
- Mean age at diagnosis was 3.5 years
- Males predisposed

(Jurina & Grevel, 2004)

Ocular conditions

Entropion

- Clear breed predispositions and polygenic inheritance suspected
- Rottweiler comprised 19.4% of referral caseload in Australia

(Read & Broun, 2007)

Myopia (short-sightedness)

- Rottweiler had 43.5% prevalence among privately owned dogs in the USA
- Rottweiler had the lowest mean refractive error (–1.77) among breeds tested in the USA

(Murphy *et al.*, 1992; Kubai *et al.*, 2008)

Uveitis

- Rottweiler showed 12.8% prevalence of uveitis among ophthalmic referrals in South Africa

(Petrick, 1996)

Physiological conditions

Pronounced eosinophilic response

- Rottweiler were over-represented, with the highest incidence of eosinophilia and the highest median eosinophil count, among dogs with disease in Sweden

(Lilliehöök *et al.*, 2000)

Hypercholesterolaemia

- Healthy Rottweilers had the highest plasma cholesterol among the breeds tested in Italy

(Pasquini *et al.*, 2008)

Litter size

- Larger litters associated with younger bitches and larger breeds
- Rottweiler had the tenth largest mean litter size (7.4 puppies) among registered breeds in Norway

(Borge *et al.*, 2011)

Renal and urinary conditions

Familial renal disease (familial nephropathy)

- Described in related Rottweilers in the USA

(Wakamatsu *et al.*, 2007)

Kidney disease

- Rottweiler had an incidence of 26 (95% CI 21–31) cases per 10 000 DYAR, compared with 15.8 per 10 000 DYAR overall, among insured dogs in Sweden

(Pelander *et al.*, 2015)

Urethral sphincter mechanism incompetence

- Larger breeds had 7.2 OR compared with smaller breeds in the USA
- Rottweiler over-represented in the UK

(Holt & Thrusfield, 1993; Forsee *et al.*, 2013)

Urolithiasis – cystine

- OR 7.0 (95% CI 4.3–11.4) compared with all dogs in the UK

(Roe *et al.*, 2012)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- Rottweiler showed RR 4.4 (95% CI 3.3–5.4) compared with all bitches insured by Agria for veterinary care in Sweden
- 58% of insured Rottweiler bitches develop the condition by 10 years of age, compared with 19% for bitches overall
- OR 2.29 (95% CI 1.68–3.12) compared with all entire bitches in Finland

(Niskanen & Thrusfield, 1998; Egenvall *et al.*, 2001; Smith, 2006; Jitpean *et al.*, 2012)

Respiratory conditions

Laryngeal paralysis–polyneuropathy syndrome

- Larger breeds and overweight individuals predisposed
- Autosomal recessive mode of inheritance suspected
- Described in unrelated Rottweiler puppies in the USA
- RR 2.07 (95% CI 1.02–4.19) compared with an overall referral population in New Zealand

(Mahony *et al.*, 1998; Broome *et al.*, 2000)

Soft-tissue conditions

Calcinosis circumscripta

- Rottweiler was over-represented, comprising 13% of a US referral caseload

(Tafti *et al.*, 2005)

Perineal herniation

- Rottweiler accounted for 12.5% of referral cases in Croatia

(Vnuk *et al.*, 2008)

ROUGH COLLIE

See *Collies – Rough and Smooth*

RUSSIAN BLACK TERRIER (TCHIORNY, RUSSIAN BEAR SCHNAUZER, CHORNYI)

Musculoskeletal conditions

Elbow dysplasia

- Russian Black Terrier had 1.9% prevalence, compared with 0.7% in the overall population among radiographed dogs in Poland

(Narojek *et al.*, 2008; Michelsen, 2013)

Neurological conditions

Polyneuropathy with ocular abnormalities and neuronal vacuolation (POANV)

- Autosomal recessive inheritance
- RAB3GAP1:c.743delC mutation identified in Russian Black Terrier

(Mhlanga-Mutangadura *et al.*, 2016)

Renal and urinary conditions

Hyperuricosuria

- Russian Black Terriers in the USA had 0.51 allele frequency for the *SLC2A9* mutation associated with hyperuricosuria, and 27% of these dogs were estimated to be hyperuricosuric

(Karmi *et al.*, 2010b)

ST BERNARD

Cardiovascular conditions

Dilated cardiomyopathy (DCM)

- Males of large and giant breeds predisposed
- Generally occurs from 5–8 years
- Median survival 19 weeks
- St Bernard comprised 10% of a referral caseload in Italy
- St Bernard was commonly recorded in a UK study and was over-represented in a US study

(Tidholm & Jonsson, 1997; Borgarelli *et al.*, 2006; Martin *et al.*, 2009)

Heart disease

- St Bernard had the fourth-highest breed incidence of death from heart disease in insured dogs in Sweden: 151 (95% CI 103–199) deaths per 10 000 DYAR

(Egenvall *et al.*, 2006)

Dermatological conditions

Dermal arteritis of the nasal philtrum

- Described in related St Bernards in the USA

(Torres *et al.*, 2002)

Endocrine conditions

Hypoadrenocorticism (Addison's disease)

- Complex inheritance pattern likely
- St Bernard was over-represented, comprising 8.6% of dogs with Addison's disease but only 4.6% of a total referral population in the USA

(Thompson *et al.*, 2007)

Primary hypoparathyroidism

- St Bernard was the most common breed (17.6%) affected in Australia
- Successfully treatable with synthetic vitamin D

(Jones & Alley, 1985; Russell *et al.*, 2006)

Gastrointestinal conditions

Palate agenesis, anotia and polydactyly

- Described in related St Bernards in Mexico
- Fully penetrant autosomal recessive inheritance

(Villagómez & Alonso, 1998)

Gastric dilatation/volvulus (bloat, GDV)

- 15.1% of UK pedigree St Bernard dogs died of the condition
- Pedigree St Bernard had seventh-highest breed prevalence (4.6%) in the UK
- St Bernard had an incidence of 6 cases per 1000 DYAR (95% CI 0–14) in the USA, with 0.6% of dogs affected per year
- St Bernard had 3.76% prevalence, compared with 0.20% for crossbreeds, in a US referral study, and were over-represented in two US referral studies

(Glickman *et al.*, 2000a; Evans & Adams, 2010b;; Beer *et al.*, 2012; Green *et al.*, 2012; Bellumori *et al.*, 2013)

Musculoskeletal conditions

Cranial cruciate ligament (CCL) disease

- Estimated heritability of 0.48 and is a highly polygenic complex trait
- OR 1.42 (95% CI 1.28–1.58) compared with an overall referral population in the USA
- St Bernard had 15.0% prevalence, compared with 1.58% overall in referred dogs in the Czech Republic

(Nečas *et al.*, 2000; Witsberger *et al.*, 2008; Baker *et al.*, 2017)

Polydactyly

- Large and giant breeds predisposed
- Ruled as an undesirable characteristic in pedigree St Bernards

(Alberch, 1985)

Elbow dysplasia

- St Bernard had 19.4% prevalence in the UK and 15.3% in the USA
- OR 53.4 (95% CI 28.1–101.6) for fragmented coronoid process and OR 14.2 (95% CI 6.7–30.3) for ununited anconeal process compared to crossbreeds in the USA
- St Bernard had 1.8% prevalence, compared with 0.7% in the overall population, among radiographed dogs in Poland

(LaFond *et al.*, 2002; Michelsen, 2013; Kennel Club, 2016; Orthopedic Foundation for Animals, 2016)

Hip dysplasia

- Two studies report St Bernard with OR 6.1 (95% CI 4.2–8.8) and OR 4.87 (95% CI 4.62–5.13) compared to crossbreeds in the USA
- St Bernard had sixth-highest prevalence in the USA: 49.2%

(LaFond *et al.*, 2002; Witsberger *et al.*, 2008; Ginja *et al.*, 2010; Orthopedic Foundation for Animals, 2016)

Osteochondrosis – shoulder

- The coefficient of heritability varies from 0.25 to 0.45
- Age of onset usually 4–7 months, the period of rapid growth
- Males predisposed
- OR 12.2 (95% CI 6.4–23.2) compared to crossbreeds in the USA

(Rudd *et al.*, 1990; Nečas, *et al.*, 1999; LaFond *et al.*, 2002)

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- OR 2.5 (95% CI 1.6–3.9) compared to crossbreeds in the USA

(LaFond *et al.*, 2002; Trostel *et al.*, 2003)

Neoplastic conditions

Bone tumour

- The majority of bone tumours are thought to be osteosarcoma
- St Bernards had the second-highest incidence rate (78 per 10 000 DYAR; 95% CI 43–113) among insured dogs in Sweden

(Egenvall *et al.*, 2007)

Haemangiosarcoma

- OR 2.82 (95% CI 1.16–6.83) for cutaneous haemangiosarcoma compared with crossbreeds in the USA

(Hargis *et al.*, 1992; Goldschmidt & Mcmanus, 2000)

Lymphoma

- OR 2.3 (95% CI 2.0–2.7) compared with a US referral population
- RR 2.63 (95% CI 1.09–6.32) compared with an overall referral population in the Netherlands

(Teske *et al.*, 1994; Villamil *et al.*, 2009)

Osteosarcoma

- Highly heritable
- St Bernard had the second-highest incidence in Sweden: 78 (95% CI 42–113) per 10 000 DYAR
- OR 11.9 (95% CI 6.9–20.6) for malignant bone tumour compared to crossbreeds in the USA

(Ru *et al.*, 1998; Egenvall *et al.*, 2007; Karlsson *et al.*, 2013)

Neurological conditions

Dysplasia of the cerebellar cortex

- Associated with hydrocephalus
- Described in St Bernards in the UK
- Neurological signs evident at 4 weeks of age

(Franklin *et al.*, 1997)

Fibrocartilaginous embolic myelopathy (FCEM)

- St Bernard comprised 9.1% of a US referral caseload

(Cauzinille & Kornegay, 1996)

Reproductive conditions

Dystocia

- 41.2% of St Bernard litters born by caesarean section in the UK

(Evans & Adams, 2010a)

High perinatal mortality

- Older dams and increasing litter size associated with increased perinatal mortality
- Overall perinatal mortality risk in Norway was 8.0%
- St Bernard had the fifth-highest perinatal mortality (16.9%) among registered purebred litters in Norway

(Tønnessen *et al.*, 2012)

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- OR 3.29 (95% CI 1.78–6.07) compared with all entire bitches in Finland

(Niskanen & Thrusfield, 1998; Egenvall *et al.*, 2001; Smith, 2006)

SALUKI (PERSIAN GREYHOUND, PERSIAN SIGHTHOUND, TANJI, GAZELLE HOUND, ARABIAN HOUND)

Cardiovascular conditions

Dilated cardiomyopathy (DCM)

- Prevalence increases with age, male and body size
- Saluki had 5.88% prevalence, compared with 0.16% in crossbreeds, in a US referral caseload
- Autosomal dominant transmission suspected

(Dukes-McEwan *et al.*, 2003; Bellumori *et al.*, 2013)

Dermatological conditions

Black hair follicular dysplasia

- Changes usually seen by 4 weeks of age
- Described in Saluki puppies

(Hargis *et al.*, 1991; Schmutz *et al.*, 1998)

Neoplastic conditions

Cardiac tumour

- Uncommon, and can occur both as primary and as metastatic lesions
- Saluki had the highest incidence (1.5%) and RR 7.75 (95% CI 3.92–15.38) compared with an overall referral population in the USA

(Ware & Hopper, 1999)

Haemangiosarcoma

- OR 9.19 (95% CI 1.40–60.17) compared with crossbreeds in the USA

(Hargis *et al.*, 1992)

Mammary neoplasia

- 26% of insured Saluki bitches in Sweden develop the condition by 10 years of age, compared with 13% for bitches overall

(Jitpean *et al.*, 2012)

Physiological conditions

Thyroid hormones

- Healthy Salukis had lower thyroid hormone values than non-sighthounds in Ireland

(Shiel *et al.*, 2010b)

SAMOYED

Dermatological conditions

Endocrine alopecia

- Samoyed comprised 3.4% of an endocrine alopecia caseload of neutered dogs in the USA

(Frank *et al.*, 2003)

Drug reactions

Sulfonamide-associated hypersensitivity

- Neutered female dogs predisposed in the USA ($p = 0.004$)
- Samoyed comprised 7.5% of a US referral caseload and were significantly over-represented ($p < 0.001$)

(Trepanier *et al.*, 2003)

Endocrine conditions

Diabetes mellitus

- Familial and inherited
- Older entire females are predisposed
- OR 21.7 (95% CI 14.7–31.9) compared with crossbreeds in the UK
- OR 11.8 (95% CI 5.5–23.3) compared with crossbreeds in a US referral study
- Samoyed had second-highest breed incidence in Sweden: 104 cases per 10 000 DYAR (95% CI 72–136)
- Samoyed comprised 4.6% of cases, compared with < 0.1% of the overall population of insured dogs, in the UK

(Hess *et al.*, 2000; Kimmel *et al.*, 2002; Davison *et al.*, 2005; Fall *et al.*, 2007; Catchpole *et al.*, 2008)

Gastrointestinal conditions

Chronic hepatitis

- Multiple possible causes, so breed predisposition may change with time and geographic location due to genetic and environmental factors
- Median age at diagnosis in the UK was 8 years
- Samoyed had OR 12.6 (95% CI 5.3–29.9) compared with an overall laboratory population in the UK

(Bexfield *et al.*, 2012a)

Congenital portosystemic shunt

- Referred Samoyeds (0.15% prevalence) had OR 2.9 (95% CI 1.1–7.6) compared with an overall US referral population

(Tobias & Rohrbach, 2003)

Musculoskeletal conditions

Hip dysplasia

- Two studies report odds ratios of 4.5 (95% CI 3.4–5.9) and 2.70 (95% CI 2.50–2.92) compared to crossbreeds in the USA
- Samoyed had 11.4% prevalence in the USA

(LaFond *et al.*, 2002; Witsberger *et al.*, 2008; Ginja *et al.*, 2010; Orthopedic Foundation for Animals, 2016)

Neoplastic conditions

Squamous cell carcinoma – lingual

- Females predisposed: OR 2.26 (95% CI 1.45–3.54)
- OR 24.63 (95% CI 2.85–212.92) compared with other breeds with lingual neoplasia at a US diagnostic laboratory

(Dennis *et al.*, 2006)

Neurological conditions

Hypomyelination syndrome

- Reported in related Samoyed dogs
- Sex-linked inheritance suspected
- Signs seen at 2–8 weeks

(Cummings *et al.*, 1986)

Ocular conditions

Cataract

- 28% of cataracts reported as breed-related in France
- Prevalence of primary cataract 2.42%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005; Donzel *et al.*, 2016)

Glaucoma – primary

- Evidence for a hereditary component in the Samoyed
- Samoyed had 1.59% prevalence in a US referral population, 1994–2002

(Ekesten & Torrång, 1995; Gelatt & MacKay, 2004a)

Renal and urinary conditions

Familial renal disease (familial nephropathy)

- Familial glomerular diseases which may progress to renal failure
- Presents from 3 months onwards, with males predisposed
- 25% of one experimental group affected in the USA
- Described in Samoyeds in Canada

(Bernard & Valli, 1977; Jansen *et al.*, 1987)

Urolithiasis – calcium oxalate

- Small breeds and males are predisposed
- OR 4.69 compared with crossbreeds in the USA

(Lekcharoensuk *et al.*, 2000a)

Urolithiasis – silica

- OR 4.2 (95% CI 2.6–6.6) compared with crossbred dogs in the USA

(Low *et al.*, 2010)

SAVOY SHEEPDOG (FRENCH ALPINE MASTIFF)

Musculoskeletal conditions

Short tail (bobtail)

- 11.8% of Savoy Sheepdogs tested in Finland affected

(Hytönen *et al.*, 2009)

SCHAPENDOES (DUTCH SHEEPDOG)

Ocular conditions

Progressive retinal atrophy (PRA)

- Genetics of generalized PRA (GPRA) reported in Schapendoes in Germany: gPRA locus on canine chromosome 20 identified
- Autosomal recessive inheritance described in Schapendoes

(Lippmann *et al.*, 2007; Dekomien *et al.*, 2010)

SCHIPPERKE

Dermatological conditions

Pemphigus foliaceus

- Schipperke had significantly higher risk than an overall referral population in the USA

(Ihrke *et al.*, 1985)

Endocrine conditions

Diabetes mellitus

- Familial and inherited
- Older entire females are predisposed
- Schipperke had RR 4.9 (95% CI 2.4–10.8) compared with an overall US referral population

(Marmor *et al.*, 1982)

Musculoskeletal conditions

Short tail (bobtail)

- 66.7% of Schipperke tested in Finland affected

(Hytönen *et al.*, 2009)

Neurological conditions

Idiopathic epilepsy

- Hereditary basis established in several breeds
- Genetic pathway implicating the *ADAM23* gene shown in Schipperke
- Schipperke had 3.42% prevalence, compared with 0.91% for crossbreeds, in a US referral study

(Bellumori *et al.*, 2013; Koskinen *et al.*, 2015)

Mucopolysaccharidosis IIIB

- Autosomal recessive inheritance suspected
- Progressive and fatal
- Schipperke can be an animal model for the human variant of this disease

(Ellinwood *et al.*, 2003)

Ocular conditions

Cataract

- Schipperke showed 9.1% prevalence of cataract among ophthalmic referrals in South Africa

(Petrick, 1996)

Reproductive conditions

Dystocia

- 28.9% of Schipperke litters born by caesarean section in the UK

(Evans & Adams, 2010a)

SCHNAUZER (UNSPECIFIED VARIANT)

Behavioural conditions

Aggression

- Schnauzer (unspecified) had 1.33 times the risk of attacking children in Austria

(Schalamon *et al.*, 2006)

Gastrointestinal conditions

Congenital portosystemic shunt

- Referred Schnauzers (2.0% incidence) had an OR of 3.6 (95% CI 1.4–9.2) compared with an overall Australian referral population

(Hunt, 2004)

Metabolic conditions

Overweight/obesity

- 35.6% of Schnauzers (unspecified) attending veterinary clinics in China were obese

(Courcier *et al.*, 2010; Mao *et al.*, 2013; Raffan *et al.*, 2016)

Neoplastic conditions

Cutaneous melanoma

- Schnauzers (unspecified) had an OR significantly above 1.0 ($p < 0.05$) compared with crossbreeds from a cancer registry in Switzerland

(Grüntzig *et al.*, 2016)

Mast cell tumour (MCT)

- Median age of 9 years
- Schnauzer (unspecified) comprised 10% of a US referral caseload of cutaneous MCT

(Patnaik *et al.*, 1984a)

Squamous cell carcinoma

- Schnauzers (unspecified) had an OR significantly above 1.0 ($p < 0.05$) compared with crossbreeds from a cancer registry in Switzerland

(Grüntzig *et al.*, 2016)

SCHNAUZER – GIANT

Drug reactions

Low thiopurine methyltransferase (TPMT) activity in red blood cells

- Azathioprine is a cytotoxic thiopurine antimetabolite used to treat neoplasia, control immune-mediated diseases and prevent organ transplant rejection

- Giant Schnauzers in the USA had much lower TPMT activity ($p < 0.001$) than other breeds
- Low TPMT levels may predispose to myelotoxicity with thiopurine drugs

(Kidd *et al.*, 2004)

Endocrine conditions

Hypothyroidism

- A genetic pathway for the Giant Schnauzer has been identified
- Congenital hypothyroid dwarfism with suspected autosomal inheritance reported in Giant Schnauzers in the USA
- Giant Schnauzer had a prevalence of 10% in Sweden, and 11.45% prevalence, compared with 1.54% for crossbreeds, in a US referral caseload
- Giant Schnauzer had OR 1.72 ($p = 0.001$) for serum thyroid hormone autoantibodies (THAA) compared with all other breeds in the USA

(Greco *et al.*, 1991; Nachreiner *et al.*, 2002; Ferm *et al.*, 2009; Wilbe *et al.*, 2010a; Bellumori *et al.*, 2013)

Metabolic conditions

Overweight/obesity

- Giant Schnauzer had significantly higher body condition score (5.60) than other show dogs in Holland

(Courcier *et al.*, 2010; Corbee, 2013; Raffan *et al.*, 2016)

Musculoskeletal conditions

Elbow dysplasia

- Giant Schnauzer had 5.3% prevalence in the UK, 8.2% in the USA, and 25.0% in South Africa
- Giant Schnauzer had 1.9% prevalence, compared with 0.7% in the overall population, among radiographed dogs in Poland

(Kirberger & Stander, 2007; Narojek *et al.*, 2008; Michelsen, 2013; Kennel Club, 2016; Orthopedic Foundation for Animals, 2016)

Hip dysplasia

- Giant Schnauzer prevalence was 18.2% in the USA and 16% in Belgium
- OR 3.0 (95% CI 1.5–6.0) compared to crossbreeds in the USA

(LaFond *et al.*, 2002; Coopman *et al.*, 2008; Ginja *et al.*, 2010; Orthopedic Foundation for Animals, 2016)

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- OR 3.4 (95% CI 1.7–6.7) compared to crossbreeds in the USA

(LaFond *et al.*, 2002)

Neoplastic conditions

Cutaneous haemangioma

- OR 2.7 (95% CI 1.1–6.6) compared to crossbreeds in the USA

(Goldschmidt & Mcmanus, 2000)

Neoplasia – overall

- Giant Schnauzer had the tenth-highest proportional mortality from cancer among pedigree breeds in the UK: 41.0% (95% CI 25.6–56.6%)

(Adams *et al.*, 2010)

Osteosarcoma

- Highly heritable
- Increased incidence reported in large Schnauzers in Romania, comprising 19.2% of a general caseload

(Muste *et al.*, 2010)

Squamous cell carcinoma – digit

- Associated with black coloration in middle-aged to older large-breed dogs
- Reported in related Giant Schnauzers

(Paradis *et al.*, 1989)

Renal and urinary conditions

Hyperuricosuria

- Giant Schnauzer had 11.2% prevalence of carriers for the mutation in the USA

(Karmi *et al.*, 2010a)

Kidney disease

- Giant Schnauzer had an incidence of 29 (95% CI 19–39) cases per 10 000 DYAR, compared with 15.8 per 10 000 DYAR overall, among insured dogs in Sweden

(Pelander *et al.*, 2015)

Urethral sphincter mechanism incompetence

- Larger breeds had OR 7.2 compared with smaller breed in the USA
- Giant Schnauzer had increased risk in Germany

(Arnold, 1997; Forsee *et al.*, 2013)

SCHNAUZER – MINIATURE

Cardiovascular conditions

Atherosclerosis

- Across all breeds, mean age at diagnosis was 8.5 years, with males over-represented
- Miniature Schnauzer had a higher prevalence among necropsy referral cases in the USA

(Liu *et al.*, 1986)

Mitral valve disease

- OR 2.5 (95% CI 1.0–6.4) compared with crossbreeds in a UK primary-care veterinary population

(Parker & Kilroy-Glynn, 2012; Mattin *et al.*, 2015a, 2015b)

Patent ductus arteriosus

- Miniature Schnauzer comprised 30.8% of a referral caseload in Germany
- Median age at presentation was 5.7 months

(Schneider *et al.*, 2001)

Sick sinus syndrome

- Females predisposed
- Miniature Schnauzer was the most commonly affected breed among referral dogs undergoing pacemaker implantation in the USA
- Characterized in Miniature Schnauzer in the USA

(Jochman-Edwards *et al.*, 2002; Wess *et al.*, 2006)

Dental conditions

Canine odontogenic parakeratinized cyst

- Miniature Schnauzer comprised 22.2% of a US referral caseload and was significantly ($p < 0.001$) over-represented compared with the overall hospital population

(Verstraete *et al.*, 2011)

Drug reactions

Vaccine-associated adverse effect

- Smaller breeds predisposed
- Miniature Schnauzer had the seventh-highest incidence (64.7 per 10 000 dogs within 3 days of vaccine administration; 95% CI 52.6–78.7), which was significantly higher than the overall incidence in a US primary-care population (38.2 per 10 000 dogs; 95% CI 37.1–39.3)

(Moore *et al.*, 2005)

Sulfonamide-associated hypersensitivity

- Neutered female dogs predisposed in the USA ($p = 0.004$)
- Miniature Schnauzers comprised 12.5% of a US referral caseload and were significantly over-represented ($p < 0.001$)

(Trepanier *et al.*, 2003)

Endocrine conditions

Diabetes mellitus

- Familial and inherited
- Older entire females are predisposed
- Miniature Schnauzer had odds ratios of 3.13 (95% CI 2.61–3.76) in the USA and 4.1 (95% CI 2.5–6.8) in the UK, compared with crossbreeds
- OR 9.9 (95% CI 6.0–16.0) compared with crossbreeds in a US referral study
- Miniature Schnauzer had an incidence of 20 cases per 10 000 DYAR (95% CI 10–30) in Sweden
- OR 2.6 (95% CI 1.9–3.5) compared with an overall US referral population

(Marmor *et al.*, 1982; Hess *et al.*, 2000; Guptill *et al.*, 2003; Fall *et al.*, 2007; Catchpole *et al.*, 2008)

Hypothyroidism

- Miniature Schnauzer was at increased risk in a US referral study

(Milne & Hayes, 1981)

Primary hypoparathyroidism

- Miniature Schnauzer comprised 14.3% of a US referral case series

(Bruyette & Feldman, 1988)

Gastrointestinal conditions

Cleft lip and/or palate

- Birth defect; small breeds predisposed
- Miniature Schnauzers had RR 11.0 compared with all referral dogs in the USA

(Mulvihill *et al.*, 1980)

Congenital megaoesophagus

- Affects puppies, but most recover by 6 months of age
- Autosomal dominant or a 60% penetrance autosomal recessive mode of inheritance suspected, but polygenic inheritance in outcrosses
- Described in Miniature Schnauzer puppies from a colony

(Cox *et al.*, 1980)

Congenital portosystemic shunt
- Small breeds predisposed
- Usually presents in younger dogs
- Referred Miniature Schnauzers (1.0% prevalence) had OR 19.8 (95% CI 14.0–28.0) compared with an overall US referral population
- Miniature Schnauzers comprised 8.0% and 14.0% of two US referral caseloads

(Tobias & Rohrbach, 2003; Winkler *et al.*, 2003; Toulza *et al.*, 2006)

Gallbladder mucocoele
- Associated with hyperlipidaemia
- Older dogs predisposed
- Miniature Schnauzers had OR 3.80 (95% CI 2.21–12.37) compared with overall referral population in Japan

(Kutsunai *et al.*, 2014)

Pancreatitis
- Middle-aged to older, overweight and dogs with diabetes mellitus predisposed
- May be associated with variants of the *SPINK1* gene in Miniature Schnauzers
- OR 4.1 (95% CI 1.9–9.2) compared with an overall referral population in the USA

(Jaeger *et al.*, 2003; Lem *et al.*, 2008; Bishop *et al.*, 2010)

Haematological/immunological conditions

Immune-mediated haemolytic anaemia (IMHA)
- Females and neutered animals predisposed
- Miniature Schnauzer (4% of cases) was significantly ($p < 0.001$) over-represented compared with a US control referral population (1% were Miniature Schnauzers)

(Weinkle *et al.*, 2005)

Musculoskeletal conditions

Myotonia
- Puppies show myotonia and skeletal muscle hypertrophy from a few weeks of age
- Associated with severe prognathism in Miniature Schnauzers
- Missense mutation in the ClC-1 allele identified that may be transmitted as an autosomal dominant (Thomsen's disease) or recessive (recessive generalized myotonia) trait

(Rhodes *et al.*, 1999; Bhalerao *et al.*, 2002)

Spondylocostal dysostosis
- Reported in three puppies of a litter of eight Miniature Schnauzers in Australia
- Consistent with a highly penetrant autosomal recessive monogenic trait
- Frameshift mutation with a single-base deletion in the coding region of *HES7* identified

(Willet *et al.*, 2015)

Neoplastic conditions

Cutaneous melanoma
- Miniature Schnauzer had OR 7.5 (95% CI 6.0–9.5) compared with a US referral population

(Villamil *et al.*, 2011)

Histiocytic sarcoma
- Miniature Schnauzers had OR 4.8 (95% CI 2.4–88) compared with an overall referral population in the USA

(Lenz *et al.*, 2017)

Meningioma
- Meningiomas represent 51.5% of primary intracranial neoplasms in the USA
- Older dogs predisposed
- Meningioma was more common in Miniature Schnauzers necropsied (4.85% prevalence) than in the overall referral population in the USA ($p = 0.0089$)

(Song *et al.*, 2013)

Neurological conditions

Catechol-O-methyltransferase gene polymorphism
- Miniature Schnauzer had allele frequencies of 18.8% and 25.0% for two abnormal polymorphisms

(Masuda *et al.*, 2004)

Fibrocartilaginous embolic myelopathy (FCEM)
- Miniature Schnauzer comprised 11.5% of a referral caseload in Japan
- FCEM is the most frequent cause of myelopathy in Miniature Schnauzers
- Mortality is lower in affected Miniature Schnauzers (22%) than in giant breeds (64%)

(Hawthorne *et al.*, 2001; Nakamoto *et al.*, 2009)

Idiopathic epilepsy
- Hereditary basis established in several breeds
- Miniature Schnauzer had an incidence of 22.5 per 10 000 DYAR (95% CI 16.9–28.0) among

insured dogs in Sweden, compared with 16.1 (95% CI 14.7–17.4) for crossbreeds
(Heske *et al.*, 2014)

Intervertebral disc disease (IVDD)
- Males and older dogs predisposed
- Miniature Schnauzer had an incidence rate of 35.83 (95% CI 28.8–42.8), compared with 27.8 for an overall population of insured dogs in Sweden
- Miniature Schnauzer was significantly ($p < 0.01$) over-represented, comprising 1.67% of referral cases, in the Czech Republic

(Nečas, 1999; Bergknut *et al.*, 2012)

Ocular conditions

Cataract
- 28% of cataracts reported as breed-related in France
- Prevalence of primary cataract 4.98%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)
- Miniature Schnauzer had an OR of 3.7 compared with an overall referral population in the USA

(Adkins & Hendrix, 2005; Gelatt & MacKay, 2005; Donzel *et al.*, 2016)

Progressive retinal atrophy (PRA)
- 23% of a US ophthalmological Miniature Schnauzers caseload affected with photoreceptor dysplasia
- PRA mutation identified in Miniature Schnauzer in the UK

(Parshall *et al.*, 1991; Zhang *et al.*, 1998, 1999; Downs *et al.*, 2014a)

Myopia (short-sightedness)
- Miniature Schnauzer had 40.5% prevalence among privately-owned dogs in the USA
- Miniature Schnauzer had a low mean refractive error (–0.67) in the USA

(Murphy *et al.*, 1992; Kubai *et al.*, 2008)

Persistent hyperplastic primary vitreous (PHPV)
- Prevalence of 14.2% in Miniature Schnauzers in Canada
- Autosomal recessive mode of inheritance

(Grahn *et al.*, 2004)

Photoreceptor dysplasia
- Autosomal recessive disease of Miniature Schnauzers causing retinal degeneration
- Missense mutation disorder (Arg82Gly) identified but other causal mutations are also likely

(Zhang *et al.*, 1998)

Retinal dysplasia
- Prevalence of 22.6% in Miniature Schnauzers in Canada
- Autosomal recessive mode of inheritance

(Grahn *et al.*, 2004)

Solid intraocular xanthogranuloma
- Associated with concurrent diabetes mellitus, hyperlipidaemia, cataract formation and lens-induced uveitis in Miniature Schnauzers
- Seen in older dogs (9–13 years)
- Reported in Miniature Schnauzers in the USA

(Zarfoss & Dubielzig, 2007)

Sudden acquired retinal degeneration (SARD, amaurosis)
- Small breeds predisposed
- Median age 8.1 years
- Miniature Schnauzers comprised 10% of one US caseload, and 7.9% of another US referred caseload

(Montgomery *et al.*, 2008; Heller *et al.*, 2017)

Physiological conditions

Increased C-reactive protein (CRP)
- Serum CRP concentrations are moderately to highly inheritable (35–45%) in humans and are associated with atherosclerosis
- Median serum CRP concentrations in healthy Miniature Schnauzer dogs were slightly, but significantly, higher than in healthy non-Miniature Schnauzer dogs in Canada

(Wong *et al.*, 2011)

Primary hyperlipidaemia (primary hypertriglyceridaemia, idiopathic hypertriglyceridaemia)
- Associated with insulin resistance and pancreatitis
- Miniature Schnauzers had significantly higher plasma lipids than crossbred dogs in Japan and the USA

(Ford, 1993; Xenoulis *et al.*, 2007, 2010; Mori *et al.*, 2010)

Urine composition

- Miniature Schnauzers (0.6–1.8 urinations per 24 hours) urinated significantly less often ($p = 0.002$) than Labrador Retrievers (1.5–4.5 urinations per 24 hours) in the UK
- Miniature Schnauzers produced significantly ($p = 0.04$) lower volume of urine and significantly ($p = 0.007$) higher urine pH than Labrador Retrievers in the UK
- Low urine frequency and volume may predispose to urolithiasis

(Stevenson & Markwell, 2001)

Renal and urinary conditions

Juvenile renal disease

- Median age 8 months, invariably fatal
- Reported in a series of 8 cases among related Miniature Schnauzers in the USA and Canada

(Morton *et al.*, 1990)

Kidney disease

- Miniature Schnauzer had an incidence of 39 (95% CI 31–46) cases per 10 000 DYAR, compared with 15.8 per 10 000 DYAR overall among insured dogs in Sweden

(Pelander *et al.*, 2015)

Renal calculi

- May be associated with urinary tract infections
- Miniature Schnauzer had OR 14.55 ($p < 0.001$) in females and OR 11.62 ($p < 0.001$) in males compared with crossbreeds in a US referral study

(Ling *et al.*, 1998c)

Urinary tract infections (UTI)

- Miniature Schnauzer (3.9%) was the sixth most commonly affected breed among referral dogs in the USA for recurrent or persistent UTI

(Norris *et al.*, 2000)

Urolithiasis

- Miniature Schnauzer was the second most common breed for uroliths overall submitted for laboratory testing from Spain and Portugal (11.5%) and the eleventh most common in the UK (2.5%)

(Rogers *et al.*, 2011; Vrabelova *et al.*, 2011)

Urolithiasis – apatite

- Miniature Schnauzer had OR 9.5 (95% CI 8.8–10.4) compared with crossbred dogs in the USA
- Females are predisposed

(Low *et al.*, 2010)

Urolithiasis – calcium oxalate

- Small breeds and males are predisposed
- Miniature Schnauzer was the most common breed with submissions for calcium oxalate uroliths in Canada
- Miniature Schnauzer had odds ratios of 21.6 (95% CI 19.9–23.4) and 3.9 (95% CI 3.1–4.9) compared with crossbred dogs in two US studies, and 8.3 (95% CI 6.8–10.1) compared with all dogs in the UK
- OR 14.1 (95% CI 10.2–19.5) compared with crossbreeds in the USA

(Lekcharoensuk *et al.*, 2000a; Ling *et al.*, 2003; Houston & Moore, 2009; Low *et al.*, 2010; Roe *et al.*, 2012; Okafor *et al.*, 2014)

Urolithiasis – silica

- Miniature Schnauzer had OR 10.1 (95% CI 8.4–12.2) compared with crossbred dogs and OR 8.3 ($p < 0.001$) compared with all dogs in two US studies

(Aldrich *et al.*, 1997; Low *et al.*, 2010)

Urolithiasis – struvite (magnesium ammonium phosphate)

- Small breeds and females are predisposed
- Miniature Schnauzer was the third most common breed with submissions for struvite uroliths in Canada
- Miniature Schnauzer had OR 8.0 (95% CI 7.5–8.7) compared with crossbred dogs in the USA and OR 6.3 (95% CI 5.3–7.6) compared with all dogs in the UK

(Houston & Moore, 2009; Low *et al.*, 2010; Roe *et al.*, 2012; Okafor *et al.*, 2014)

Urolithiasis – urate

- Miniature Schnauzer had OR 12.5 (95% CI 11.3–14.0) compared with crossbred dogs in the US and OR 3.1 (95% CI 2.0–4.9) compared with all dogs in the UK
- Younger and female animals predisposed

(Low *et al.*, 2010; Roe *et al.*, 2012)

Reproductive conditions

Cryptorchidism

- Miniature Schnauzer had RR 1.8 (95% CI 1.5–2.3) and OR 2.2 (95% CI 1.52–3.03) compared with overall referral populations in two US studies
- Evidence of inheritance in US Miniature Schnauzers

(Pendergrass & Hayes, 1975; Cox *et al.*, 1978; Hayes *et al.*, 1985)

Dystocia
- Miniature Schnauzer had an incidence of 10.1 cases per 1000 DYAR among insured bitches in Sweden, compared with 5.7 per 1000 DYAR overall

(Bergström *et al.*, 2006)

Male pseudohermaphroditism (persistent Müllerian duct syndrome)
- Affected Miniature Schnauzers are 78,XY males with both male and female reproductive organs
- Inherited as an autosomal recessive trait with expression limited to homozygous males
- Caused by C-to-T transition in exon 3 of the Müllerian inhibiting substance type II receptor (MISRII)
- The mutation is identical by descent in affected Miniature Schnauzers in the USA

(Pujar & Meyers-Wallen, 2009; Vegter *et al.*, 2010)

Pyometra (cystic endometrial hyperplasia–pyometra complex)
- OR 2.74 (95% CI 1.74–4.29) compared with all entire bitches in Finland

(Niskanen & Thrusfield, 1998; Egenvall *et al.*, 2001; Smith, 2006)

SCHNAUZER – STANDARD

Cardiovascular conditions

Congenital heart disease
- Includes a range of congenital heart disorders
- Standard Schnauzer had OR 7.1 compared with all referral dogs in Italy

(Oliveira *et al.*, 2011)

Endocrine conditions

Diabetes mellitus
- Familial and inherited
- Peak incidence age 7–9 years
- Older entire females are predisposed
- OR 4.78 (95% CI 2.91–7.82) compared with crossbreeds in the USA

(Guptill *et al.*, 2003; Catchpole *et al.*, 2008)

Gastrointestinal conditions

Congenital portosystemic shunt
- Referred Standard Schnauzers (0.82% prevalence) had an OR of 16.1 (95% CI 8.0–30.0) compared with an overall US referral population

(Tobias & Rohrbach, 2003)

Neoplastic conditions

Haemangiosarcoma
- Standard Schnauzer had OR 10.08 (95% CI 0.72–141.95) compared with crossbreeds in the USA

(Hargis *et al.*, 1992)

Osteosarcoma
- Highly heritable
- Standard Schnauzer had incidence rate of 9 (95% CI 2–15) per 10 000 DYAR in Sweden

(Egenvall *et al.*, 2007; Karlsson *et al.*, 2013)

Ocular conditions

Cataract
- 28% of cataracts reported as breed-related in France
- Prevalence of primary cataract 4.73%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005; Donzel *et al.*, 2016)

Renal and urinary conditions

Urolithiasis – calcium oxalate
- Small breeds and males are predisposed
- Standard Schnauzer had OR 18.06 compared with crossbreeds in the USA

(Lekcharoensuk *et al.*, 2000a)

SCOTTISH DEERHOUND (DEERHOUND)

Musculoskeletal conditions

Arthrosis of cervical articular facet joints
- Described in 64.3% of Scottish Deerhounds tested in Germany

(Kinzel *et al.*, 2003)

Osteochondrodysplasia
- Described in related Scottish Deerhound pups
- Single autosomal recessive mode of inheritance suspected
- Pups appear normal at birth but show exercise intolerance and retarded growth by 4–5 weeks of age

(Breur *et al.*, 1989)

Neoplastic conditions

Osteosarcoma
- Highly heritable: heritability estimated at 0.69

- May be at least two different genetic risk factors for osteosarcoma in Scottish Deerhounds, with differing inheritance patterns

(Phillips, 2007; Phillips *et al.*, 2010; Karlsson *et al.*, 2013; Dillberger & McAtee, 2017)

Physiological conditions

Unusual haematological and biochemical normal values

- Scottish Deerhounds in the USA and Canada shared clinicopathological similarities with other sighthound breeds that are not found in other breeds: low platelet counts, high mean corpuscular volume (MCV), low total calcium concentration, high alanine aminotransferase (ALT) activity
- High serum cholesterol appeared unique to Scottish Deerhounds: high serum cholesterol

(Sheerer *et al.*, 2013)

SCOTTISH TERRIER

Behavioural conditions

Aggression

- A genetic basis for aggression has been described
- A survey of UK veterinarians classified Scottish Terrier as having high aggression

(Bradshaw & Goodwin, 1999)

Dermatological conditions

Demodicosis

- Scottish Terrier was described as a predilected breed in a Swedish referral study

(Holm, 2003)

Familial vasculopathy of the nasal planum, nostrils and nasal mucosa

- Described in Scottish Terrier puppies
- Probably autosomal dominant inheritance

(Pedersen & Scott, 1991)

Superficial necrolytic dermatitis

- Males and older dogs may be predisposed
- Scottish Terrier suggested as predisposed, and comprised 8.3% of a US referral caseload

(Outerbridge *et al.*, 2002)

Endocrine conditions

Primary hypoparathyroidism

- Scottish Terrier comprised 7.1% of a US referral case series

(Bruyette & Feldman, 1988)

Gastrointestinal conditions

Chronic hepatitis

- Scottish Terrier was 10 times over-represented ($p < 0.001$) in laboratory samples in Sweden

(Andersson & Sevelius, 1991)

Congenital portosystemic shunt

- Referred Scottish Terriers (0.23% prevalence) had an OR of 4.4 (95% CI 1.4–10.8) compared with an overall US referral population

(Tobias & Rohrbach, 2003)

Haematological/immunological conditions

Low immunological response to vaccination

- Scottish Terrier was in the lowest quartile for titre response to rabies vaccination in the UK

(Kennedy *et al.*, 2007)

Raised serum alkaline phosphatase (ALP)

- Scottish Terriers had significantly ($p < 0.001$) higher mean serum ALP activity (mean ± SD, 1520 ± 2010 U/l) than control dogs (306 ± 697 U/l)
- Scottish Terriers also had OR 2.4 (95% CI 1.3–4.3) to have a disease associated with high serum ALP activity compared with a control population

(Nestor *et al.*, 2006)

von Willebrand's disease (vWD)

- Scottish Terriers are affected by type III vWD, and the genetic mechanism in this breed in the USA has been elucidated
- Scottish Terriers in Australia had a prevalence of 27%

(Stokol *et al.*, 1995; Venta *et al.*, 2000)

Musculoskeletal conditions

Patellar luxation

- 6.1% of US Scottish Terriers affected
- Mainly medial luxation observed, often bilateral

(Orthopedic Foundation for Animals, 2015)

Neoplastic conditions

Cardiac tumour

- Uncommon, and can occur both as primary and as metastatic lesions
- Scottish Terrier had the highest incidence (0.49% incidence) and RR 2.50 (95% CI 1.55–4.03) compared with an overall referral population in the USA

(Ware & Hopper, 1999)

Cutaneous melanoma
- OR 3.1 (95% CI 1.7–5.6) compared with a US referral population

(Villamil *et al.*, 2011)

Lower urinary tract neoplasia
- Scottish Terrier was over-represented for urinary bladder neoplasia in the UK, comprising 5.7% of a referral caseload, and also comprised 22.6% of a US referral caseload
- OR 11.6 for lower urinary tract tumours compared with an overall referral population in Canada

(Burnie & Weaver, 1983; Norris *et al.*, 1992; Schrempp *et al.*, 2013)

Lymphoma
- Scottish Terrier had odds ratios of 3.4 (95% CI 3.0–3.9) and 5.6 (95% CI 3.4–9.0) compared with referral populations in two US studies, and was significantly ($p < 0.05$) over-represented in another US referral study
- RR 9.16 (95% CI 3.05–27.21) compared with an overall referral population in the Netherlands

(Keller *et al.*, 1993; Teske *et al.*, 1994; Villamil *et al.*, 2009, 2011)

Primary brain tumour
See under *Neurological conditions*

Prostate neoplasia
- Neutering associated with 3.56 times increased odds
- OR 3.81 ($p < 0.0001$) compared with an overall referral population in the USA
- OR 7.43 (95% CI 2.79–18.6) compared with an overall referral population in the Netherlands

(Teske *et al.*, 2002; Bryan *et al.*, 2007)

Neurological conditions

Acquired myasthenia gravis
- Scottish Terrier had significantly higher risk than crossbred dogs in the USA

(Shelton *et al.*, 1997)

Central axonopathy
- Described in related Scottish Terriers in Switzerland
- Heritability suspected
- Tremors occur at 10–12 weeks

(van Ham *et al.*, 1994)

Cerebellar degeneration
- Cases identified from several countries around the world
- Litter analysis consistent with fully penetrant simple autosomal recessive inheritance
- Minimum prevalence of 0.07% among Scottish Terriers registered with the American Kennel Club
- Characterized in in Scottish Terriers in the USA

(Urkasemsin *et al.*, 2010)

Muscle cramping ('Scottie cramp')
- Autosomal recessive inheritance
- Age of onset 6 weeks to 18 months
- Females over-represented
- Characterized in in Scottish Terriers in the USA

(Urkasemsin & Olby, 2015)

Primary brain tumour
- Scottish Terriers were over-represented in the USA, comprising 5% of cases but < 1% of the overall referral population

(Heidner *et al.*, 1991)

Renal and urinary conditions

Urolithiasis – struvite (magnesium ammonium phosphate)
- OR 4.8 (95% CI 3.7–6.2) compared with all dogs in the UK
- Small breeds and males predisposed

(Roe *et al.*, 2012)

Urolithiasis – urate
- OR 4.2 (95% CI 3.2–5.5) compared with crossbred dogs in the USA
- Younger and female animals predisposed

(Low *et al.*, 2010)

Reproductive conditions

Dystocia
- 59.8% of Scottish Terrier litters born by caesarean section in the UK
- Scottish Terrier had the highest incidence (38.3 cases per 1000 DYAR) among insured bitches in Sweden, compared with 5.7 per 1000 DYAR overall

(Bergström *et al.*, 2006; Evans & Adams, 2010a)

Pyometra (cystic endometrial hyperplasia–pyometra complex)
- 41% of insured Scottish Terrier bitches develop the condition by 10 years of age, compared with 19% for bitches overall

(Jitpean *et al.*, 2012)

SEALYHAM TERRIER

Ocular conditions

Keratoconjunctivitis sicca
- Sealyham Terriers were the second most commonly affected breed in a European multi-centre study, comprising 17% of the cases

(Ofri *et al.*, 2009)

Lens luxation – primary
- *ADAMTS17* mutation has been identified: 49.0% of UK and 36.0% of US Sealyham Terriers were carriers

(Gould *et al.*, 2011)

SENNENHUND

See *Swiss Mountain Dog*

SHAR PEI (CHINESE SHAR PEI)

Dermatological conditions

Acute febrile neutrophilic vasculitis
- Acute widespread dermatopathy associated with fever and malaise
- Described in 3 Shar Pei in Australia

(Malik *et al.*, 2002)

Atopic dermatitis (atopy)
- 41.7% prevalence among Shar Peis in the Czech Republic
- Shar Pei comprised 2.6% (95% CI 1.1–5.3) of the atopic caseload, compared with 0.7% of overall hospital population, in a US referral study
- OR 25.53 ($p = 0.0005$) compared with a referral population in Greece

(Saridomichelakis *et al.*, 1999; Zur *et al.*, 2002; Počta & Svoboda, 2007)

Cutaneous mucinosis
- Condition is associated with the distinctive wrinkled, thickened skin selected for in Shar Pei
- Associated with mast cell activity, hyaluronic acid and a consequence of over-transcription or increased activity of the HAS2 allele

(Welle *et al.*, 1999; Zanna *et al.*, 2008, 2009; Docampo *et al.*, 2011)

Demodicosis
- An inheritance pathway has been described
- Short-haired breeds predisposed
- Shar Pei had the third-highest breed OR of 7.2 (95% CI 2.9–17.6) compared with an overall US first-opinion population

(It *et al.*, 2010; Plant *et al.*, 2011)

Folliculitis
- Shar Pei had 36.4% prevalence in the USA

(Miller *et al.*, 1992)

Malassezia dermatitis
- Shar Pei had the third-highest prevalence (6.8%) among a dermatology referral caseload in Romania

(Mircean *et al.*, 2010)

Otitis externa
- Shar Pei was significantly over-represented ($p < 0.001$) in Israel

(Zur *et al.*, 2011)

Pemphigus foliaceus
- OR 7.9 (95% CI 2.2–30.1) compared with a referral population in the USA

(Kuhl *et al.*, 1994)

Gastrointestinal conditions

Canine autoinflammatory disease (AID)
- Results from the dysregulation of mediators of the innate immune system
- Associated with selection for the heavily thickened and wrinkled skin traits in Shar Pei
- Genetic signature flanking the chromosome 13 AID locus identified

(Olsson *et al.*, 2013)

Hiatal hernia
- Can be congenital or acquired
- Congenital form described in related Shar Pei dogs in France, and in unrelated Shar Pei in the USA
- Ages 2–11 months at diagnosis
- Acquired form often associated with severe upper respiratory disease

(Callan *et al.*, 1993; Guiot *et al.*, 2008)

Haematological/immunological conditions

Immunodeficiency syndrome

- Associated with recurrent infections, autoimmune disease and neoplasia
- Described in ten Shar Pei dogs in the USA

(Rivas *et al.*, 1995)

Metabolic conditions

Hypocobalaminaemia

- Mutation on chromosome 13 suggested as causative in Shar Pei
- Shar Peis with or without gastrointestinal disease are predisposed
- Shar Pei had the highest breed OR (21.1, 95% CI 9.1–54.5) compared with a laboratory population in the UK
- 64.0% of Shar Pei serum samples in the USA had subnormal cobalamin concentrations, and Shar Pei had significantly lower values than all other breeds ($p < 0.05$)

(Grützner *et al.*, 2010; Bishop *et al.*, 2012; Dandrieux *et al.*, 2013)

Familial Shar Pei fever

- Part of the overall autoinflammatory disease syndrome of Shar Pei
- A 16.1 kb duplication located approximately 350 kb upstream of HAS identified and proposed as a causative mutation for both hyaluronanosis and Shar Pei fever

(Olsson *et al.*, 2011)

Musculoskeletal conditions

Elbow dysplasia

- Shar Pei prevalence was 31% in Belgium
- OR 4.6 (95% CI 2.2–9.4) for ununited anconeal process compared to crossbreeds in the USA
- Shar Pei had 3.8% prevalence, compared with 0.7% in the overall population, among radiographed dogs in Poland

(LaFond *et al.*, 2002; Coopman *et al.*, 2008; Narojek *et al.*, 2008; Michelsen, 2013)

Hip dysplasia

- Shar Pei prevalence was 16.1% in US and 21% in Belgium

(Coopman *et al.*, 2008; Ginja *et al.*, 2010; Orthopedic Foundation for Animals, 2016)

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- OR 3.5 (95% CI 2.8–4.5) compared to crossbreeds in the USA

(LaFond *et al.*, 2002)

Patellar luxation

- Mainly medial luxation observed, often bilateral
- OR 11.4 (95% CI 7.4–17.6) compared to crossbreeds in the USA

(LaFond *et al.*, 2002)

Neoplastic conditions

Canine cutaneous histiocytoma

- OR 2.10 (95% CI 1.73–2.55) compared with crossbreeds in the USA

(Goldschmidt & Mcmanus, 2000; Fulmer & Mauldin, 2007)

Histiocytic sarcoma

- OR 16.0 (95% CI 4.1–44.0) compared with an overall referral population in the USA

(Lenz *et al.*, 2017)

Lymphoma – gastrointestinal

- Shar Pei comprised 13.6% of cases in a US study

(Coyle & Steinberg, 2004)

Mast cell tumour (MCT)

- Mean age at presentation between 7.5 and 9 years, but can occur at any age
- Three US studies showed Shar Pei had odds ratios of 7.81 (95% CI 2.71–22.55), 2.4 (95% CI 2.0–2.9) and 3.84 (95% CI 2.89–5.11) compared with crossbreeds
- Shar Pei comprised 2.2% of MCTs but 1% of the submitting population to a US diagnostic laboratory

(Miller, 1995; Goldschmidt & Mcmanus, 2000; Villamil *et al.*, 2011; White *et al.*, 2011)

Melanoma- oral

- Large-breed dogs predisposed compared with small-breed dogs: OR 6.88 (95% CI 2.95–15.05)
- Shar Pei had OR 24.43 (95% CI 2.98–200.18) compared with other breeds with lingual neoplasia at a US diagnostic laboratory

(Dennis *et al.*, 2006)

Ocular conditions

Entropion

- Clear breed predisposition, and polygenic inheritance suspected
- Shar Pei comprised 20.0% of referral caseload in Australia

(Read & Broun, 2007)

Glaucoma – primary

- Shar Pei had 4.4% prevalence in a US referral population, 1994–2002

(Gelatt & MacKay, 2004a)

Lens luxation – primary

- Autosomal recessive inheritance suspected
- Shar Pei comprised 20% and 23.5% of two US ophthalmology caseloads
- RR 7.18 (95% CI 5.66–9.12) and RR 44.66 (95% CI 16.94–117.73) compared with overall referral dogs in the USA

(Lazarus *et al.*, 1998; Binder *et al.*, 2007; Sargan *et al.*, 2007)

Prolapse of the gland of the nictitating membrane ('cherry eye')

- Usually presents in the first 1–2 years of life
- Inheritance is complex and potentially multigenic
- Shar Pei significantly over-represented in France

(Mazzucchelli *et al.*, 2012; Edelmann *et al.*, 2013)

Renal and urinary conditions

Renal amyloidosis

- Inherited disease with complicated inheritance pattern
- Median age at presentation 4.5 years and median survival time 5 days in Israel
- Reported in 16 related Shar Pei in the USA
- Amyloidosis was over-represented among Shar Pei with glomerulonephritis (88.9% of cases) in the USA

(DiBartola *et al.*, 1990; Rivas *et al.*, 1993; Segev *et al.*, 2012; Schneider *et al.*, 2013)

Respiratory conditions

Brachycephalic obstructive airway syndrome (BOAS)

- Shar Pei had a prevalence of 6.67% among referral dogs in Belgium

(Njikam Nsangou *et al.*, 2009; Roedler *et al.*, 2013; Marchant *et al.*, 2017)

Soft-tissue conditions

Hiatal hernia

See *Gastrointestinal conditions*

Perineal herniation

- Shar Pei suggested as predisposed by case reports from the USA, UK and Canada

(Williams, 1990; Callan *et al.*, 1993; Auger & Riley, 1997)

SHETLAND SHEEPDOG (SHELTIE)

Behavioural conditions

Vocalization

- Shetland Sheepdog had 8.9% prevalence, compared with an overall prevalence of 1.5%, in a US hospital population

(Bamberger & Houpt, 2006)

Cardiovascular conditions

Left atrial rupture

- Associated with chronic mitral valve insufficiency
- Shetland Sheepdog was the most commonly affected breed in a US referral study, comprising 21.4% of the caseload

(Reineke *et al.*, 2008)

Patent ductus arteriosus

- Small breeds (median body weight 5 kg) and females predisposed
- Median age was 4 months
- Shetland Sheepdog was the most common breed affected, comprising 13.5% of a US referral caseload

(Bureau *et al.*, 2005)

Dermatological conditions

Familial canine dermatomyositis

- Shetland Sheepdogs and collie breeds predisposed
- Described in Shetland Sheepdog in the UK
- Inherited as an autosomal dominant trait with incomplete penetrance
- Linkage disequilibrium identified a microsatellite marker FH3570 on chromosome 35 in Shetland Sheepdogs in the USA

(Ferguson *et al.*, 2000; Clark *et al.*, 2005; Wahl *et al.*, 2008)

Superficial necrolytic dermatitis

- Males and older dogs may be predisposed
- Shetland Sheepdogs suggested as predisposed; comprised 13.9% of a US referral caseload

(Outerbridge *et al.*, 2002)

Vesicular cutaneous lupus erythematosus

- Associated with summertime and sun exposure
- Autoimmune pathogenesis suggested
- Described in Shetland Sheepdogs in the USA

(Jackson, 2004; Jackson *et al.*, 2004)

Drug reactions

Multiple drug sensitivity

- High doses of many drugs (e.g. ivermectin or milbemycin) cause neurological signs
- Associated with the nt230(del4) *MDR1* mutation
- Shetland Sheepdog had a 30.3% allelic frequency with 9% recessive mutant allele frequency in Europe, and a 36% allelic frequency with 12% recessive mutant allele frequency in the UK
- Shetland Sheepdog had a 7.9% allelic frequency in Brazil

(Geyer *et al.*, 2005; Dowling, 2006; Gramer *et al.*, 2011; Tappin *et al.*, 2012; Monobe *et al.*, 2015; Firdova *et al.*, 2016)

Endocrine conditions

Hypothyroidism

- Shetland Sheepdog was at increased risk in a US referral study
- OR 1.69 ($p = 0.001$) for serum thyroid hormone autoantibodies (THAA) compared with all other breeds in the USA

(Milne & Hayes, 1981; Nachreiner *et al.*, 2002)

Gastrointestinal conditions

Congenital portosystemic shunt

- Referred Shetland Sheepdogs (0.26% prevalence) had OR 5.2 (95% CI 3.1–8.8) compared with an overall US referral population

(Tobias & Rohrbach, 2003)

Gallbladder mucocoele

- Mutation identified for gallbladder mucocoele in Shetland Sheepdog
- OR 7.2 ($p < 0.001$) compared with the overall referral population in the USA: 10.2% of Shetland Sheepdogs affected, compared with 1.6% of the overall population
- OR 4.52 (95% CI 2.43–15.86) compared with overall referral population in Japan
- Shetland Sheepdog comprised 8.8% of a US referral caseload

(Aguirre *et al.*, 2007; Crews *et al.*, 2009; Mealey *et al.*, 2010; Kutsunai *et al.*, 2014)

Haematological/immunological conditions

Hypercholesterolaemia

- Plasma cholesterol was above normal in 43.8% of Shetland Sheepdogs, compared with 12.2% of control dogs, in Japan

(Sato *et al.*, 2000)

Low immunological response to vaccination

- Shetland Sheepdog was in the lowest quartile for titre response to rabies vaccination in the UK

(Kennedy *et al.*, 2007)

von Willebrand's disease (vWD)

- Shetland Sheepdog had a 23% prevalence among tested dogs in the USA
- This breed affected by severe type III disease

(Raymond *et al.*, 1990; Pathak, 2004)

Metabolic conditions

Overweight/obesity

- Shetland Sheepdogs had an OR of 1.9 (95% CI 1.2–2.8) for obesity in the USA, and were significantly associated with obesity in the UK

(Edney & Smith, 1986; Lund *et al.*, 2006; Courcier *et al.*, 2010; Raffan *et al.*, 2016)

Musculoskeletal conditions

Distal tibial valgus deformity

- Median age at presentation was 9 months
- RR 12.3 (95% CI 1.5–30.5) compared with an overall referral population in the USA

(Jaeger *et al.*, 2007)

Elbow dysplasia

- Shetland Sheepdog had 3.0% prevalence, compared with 0.7% in the overall population, among radiographed dogs in Poland

(Narojek *et al.*, 2008; Michelsen, 2013)

Lateral luxation of the superficial digital flexor tendon

- Simple autosomal recessive inheritance
- Genetics characterized in Shetland Sheepdogs in Finland

(Solanti *et al.*, 2002)

Neoplastic conditions

Lower urinary tract neoplasia

- Shetland Sheepdog comprised 16.1% of a US referral caseload

(Schrempp *et al.*, 2013)

Oral epulis

- Shetland Sheepdog comprised 19.6% of a fibromatous epulis caseload in Japan

(Yoshida *et al.*, 1999)

Prostate neoplasia

- Neutering associated with 3.56 times increased odds
- Shetland Sheepdog had OR 1.82 ($p = 0.0005$) compared with an overall referral population in the USA

(Bryan *et al.*, 2007)

Thyroid neoplasia

- Large breeds and older dogs predisposed
- Shetland Sheepdog had OR 1.7 (95% CI 1.05–2.77) compared with an overall referral population in the USA

(Wucherer & Wilke, 2010)

Neurological conditions

Canine spongiform leucoencephalomyelopathy

- Described in related Shetland Sheepdogs in the USA
- Clinical signs develop from 7 days to 3 weeks
- Missense mutation in cytochrome b identified, and maternal inheritance suggested

(Li *et al.*, 2006)

Idiopathic epilepsy

- Hereditary basis established in several breeds
- Shetland Sheepdog had an incidence of 19.6 per 10 000 DYAR (95% CI 15.2–24.0) among insured dogs in Sweden, compared with 16.1 (95% CI 14.7–17.4) for crossbreeds
- Cliniconeuropathology described in Shetland Sheepdogs in Japan

(Morita *et al.*, 2002; Heske *et al.*, 2014)

Intervertebral disc disease (IVDD)

- Shetland Sheepdog comprised 1.5% of a cervical IVDD caseload at a Japanese referral hospital

(Itoh *et al.*, 2008)

Leucodystrophy

- Described in related Shetland Sheepdogs in the USA
- Mode of inheritance unknown
- Clinical signs began at 7 days to 3 weeks of age

(Wood & Patterson, 2001)

Ocular conditions

Chronic superficial keratitis (pannus)

- Shetland Sheepdog was significantly overrepresented in the USA, comprising 2.38% of referral cases

(Slatter *et al.*, 1977)

Collie eye anomaly

- Congenital; autosomal recessive inheritance with nearly 100% penetrance
- Genetic mechanism in Shetland Sheepdog identified

(Lowe *et al.*, 2003; Parker *et al.*, 2007)

Physiological conditions

Low Schirmer tear test (STT)

- Shetland Sheepdog had lower normal STT results than other breeds tested
- Mean value for STT was 15.8 ± 1.8 mm/min in Shetland Sheepdogs in the USA

(Hamor, 2000)

Primary hyperlipidaemia (primary hypertriglyceridaemia, idiopathic hypertriglyceridaemia)

- Shetland Sheepdog had significantly higher plasma lipids than crossbred dogs in Japan

(Mori *et al.*, 2010)

Renal and urinary conditions

Kidney disease

- Shetland Sheepdog had an incidence of 31 (95% CI 25–37) cases per 10 000 DYAR, compared with 15.8 per 10 000 DYAR overall among insured dogs in Sweden

(Pelander *et al.*, 2015)

Reproductive conditions

Cryptorchidism

- Shetland Sheepdog had RR 1.8 (95% CI 1.4–2.4) and OR 2.0 (95% CI 1.24–3.10) compared with overall referral populations in two US studies
- Shetland Sheepdog had 3.2% prevalence, compared with 2.1% in an overall population in the Netherlands

(Pendergrass & Hayes, 1975; Hayes *et al.*, 1985; Gubbels *et al.*, 2009)

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- RR 2.4 (95% CI 1.5–3.3) compared with all bitches insured by Agria for veterinary care in Sweden

(Egenvall *et al.*, 2001; Smith, 2006)

Testicular neoplasia

- Shetland Sheepdog had a proportional morbidity ratio of 5.7 (95% CI 3.8–8.6) compared with all other dogs in a Norwegian cancer registry

(Nødtvedt *et al.*, 2011)

SHIBA INU

See *Japanese Shiba Inu*

SHIH TZU

Behavioural conditions

Aggression

- A genetic basis for aggression has been described
- A Canadian veterinary survey showed that 22.0% of Shih Tzu aged ≥ 1 year had bitten

(Guy *et al.*, 2001; Zapata *et al.*, 2016)

Cardiovascular conditions

Mitral valve disease

- OR 2.9 (95% CI 1.5–5.5) compared with crossbreeds in a UK primary-care veterinary population

(Parker & Kilroy-Glynn, 2012; Mattin *et al.*, 2015a, 2015b)

Dental conditions

Dentigerous cyst

- Brachycephalic breeds over-represented
- Shih Tzu comprised 6.9% of a US referral caseload and was significantly ($p < 0.001$) over-represented compared with the overall hospital population

(Verstraete *et al.*, 2011)

Periodontal disease

- Shih Tzu comprised 15.4% of a dental referral caseload of small breeds in South Korea

(Kim *et al.*, 2013)

Dermatological conditions

Demodicosis

- Shih Tzu was over-represented in the UK: 6.45% of laboratory diagnoses versus 0.45% of normal clinic population

(Day, 1997a)

Malassezia dermatitis

- RR 6.46 compared to a general laboratory population in the USA

(Mauldin *et al.*, 1997)

Drug reactions

Anaesthetic-related complications

- Shih Tzu had 5% incidence among general small animal practices in Canada

(Dyson *et al.*, 1998)

Gastrointestinal conditions

Chronic hypertrophic pyloric gastropathy

- Shih Tzu was the most commonly affected breed in a referral case series in Australia
- Mean age was 8.2 years and mean body weight was 6.5 kg
- Males may be predisposed

(Bellenger *et al.*, 1990)

Congenital portosystemic shunt

- Usually presents in young dogs
- Referred Shih Tzu (0.78% prevalence) had OR 15.4 (95% CI 10.1–23.4) compared with an overall US referral population
- Referred Shih Tzu (3.4% incidence) had OR 3.9 (95% CI 1.8–8.2) compared with an overall Australian referral population
- Shih Tzu comprised 5.3% and 10.9% of two US referral caseloads

(Tobias & Rohrbach, 2003; Winkler *et al.*, 2003; Hunt, 2004; Toulza *et al.*, 2006)

Portal vein hypoplasia

- May occur in conjunction with portosystemic shunt (PSS)
- Cases present from 6 months to 6 years
- Shih Tzu comprised 10.7% of a US referral caseload

(Christiansen *et al.*, 2000)

Metabolic conditions

Overweight/obesity

- 32.2% of Shih Tzu attending veterinary clinics in China were obese

(Courcier *et al.*, 2010; Mao *et al.*, 2013; Raffan *et al.*, 2016)

Musculoskeletal conditions

Chondrodysplasia (short-limbed or disproportional dwarfism)

- Part of the Shih Tzu breed description
- An *fgf4* retrogene identified as a cause of chondrodysplasia

(Israel *et al.*, 2009; Parker *et al.*, 2009)

Patellar luxation

- Mainly medial luxation observed, often bilateral
- Shih Tzu had 2.3 OR (95% CI 1.6–3.4) compared to crossbreeds in the USA

(LaFond *et al.*, 2002)

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- OR 1.4 (95% CI 1.1–1.8) compared to crossbreeds in the USA

(LaFond *et al.*, 2002; Trostel *et al.*, 2003)

Neoplastic conditions

Mast cell tumour (MCT)

- Shih Tzu had an OR of 3.58 for high-grade MCT tumours compared with all breeds and showed an approximately twofold increase in the proportion of high-grade MCT tumours compared with all breeds (16.9 vs. 8.2%)

(Mochizuki *et al.*, 2016)

Oral epulis

- Shih Tzu comprised 9.3% of a fibromatous epulis caseload in Japan

(Yoshida *et al.*, 1999)

Neurological conditions

Atlantoaxial subluxation/instability

- Congenital or developmental condition
- Young small breeds affected
- Shih Tzu comprised 6.5% and 16.7% of two US referral caseloads

(Beaver *et al.*, 2000; Sanders *et al.*, 2004)

Intervertebral disc disease (IVDD)

- Males and older dogs predisposed
- Shih Tzu comprised 11.4% of a cervical IVDD caseload and 4.8% of a thoracolumbar IVDD caseload at a Japanese referral hospital
- Shih Tzu comprised 5.1% of a US thoracolumbar caseload, and 2.2% of a US referral population
- RR 3.9 ($p < 0.01$) compared with an overall referral population in the USA
- Shih Tzu had an incidence rate of 39.6 (95% CI 30.6–48.6), compared with 27.8 for an overall population of insured dogs in Sweden

(Priester, 1976; Bartels *et al.*, 2003; Itoh *et al.*, 2008; Israel *et al.*, 2009; Bergknut *et al.*, 2012)

Necrotizing meningoencephalitis

- Identified in a US Shih Tzu

(Cooper *et al.*, 2014b)

Ocular conditions

Bacterial keratitis

- OR 44.7 (95% CI 8.5–234.6) compared with a US referral population

(Tolar *et al.*, 2006)

Cataract

- 28% of cataracts reported as breed-related in France
- Prevalence of primary cataract 4.14%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005; Donzel *et al.*, 2016)

Corneal ulceration (ulcerative keratitis)

- Shih Tzu was the commonest breed, comprising 50% of a referral caseload in Korea
- Shih Tzu had the third-highest primary-care veterinary predisposition in the UK, with an OR of 10.04 (95% CI 7.30–13.80) compared with crossbreeds

(Kim *et al.*, 2009; O'Neill *et al.*, 2017b)

Epiphora

- Associated with anatomical features such as medial canthal entropion, trichiasis, tight medial palpebral ligament and close apposition of the eyelids to the globe
- Shih Tzu comprised 65.2% of a surgical referral caseload in Korea

(Yi *et al.*, 2006)

Glaucoma

- Shih Tzu had 1.58% prevalence in a US referral population, 1994–2002
- 9.6% of Shih Tzu referred for eye or neurological conditions in Japan were affected

(Gelatt & MacKay, 2004a; Kato *et al.*, 2006)

Keratoconjunctivitis sicca
- Shih Tzu was the fourth most common breed in a UK referral study

(Sanchez *et al.*, 2007)

Renal and urinary conditions

Kidney disease
- Shih Tzu had an incidence of 30 (95% CI 23–38) cases per 10 000 DYAR, compared with 15.8 per 10 000 DYAR overall among insured dogs in Sweden

(Pelander *et al.*, 2015)

Renal calculi
- May be associated with urinary tract infections
- Shih Tzu had odds ratios of 11.74 ($p < 0.001$) in females and 15.75 ($p < 0.001$) in males compared with crossbreeds in a US referral study

(Ling *et al.*, 1998c)

Familial renal disease (familial nephropathy)
- No sex predisposition in Shih Tzu
- Shih Tzu comprised 15.6% of a US referral caseload

(Picut & Lewis, 1987b; Hoppe *et al.*, 1990)

Urolithiasis
- Shih Tzu was the fifth most common breed for uroliths overall submitted for laboratory testing from Spain and Portugal (2.6%) and was the third most common in the UK (6.0%)

(Rogers *et al.*, 2011; Vrabelova *et al.*, 2011)

Urolithiasis – apatite
- OR 8.6 (95% CI 7.8–9.5) compared with crossbred dogs in the USA
- Females are predisposed

(Low *et al.*, 2010)

Urolithiasis – calcium oxalate
- Small breeds and males are predisposed
- Shih Tzu was the second most common breed with submissions for calcium oxalate uroliths in Canada
- Odds ratios of 10.2 (95% CI 9.2–11.3) and 1.4 (95% CI 1.1–1.9) compared with crossbred dogs in two US studies, and 5.6 (95% CI 4.7–6.7) compared with all dogs in the UK
- OR 4.49 compared with crossbreeds in the USA

(Lekcharoensuk *et al.*, 2000a; Ling *et al.*, 2003; Houston & Moore, 2009; Low *et al.*, 2010; Roe *et al.*, 2012; Okafor *et al.*, 2014)

Urolithiasis – silica
- OR 6.7 ($p < 0.001$) compared with all dogs in a US study

(Aldrich *et al.*, 1997)

Urolithiasis – struvite (magnesium ammonium phosphate)
- Shih Tzu was the most common breed with submissions for struvite uroliths in Canada
- Odds ratios of 7.4 (95% CI 6.8–8.1) compared with crossbred dogs in the USA and 9.8 (95% CI 8.6–11.2) compared with all dogs in the UK
- Small breeds and females are predisposed

(Houston & Moore, 2009; Low *et al.*, 2010; Okafor *et al.*, 2014)

Urolithiasis – urate
- OR 6.4 (95% CI 4.9–8.4) compared with all dogs in the UK
- Younger and female animals predisposed

(Low *et al.*, 2010; Roe *et al.*, 2012)

Respiratory conditions

Brachycephalic obstructive airway syndrome (BOAS)
- Shih Tzu had a prevalence of 13.33% among referral dogs in Belgium

(Njikam Nsangou *et al.*, 2009; Roedler *et al.*, 2013; Marchant *et al.*, 2017)

Tracheal collapse
- Shih Tzu comprised 10.8% of a US referral caseload

(Johnson & Fales, 2001)

Reproductive conditions

Cryptorchidism
- Shih Tzu had a 9.5% prevalence in the UK, which was significantly higher than for crossbreeds ($p = 0.012$)

(Yates *et al.*, 2003)

Dystocia
- OR 2.1 (95% CI 1.1–3.8) compared with first-opinion emergency-care crossbred bitches in the UK

(O'Neill *et al.*, 2017c)

Eclampsia (puerperal tetany)
- Small-sized bitches predisposed
- Shih Tzu was over-represented and comprised 6% of a US referral caseload

(Drobatz & Casey, 2000)

SIBERIAN HUSKY

Dermatological conditions

Endocrine alopecia

- Siberian Husky comprised 3.0% of an endocrine alopecia caseload of neutered dogs in the USA

(Frank *et al.*, 2003)

Zinc-responsive dermatosis

- Northern-breed dogs (e.g. Husky, Malamute, Samoyed) predisposed
- Siberian Husky represented 75.6% of affected cases from the USA, France and Israel

(White *et al.*, 2001)

Gastrointestinal conditions

Congenital portosystemic shunt

- Referred Siberian Huskies (0.13% prevalence) had an OR of 2.5 (95% CI 1.1–5.9) compared with an overall US referral population

(Tobias & Rohrbach, 2003)

Infectious conditions

Canine distemper

- Younger dogs and dolicocephalic breeds predisposed
- Siberian Husky was over-represented, comprising 4.0% of a general caseload in Brazil

(Headley & Graça, 2000)

Neoplastic conditions

Cutaneous soft-tissue sarcoma

- OR 2.7 (95% CI 2.0–3.6) compared with a US referral population

(Villamil *et al.*, 2011)

Palpebral neoplasia

- Mean age 9.6 years
- Siberian Husky at higher risk than general population

(Roberts *et al.*, 1986)

Thyroid neoplasia

- Large breeds and older dogs predisposed
- Siberian Husky had OR 2.47 (95% CI 1.50–4.07) compared with an overall referral population in the USA

(Wucherer & Wilke, 2010)

Neurological conditions

Degenerative myelopathy

- Reported in three related Siberian Huskies
- Suspected to be inherited

(Bichsel *et al.*, 1983)

Ocular conditions

Cataract

- 28% of cataracts reported as breed-related in France
- Prevalence of primary cataract 4.68%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005; Donzel *et al.*, 2016)

Chronic superficial keratitis (pannus)

- Siberian Husky significantly over-represented, comprising 2.38% of referral cases in the USA
- Siberian Husky was disproportionately affected among referral dogs in another US study

(Slatter *et al.*, 1977; Chavkin *et al.*, 1994)

Congenital achromatopsia (rod monochromacy, day blindness)

- Autosomal recessive disease
- Five casual mutations identified: *PDE6C*, *PDE6H*, *GNAT2*, *CNGA3* and *CNGB3*
- Siberian Huskies in the USA had 0.877% frequency of the *CNGB3* deletion mutation

(Yeh *et al.*, 2013)

Corneal dystrophy

- Prevalence of 14% in screened Siberian Huskies
- Prevalence increased with age

(MacMillan *et al.*, 1979)

Glaucoma – primary

- Siberian Husky had 1.88% prevalence in a US referral population, 1994–2002
- OR 5.06 ($p < 0.01$) compared with an overall referral population in Switzerland

(Gelatt & MacKay, 2004a; Strom *et al.*, 2011a)

Progressive retinal atrophy (PRA)

- X-linked recessive inheritance in Siberian Husky

(Acland *et al.*, 1994)

Physiological conditions

Benign familial hyperphosphatasaemia

- Described in related Siberian Husky pups
- Markedly high serum alkaline phosphatase (ALP) levels seen in affected Siberian Husky
- Familial and autosomal inheritance

(Lawler *et al.*, 1996)

Renal and urinary conditions

Ectopic ureter

- Siberian Husky bitches had risk ratios of 21.7 (95% CI 15.2–30.9) and 49.81 (95% CI 28.74–127.86) compared with overall referral populations in two US studies
- Siberian Husky comprised 9.1% of a US referral caseload

(Hayes, 1974b, 1984; Ho *et al.*, 2011)

Reproductive conditions

Cryptorchidism

- Siberian Husky reported as over-represented in a US study
- OR 2.4 (95% CI 1.32–4.27) compared with an overall US referral population

(Pendergrass & Hayes, 1975; Zhao *et al.*, 2010)

Testicular neoplasia

- Siberian Husky had a proportional morbidity ratio of 2.0 (95% CI 1.0–4.3) compared with all other dogs in a Norwegian cancer registry

(Nødtvedt *et al.*, 2011)

Respiratory conditions

Bronchiectasis

- Siberian Husky had 2.86 OR, (95% CI 1.47–5.55) compared with an overall US referral population

(Hawkins *et al.*, 2003)

Spontaneous pneumothorax

- Siberian Husky comprised 18.8% of a US referral caseload and had an OR of 28.8 (95% CI 6.3–277.4) compared with a control population

(Puerto *et al.*, 2002)

SILKEN WINDHOUND

Drug reactions

Multiple drug sensitivity

- High doses of many drugs (e.g. ivermectin or milbemycin) cause neurological signs
- Associated with the nt230(del4) *MDR1* mutation
- Silken Windhound had a 28.1% allelic frequency with 3.8% recessive mutant allele frequency in Europe

(Firdova *et al.*, 2016)

SILKY TERRIER

See *Australian Silky Terrier*

SKYE TERRIER

Endocrine conditions

Hypothyroidism

- Females and younger dogs are predisposed to having serum thyroid hormone autoantibodies (THAA) that are associated with hypothyroidism
- Skye Terrier had an OR of 3.04 ($p = 0.001$) for THAA compared with all other breeds

(Nachreiner *et al.*, 2002)

Gastrointestinal conditions

Chronic hepatitis

- Familial
- Associated with copper accumulation in Skye Terrier

(Haywood *et al.*, 1988; McGrotty *et al.*, 2003)

Musculoskeletal conditions

Elbow dysplasia

- Skye Terrier had 7.2% prevalence, compared with 0.7% in the overall population, among radiographed dogs in Poland
- Elbow joint incongruity was scored as grade 1 in 49%, grade 2 in 31% and grade 3 in 18% of Skye terriers in Finland. Lameness was reported at < 1 year old in 33% of dogs and was so common that it was called 'Skye limp'

(Narojek *et al.*, 2008; Michelsen, 2013; Lappalainen *et al.*, 2016)

Renal and urinary conditions

Ectopic ureter

- Skye Terrier bitches had an OR of 86.6 (95% CI 31.6–258.6) compared with a general UK referral population

(Holt & Moore, 1995; Holt *et al.*, 2000)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- Nulliparous Skye Terrier bitches had an OR of 3.9 (95% CI 1.84–8.29) compared with all dogs attending primary-care practice in Finland

(Niskanen & Thrusfield, 1998)

SLOUGHI (ARABIAN GREYHOUND, SLOUGHI MOGHREBI, LEVRIER MAROCAIN)

Ocular conditions

Progressive retinal atrophy (PRA)

- Autosomal recessive inheritance with candidate gene identified in Sloughi

(Dekomien *et al.*, 2000)

Physiological conditions

Reduced thyroxine levels

- Sighthounds predisposed to physiologically lower thyroxine levels
- Privately owned Sloughis from Germany, the Czech Republic and France had lower thyroid concentrations than healthy controls ($p < 0.0001$)

(Panakova *et al.*, 2008)

SMOOTH COLLIE

See *Collies – Rough and Smooth*

SOFT-COATED WHEATEN TERRIER

Behavioural conditions

Aggression

- Soft-coated Wheaten Terrier had a prevalence of 16.2%, compared with 10.7% in the study dogs overall in the USA

(Duffy *et al.*, 2008)

Dermatological conditions

Atopic dermatitis (atopy)

- Soft-coated Wheaten Terrier had the 13th-highest incidence in insured dogs in Sweden: 3.3 cases per 1000 DYAR (95% CI 2.6–4.0)

(Nødtvedt *et al.*, 2006)

Endocrine conditions

Hypoadrenocorticism (Addison's disease)

- Complex inheritance pattern likely
- Females predisposed
- OR 6.68 (95% CI 1.11–29.49) compared with an overall US referral population

(Peterson *et al.*, 1996)

Gastrointestinal conditions

Lymphangiectasia (resulting in protein-losing enteropathy)

- Associated with protein-losing nephropathy
- Characterized in Soft-coated Wheaten Terriers in the USA
- Enhanced wheat gluten sensitivity may be one factor involved in the pathogenesis
- Familial
- Mean age at diagnosis 4.7 years

(Littman *et al.*, 2000; Vaden *et al.*, 2000)

Neoplastic conditions

Mammary neoplasia

- Soft-coated Wheaten Terrier had an incidence of 199 cases per 10 000 DYAR, compared with 116 per 10 000 DYAR in crossbreeds among insured entire bitches in Sweden

(Egenvall *et al.*, 2005)

Physiological conditions

Perinuclear antineutrophilic cytoplasmic autoantibodies (pANCA)

- 20.7% of healthy Soft-coated Wheaten Terriers in the UK had positive results for pANCA

(Wieland *et al.*, 2012)

Renal and urinary conditions

Familial renal disease (familial nephropathy)

- Associated with protein-losing enteropathy
- Described in Soft-coated Wheaten Terriers in Norway
- Complicated inheritance reported for protein-losing nephropathy, with multiple genes, variable expression and possibly environmental triggers
- Mutations causing a podocytopathy identified, associated with protein-losing nephropathy in Soft-coated Wheaten Terriers in the USA and Canada

(Eriksen & Gröndalen, 1984; Littman *et al.*, 2013; Vaden *et al.*, 2013)

Kidney disease

- Soft-coated Wheaten Terrier had an incidence of 30 (95% CI 23–37) cases per 10 000 DYAR compared with 15.8 per 10 000 DYAR overall among insured dogs in Sweden

(Pelander *et al.*, 2015)

SPANISH GREYHOUND (GALGOS ESPAÑOL)

Physiological conditions

Haematological differences

- Spanish Greyhounds have higher haematocrits, haemoglobin concentrations, red cell counts and blood pH than other dogs
- Spanish Greyhounds have lower platelet counts than other dogs

(Mesa-Sánchez *et al.*, 2012)

SPANISH MASTIFF

Behavioural conditions

Aggression

- Spanish Mastiff had higher levels of territorial aggression in Spain

(Perez-Guisado & Munoz-Serrano, 2009)

SPANISH WATER DOG

Musculoskeletal conditions

Hip dysplasia

- Spanish Water Dog had 22nd-highest prevalence in a US study: 27.0%

(Ginja *et al.*, 2010; Orthopedic Foundation for Animals, 2016)

Short tail (bobtail)

- 57.1% of Spanish Water Dog tested in Finland affected

(Hytönen *et al.*, 2009)

Renal and urinary conditions

Portal vein hypoplasia

- Can lead to urine supersaturation with uric acid (hyperuricosuria) and urate urolithiasis
- Associated with mutated *SLC2A9* gene
- Identified in a Spanish Water Dog in the UK

(Cosgrove *et al.*, 2015)

SPINONE ITALIANO

See *Italian Spinone*

SPRINGER SPANIEL (ENGLISH, WELSH, UNSPECIFIED VARIANTS)

Behavioural conditions

Aggression

- A genetic basis for aggression has been described
- 55.6% of Springer Spaniels aged < 1 year and 26.8% of those aged ≥ 1 year had bitten, in a Canadian veterinary survey
- Intense aggression was reported in 48.4% of English Springer Spaniels, and 26.3% had bitten a human in the USA
- English Springer Spaniel had a prevalence of 17.5% for dog-to-dog aggression, compared with 10.7% in study dogs overall in the USA

(Guy *et al.*, 2001; Reisner *et al.*, 2005; Duffy *et al.*, 2008; Zapata *et al.*, 2016)

Dental conditions

Canine odontogenic parakeratinized cyst

- English Springer Spaniel comprised 22.2% of a US referral caseload and was significantly ($p < 0.001$) over-represented compared with the overall hospital population

(Verstraete *et al.*, 2011)

Dermatological conditions

Atopic dermatitis (atopy)

- Welsh Springer Spaniel had the 14th-highest incidence in insured dogs in Sweden: 2.9 cases per 1000 DYAR (95% CI 2.0–3.8)
- English Springer Spaniel comprised 3.0% (95% CI 1.3–5.8) of an atopic caseload compared with 1.2% of the overall hospital population in a US referral study

(Zur *et al.*, 2002; Nødtvedt *et al.*, 2006)

Grass awn migration

See under *Soft-tissue conditions*

Pemphigus foliaceus

- English Springer Spaniel had OR 20.7 (95% CI 13.1–98.8) compared with a referral population in the USA

(Kuhl *et al.*, 1994)

Primary seborrhoea

- Described in English Springer Spaniel in the USA
- Half develop clinical signs by 2 years of age
- Familial occurrence reported in English Springer Spaniels

(Scott & Miller, 1996)

Sebaceous adenitis

- Autosomal recessive inheritance with variable expression
- Median age at diagnosis 5 years
- Springer Spaniel had the fifth-highest breed relative risk in Sweden and comprised 24.0% of a general veterinary caseload

(Tevell *et al.*, 2008)

Endocrine conditions

Diabetes mellitus

- Familial and inherited
- Older entire females are predisposed
- English Springer Spaniel had RR 4.7 (95% CI 1.7–13.0) compared with an overall US referral population

(Marmor *et al.*, 1982)

Hypoadrenocorticism (Addison's disease)

- Complex inheritance pattern likely: estimated heritability 0.49 (±0.16)
- Association with alleles in genes *COL4A4*, *OSBPL9*, *CTLA4*, *PTPN22* and *STXBP5* identified in Springer Spaniel
- Welsh Springer Spaniel had incidence rate of 6.31 (95% CI 2.96–13.7) cases per 10 000 DYAR, compared with 2.26 (95% CI 2.07–2.46) overall in insured dogs in Sweden

(Short *et al.*, 2013; Hanson *et al.*, 2016)

Gastrointestinal conditions

Chronic hepatitis

- Multiple possible causes, so breed predisposition may change with time and geographic location due to genetic and environmental factors
- Median age at diagnosis was 8 years and median survival time was 189 days in the UK
- Protective and risk-conferring alleles and haplotype identified in English Springer Spaniel in the UK
- English Springer Spaniel had OR 4.6 (95% CI 1.9–11.2) compared with overall unselected dogs from first-opinion practices in the UK and OR 5.3 (95% CI 4.2–6.7) compared with an overall laboratory population in the UK
- English Springer Spaniel had RR 3.7 (95% CI 1.1–11.9) among referral post-mortem cases in the UK

(Watson *et al.*, 2007, 2010; Bexfield *et al.*, 2011, 2012a, 2012b)

Gastrointestinal foreign bodies

- Mean age of UK affected dogs was 2.5 years
- Springer Spaniel had RR 8.3 (95% CI 4.1–16.8) compared with an overall general population in the UK

(Hayes, 2009)

Haematological/immunological conditions

Immune-mediated haemolytic anaemia (IMHA)

- Females predisposed
- Springer Spaniel had OR 10.0 (95% CI 1.3–74.7) compared with an overall referral population in Australia
- English Springer Spaniel had OR 32.4 (95% CI 2.8–379.0) compared an overall referral population in the USA

(Reimer *et al.*, 1999; McAlees, 2010)

Phosphofructokinase deficiency

- Molecular basis of a nonsense mutation in the penultimate exon of the *M-PFK* gene identified in English Springer Spaniel
- Inherited as an autosomal recessive trait

(Giger *et al.*, 1986; Smith *et al.*, 1996a; Skibild *et al.*, 2001)

Infectious conditions

Parvovirus enteritis

- English Springer Spaniel had OR 8.1 (95% CI 2.3–29.6) compared with an overall referral US population

(Glickman *et al.*, 1985)

Musculoskeletal conditions

Incomplete ossification of the humeral condyle (IOHC)

- Associated with humeral condylar fractures following minimal trauma during normal activity
- Males predisposed
- Springer Spaniels comprised 85.0% of an affected caseload in the UK

(Carrera *et al.*, 2008)

Hip dysplasia

- English Springer Spaniel had 13.1% prevalence in the USA
- Two US reports show English Springer Spaniel had odds ratios of 1.4 (95% CI 11–1.8) and 1.26 (1.16–1.37) compared with crossbreeds

(LaFond *et al.*, 2002; Witsberger *et al.*, 2008; Ginja *et al.*, 2010; Orthopedic Foundation for Animals, 2016)

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- OR 2.8 (95% CI 2.2–3.5) compared to crossbreeds in the USA

(LaFond *et al.*, 2002; Trostel *et al.*, 2003)

Neoplastic conditions

Anal sac adenocarcinoma

- Springer Spaniel had OR 3.7 (95% CI 2.5–5.3) in the UK

(Polton *et al.*, 2006)

Cutaneous haemangioma

- English Springer Spaniel had OR 1.6 (95% CI 1.2–2.2) compared with crossbreeds in the USA

(Goldschmidt & Mcmanus, 2000)

Mammary neoplasia

- English Springer Spaniel had an incidence of 319 cases per 10 000 DYAR, compared with 116 per 10 000 DYAR in crossbreeds among insured entire bitches in Sweden
- English Springer Spaniel had the third-highest relative risk ratio in Norway

(Moe, 2001; Egenvall *et al.*, 2005)

Neurological conditions

Idiopathic epilepsy

- Hereditary basis established in several breeds
- Median age at onset of seizures in English Springer Spaniels was 3 years
- Partially penetrant autosomal recessive inheritance or polygenic inheritance in English Springer Spaniels
- English Springer Spaniel had an incidence of 17.3 per 10 000 DYAR (95% CI 14.0–20.7) among insured dogs in Sweden, compared with 16.1 (95% CI 14.7–17.4) for crossbreeds

(Patterson *et al.*, 2005; Heske *et al.*, 2014)

Lysosomal storage disease – fucosidosis

- Leads to undesirable behaviour in adolescent and adult dogs that may be misdiagnosed as a primary behavioural problem or acquired neurologic disease
- Reported in English Springer Spaniel in the USA
- Autosomal recessive inheritance
- Molecular defect identified in English Springer Spaniel

(Skelly *et al.*, 1996; Smith *et al.*, 1996b)

Steroid-responsive meningitis–arteritis (SRMA)

- Young, medium- to large-breed dogs predisposed
- Suspected to be immune-mediated
- English Springer Spaniels were significantly over-represented ($p < 0.001$) in a UK referral population, comprising 20% of the caseload

(Lowrie *et al.*, 2009)

Ocular conditions

Cataract

- 28% of cataracts reported as breed-related in France
- Prevalence of primary cataract 2.22% in English Springer Spaniel and 1.99% in Welsh Springer Spaniel, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)
- Hereditary cataract described in Welsh Springer Spaniels in the UK

(Barnett, 1980; Gelatt & MacKay, 2005; Donzel *et al.*, 2016)

Corneal and anterior segment foreign body trauma

- Working dogs and dogs < 5 years predisposed
- English Springer Spaniel had OR 6.2 (95% CI 4.5–8.7) compared to other referral dogs in the UK

(Tetas Pont *et al.*, 2015)

Corneal ulceration (ulcerative keratitis)

- English Springer Spaniel had OR 1.93 (95% CI 1.17–3.19) compared with crossbreeds in the UK

(O'Neill *et al.*, 2017b)

Glaucoma – primary

- Female Welsh Springer Spaniels predisposed in the UK
- Welsh Springer Spaniel had OR 5.00 ($p = 0.04$) compared with an overall referral population in Switzerland

(Cottrell & Barnett, 1988; Strom *et al.*, 2011a)

Pectinate ligament dysplasia (PLD)

- Associated with glaucoma in many breeds
- English Springer Spaniel had 25.5% prevalence in a Norwegian screening programme
- Welsh Springer Spaniel had 61.2% prevalence among a UK general population

(Bjerkås *et al.*, 2002; Oliver *et al.*, 2016b)

Retinal dysplasia

- Clinically described in English Springer Spaniels in the USA

(O'Toole *et al.*, 1983)

Sudden acquired retinal degeneration (SARD, amaurosis)

- Median age 8.1 years
- English Springer Spaniel comprised 5% of a US caseload

(Montgomery *et al.*, 2008)

Physiological conditions

Litter size

- Larger litters associated with younger bitches and larger breeds
- English Springer Spaniel had the twelfth largest mean litter size (7.3 puppies) among registered breeds in Norway

(Borge *et al.*, 2011)

Renal and urinary conditions

Kidney disease

- English Springer Spaniel had an incidence of 23 (95% CI 19–27) cases per 10 000 DYAR, compared with 15.8 per 10 000 DYAR overall among insured dogs in Sweden

(Pelander *et al.*, 2015)

Urethral sphincter mechanism incompetence

- Larger breeds had OR 7.2 compared with smaller breed in the USA
- Springer Spaniel was over-represented in a UK referral caseload

(Holt, 1985; Forsee *et al.*, 2013)

Urinary tract infections (UTI)

- Springer Spaniel (3.4%) was the seventh most commonly affected breed among referral dogs in the USA for recurrent or persistent UTI

(Norris *et al.*, 2000)

Urolithiasis

- Springer Spaniel was the twelfth most common breed for uroliths overall submitted for laboratory testing in the UK (1.8%)

(Rogers *et al.*, 2011)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- English Springer Spaniel showed RR 1.9 (95% CI 1.3–2.5) compared with all bitches insured by Agria for veterinary care in Sweden

(Egenvall *et al.*, 2001; Smith, 2006)

Respiratory conditions

Aspiration pneumonia

- English Springer Spaniel comprised 4.4% of cases but only 0.6% of the underlying referral population in the USA

(Kogan *et al.*, 2008)

Bronchiectasis

- English Springer Spaniel had an OR of 2.39 (95% CI 1.23–4.64) compared with an overall US referral population

(Hawkins *et al.*, 2003)

Pyothorax

- May be associated with initial inhalation of foreign bodies during the scenting habits and outdoor nature of some breeds
- Springer Spaniel was the most common breed, comprising 43.8% of a UK referral caseload

(Johnson & Martin, 2007)

Soft-tissue conditions

Grass awn migration

- Grass awns comprised 61% of all foreign-body-related cases
- Ear canal (51%) was the most commonly affected site
- Springer Spaniel was significantly over-represented in the USA

(Brennan & Ihrke, 1983)

Oropharyngeal penetrating injury

- Medium- to large-breed dogs and males predisposed
- May be associated with stick-chasing activity in larger breeds and head posture during retrieving
- Springer Spaniels had 3.09 (95% CI 1.07–8.15) OR compared with a UK referral population

(Griffiths *et al.*, 2000)

STAFFORDSHIRE BULL TERRIER (SBT)

Behavioural conditions

Aggression

- A genetic basis for aggression has been described
- A survey of UK veterinarians classified SBT as having high aggression
- SBT was over-represented as the aggressor in dog–dog conflict in Germany, representing

5.8% of aggressors and 1.2% of the general population

(Roll & Unshelm, 1997; Bradshaw & Goodwin, 1999)

Dermatological conditions

Atopic dermatitis (atopy)

- SBT had the fifth-highest incidence in insured dogs in Sweden: 8.0 cases per 1000 DYAR (95% CI 5.3–10.7)

(Nødtved *et al.*, 2006)

Demodicosis

- Short-haired breeds predisposed
- An inheritance pathway has been described
- SBT was described as a predilected breed in a Swedish referral study
- SBT had the second-highest breed OR of 17.12 (95% CI 2.2–133.4) compared with an overall US first-opinion population

(Holm, 2003; It *et al.*, 2010; Plant *et al.*, 2011)

Gastrointestinal conditions

Gastrointestinal foreign bodies

- Mean age of UK affected dogs was 2.5 years
- RR 3.3 (95% CI 2.2–5.1) compared with an overall general population in the UK

(Hayes, 2009)

Infectious conditions

Angiostrongylosis

- The median age of affected dogs was 10 months, and young dogs were predisposed ($p < 0.0001$)
- SBT were significantly over-represented ($p < 0.0001$), comprising 21.7% of a UK referral caseload

(Chapman *et al.*, 2004)

Metabolic conditions

Hypocobalaminaemia

- SBT had the second-highest breed OR of 2.6 (95% CI 1.7–3.9) compared with a laboratory population in the UK

(Dandrieux *et al.*, 2013)

Musculoskeletal conditions

Elbow dysplasia

- SBT had 33.3% prevalence in the UK, 16.2% in the USA, and 31.3% in South Africa

(Kirberger & Stander, 2007; Michelsen, 2013; Kennel Club, 2016; Orthopedic Foundation for Animals, 2016)

Neoplastic conditions

Gastric carcinoma

- SBT significantly over-represented

(Sullivan *et al.*, 1987b)

Mammary neoplasia

- 25% of insured SBT bitches in Sweden develop the condition by 10 years of age, compared with 13% for bitches overall

(Jitpean *et al.*, 2012)

Mast cell tumour (MCT)

- Compared to crossbreeds, SBT had odds ratios of 4.2 (95% CI 2.2–8.2) in the UK and 4.1 (95% CI 2.4–7.1) in the USA
- OR 3.49 (95% CI 2.09–5.81) compared with an overall referral population in the UK
- SBT had the second-highest breed RR (9.97) compared with all breeds in laboratory records in the USA, and was significantly over-represented in a US referral study ($p = 0.044$)

(Goldschmidt & Mcmanus, 2000; Baker-Gabb *et al.*, 2003; Warland & Dobson, 2013; Shoop *et al.*, 2015; Mochizuki *et al.*, 2016)

Neoplasia – overall

- SBT had the eighth-highest proportional mortality from cancer among pedigree breeds in the UK: 44.4% (95% CI 35.4–53.4)

(Adams *et al.*, 2010)

Neurological conditions

L-2-Hydroxyglutaric aciduria (organic aciduria)

- Progressive neurological signs between 4 months and 7 years of age
- Described in SBT in the UK and a mutation in canine *L2HGDH* gene identified

(Abramson *et al.*, 2003; Penderis *et al.*, 2007; Short *et al.*, 2010)

Ocular conditions

Cataract

- 28% of cataracts reported as breed-related in France
- SBT showed 10.9% prevalence of cataract among ophthalmic referrals in South Africa
- Autosomal recessive mutation identified in SBT, and DNA test available

(Petrick, 1996; Mellersh *et al.*, 2006; Donzel *et al.*, 2016; Animal Health Trust, 2017)

Corneal ulceration (ulcerative keratitis)
- OR 2.50 (95% CI 1.81–3.45) compared with crossbreeds in the UK

(O'Neill *et al.*, 2017b)

Renal and urinary conditions

Urolithiasis – cystine
- OR 8.7 (95% CI 6.8–11.2) compared with all dogs in the UK

(Roe *et al.*, 2012)

Reproductive conditions

Cryptorchidism
- SBT had a 9.3% prevalence in the UK, which was significantly higher than for crossbreeds ($p = 0.0006$)

(Yates *et al.*, 2003)

Dystocia
- SBT had the sixth-highest incidence (23.6 cases per 1000 DYAR) among insured bitches in Sweden, compared with 5.7 per 1000 DYAR overall
- OR 4.1 (95% CI 2.7–6.2) compared with first-opinion emergency-care crossbred bitches in the UK

(Bergström *et al.*, 2006; O'Neill *et al.*, 2017c)

Pyometra (cystic endometrial hyperplasia–pyometra complex)
- 54% of insured SBT bitches develop the condition by 10 years of age, compared with 19% for bitches overall

(Jitpean *et al.*, 2012)

Respiratory conditions

Brachycephalic obstructive airway syndrome (BOAS)
- SBT comprised 5.5% of a US BOAS caseload

(Torrez & Hunt, 2006; Marchant *et al.*, 2017)

Soft-tissue conditions

Non-accidental injury (NAI, battered pet)
- Males ($p < 0.001$) and dogs aged < 2 years ($p < 0.001$) significantly predisposed
- SBT had OR 7.2 (95% CI 3.5–13.4) and SBT-cross dogs had OR 48 (95% CI 11–18.1) compared with the general population of dogs under primary veterinary care in the UK

(Munro & Thrusfield, 2001)

STAFFORDSHIRE BULL TERRIER – AMERICAN

See *American Staffordshire Terrier*

SUSSEX SPANIEL

Metabolic conditions

Overweight/obesity
- Sussex Spaniel had significantly higher body condition score (5.57) than other show dogs in Holland

(Courcier *et al.*, 2010; Corbee, 2013; Raffan *et al.*, 2016)

Pyruvate dehydrogenase phosphatase 1 deficiency
- Causes severe exercise intolerance
- Null mutation in *PDP1* identified
- Classic Mendelian autosomal recessive inheritance
- 63.6% of Sussex Spaniels tested in the USA were carriers

(Abramson *et al.*, 2004; Cameron *et al.*, 2007)

Musculoskeletal conditions

Elbow dysplasia
- Sussex Spaniel had 20.5% prevalence in the USA

(Michelsen, 2013; Orthopedic Foundation for Animals, 2016)

Hip dysplasia
- Sussex Spaniel had tenth-highest prevalence in a US study: 41.2%

(Ginja *et al.*, 2010; Orthopedic Foundation for Animals, 2016)

SWEDISH CATTLE DOG

See *Swedish Vallhund*

SWEDISH ELKHOUND (JÄMTHUND)

Endocrine conditions

Diabetes mellitus
- Familial and inherited
- Peak incidence age 7–9 years

- Older entire females during dioestrus and pregnancy are predisposed
- Swedish Elkhound had fourth-highest breed incidence in Sweden: 45 cases per 10 000 DYAR (95% CI 32–58)

(Fall *et al.*, 2007, 2010; Catchpole *et al.*, 2008)

Neoplastic conditions

Mammary neoplasia

- 26% of insured Swedish Elkhound bitches in Sweden develop the condition by 10 years of age, compared with 13% for bitches overall

(Jitpean *et al.*, 2012)

Neurological conditions

Idiopathic epilepsy

- Hereditary basis established in several breeds
- Swedish Elkhound had an incidence of 16.5 per 10 000 DYAR (95% CI 12.8–20.1) among insured dogs in Sweden, compared with 16.1 (95% CI 14.7–17.4) for crossbreeds

(Heske *et al.*, 2014)

Ocular conditions

Progressive retinal atrophy (PRA)

- Described in closely related Swedish Elkhound in Sweden
- Compatible with a recessive inheritance

(Hertil *et al.*, 2010)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- 40% of insured Swedish Elkhound bitches develop the condition by 10 years of age, compared with 19% for bitches overall

(Jitpean *et al.*, 2012)

SWEDISH FARMDOG

See *Danish/Swedish Farmdog*

SWEDISH LAPPHUND

Endocrine conditions

Diabetes mellitus

- Familial and inherited
- Breed at increased risk in a retrospective review of Swedish insurance data, 1995–2004
- Peak incidence age 7–9 years
- Older entire females are predisposed
- Swedish Lapphund had third-highest breed incidence in Sweden: 72 cases per 10 000 DYAR (95% CI 33–111), compared to an overall incidence for all breeds of 13 cases per 10 000 DYAR

(Fall *et al.*, 2007; Catchpole *et al.*, 2008)

SWEDISH VALLHUND (SWEDISH CATTLE DOG)

Musculoskeletal conditions

Short tail (bobtail)

- 72.7% of Swedish Vallhund tested in Finland affected

(Hytönen *et al.*, 2009)

Ocular conditions

Progressive retinal atrophy (PRA)

- Autosomal recessive mode of inheritance with environmental disease modifiers suggested in Swedish Vallhund
- Genetics and clinical presentation described in Swedish Vallhund in several countries

(Cooper *et al.*, 2014a)

SWISS MOUNTAIN DOG (SENNENHUND)

Haematological/immunological conditions

Platelet disorder

- Familial and hereditary in Greater Swiss Mountain Dogs
- Spontaneous haemorrhage is absent to mild in affected dogs, but excessive bleeding can occur following routine surgical procedures or trauma
- Platelet numbers, coagulation and von Willebrand assays are normal
- Mutation for the gene encoding the ADP receptor P2Y12 identified in Greater Swiss Mountain Dogs in Canada

(Boudreaux & Martin, 2011)

Metabolic conditions

Overweight/obesity

- Swiss Mountain Dogs had significantly higher body condition score than other show dogs in Holland

(Courcier *et al.*, 2010; Corbee, 2013; Raffan *et al.*, 2016)

Musculoskeletal conditions

Lumbosacral transitional vertebrae

- Breed at increased risk in a Swiss retrospective study of x-rays of 4000 medium- and large-breed dogs, 1996–1998. Prevalence in the 64 Swiss Mountain dogs was 9.4%, compared to an overall prevalence of 3.5%
- There was no effect of gender

(Damur-Djuric *et al.*, 2006)

Osteochondrosis – shoulder

- Breed at increased risk in retrospective study of 626 cases from VMDB entries, 1982–1986. Incidence 7.69%
- Breed at increased risk of humeral head osteochondrosis. A Swiss study demonstrated a prevalence of 14%, 1993–2013. This was suggested to be in the mid to upper range compared to reported prevalences in other breeds

(Rudd *et al.*, 1990; Ohlerth *et al.*, 2016)

Neoplastic conditions

Fibroma/fibrosarcoma

- Swiss Mountain Dogs had an OR significantly above 1.0 ($p < 0.05$) compared with cross-breeds from a cancer registry in Switzerland

(Grüntzig *et al.*, 2016)

Lymphoma

- Swiss Mountain Dogs had an OR significantly above 1.0 ($p < 0.05$) compared with cross-breeds from a cancer registry in Switzerland

(Grüntzig *et al.*, 2016)

Mast cell tumour (MCT)

- Swiss Mountain Dogs had an OR significantly above 1.0 ($p < 0.05$) compared with cross-breeds from a cancer registry in Switzerland

(Grüntzig *et al.*, 2016)

TENTERFIELD TERRIER

Endocrine conditions

Congenital hypothyroidism

- Associated with other developmental abnormalities including dwarfism, delayed epiphyseal ossification, abnormal hair texture, unresponsiveness and lethargy
- Causal missense mutation in exon 9 (R593W) identified in Tenterfield Terrier
- Autosomal recessive inheritance

(Dodgson *et al.*, 2012)

Neurological conditions

Spinocerebellar ataxia (hereditary ataxia)

- Incoordination noticed from 2–9 months of age
- Progressive and often leads to euthanasia
- Mutation in the *KCNJ10* gene identified in the Tenterfield Terrier

(Rohdin *et al.*, 2015)

Ocular conditions

Lens luxation – primary

- Tenterfield Terriers had 12% prevalence in Australia
- Frequency of the A-422 haplotype was 0.41 in the Tenterfield Terrier in Australia

(Gharahkhani *et al.*, 2012)

THAI RIDGEBACK (MAH THAI)

Neurological conditions

Dermoid sinus

- Complex dihybrid mode of inheritance suggested
- Causative mutation is a duplication of *FGF3*, *FGF4*, *FGF19* and *ORAOV1* genes that cause hair ridge and predisposition to dermoid sinus in Thai Ridgeback dogs

(Salmon Hillbertz *et al.*, 2007)

Physiological conditions

Dorsal ridge

- Breed-defining ridge of Thai Ridgebacks comes from a duplication of a specific region on chromosome 18 called the Ridge allele
- Dominant inheritance
- Homozygosity for the Ridge allele predisposes to dermoid sinus

(Waldo & Diaz, 2015)

TIBETAN MASTIFF

Musculoskeletal conditions

Elbow dysplasia

- Tibetan Mastiff had 22.8% prevalence in the UK and 14.3% in the USA

(Michelsen, 2013; Kennel Club, 2016; Orthopedic Foundation for Animals, 2016)

Neurological conditions

Hypertrophic neuropathy

- Autosomal recessive inheritance

- Described in related Tibetan Mastiffs
- Age of clinical onset 7–18 weeks

(Cummings *et al.*, 1981; Sponenberg & de Lahunta, 1981)

Physiological conditions

Adaptation to hypoxia

- Tibetan Mastiff has adapted to the extreme high-altitude environment of the Tibetan Plateau
- 12 candidate genes identified for adaptations to high altitude and roles in responses to hypoxia
- Tibetan Mastiff has lower blood haemoglobin levels and greater smooth muscle content of pulmonary blood vessel and pulmonary pleura than other breeds

(Jian-guo *et al.*, 2009; Li *et al.*, 2014; Wang *et al.*, 2014)

TIBETAN SPANIEL

Musculoskeletal conditions

Patellar luxation

- 12.6% of US referred Tibetan Spaniels affected
- Mainly medial luxation observed, often bilateral

(Orthopedic Foundation for Animals, 2015)

Neoplastic conditions

Mast cell tumour (MCT)

- Mean age at presentation between 7.5 and 9 years, but can occur at any age
- OR 7.73 (95% CI 1.03–10.69) compared with crossbreeds in Austria

(Goldschmidt & Mcmanus, 2000; Leidinger *et al.*, 2014)

Neurological conditions

Intervertebral disc disease (IVDD)

- Males and older dogs predisposed
- Tibetan Spaniel had an incidence rate of 48.7 (95% CI 37.5–59.9), compared with 27.8 for an overall population of insured dogs in Sweden

(Bergknut *et al.*, 2012)

Ocular conditions

Progressive retinal atrophy (PRA)

- PRA mutation identified in Tibetan Spaniel in the UK
- Autosomal recessive mode inheritance and rapid progression over 1 year from initial clinical signs to complete loss of vision in Tibetan Spaniel in Norway and Sweden

(Bjerkås & Narfström, 1994; Downs *et al.*, 2014a)

Renal and urinary conditions

Primary hyperoxaluria

- Reported in related Tibetan Spaniels in Norway
- Cases presented at 6 weeks and had an unusual coat colour
- May be part of an overall juvenile nephropathy syndrome in the Tibetan Spaniel

(Jansen & Arnesen, 1990)

TIBETAN TERRIER

Dermatological conditions

Atopic dermatitis (atopy)

- Tibetan Terrier comprised 1.9% (95% CI 0.6–4.3) of an atopic caseload, compared with 0.25% of the overall hospital population, in a US referral study
- Tibetan Terrier had 5.86% prevalence, compared with 1.08% for crossbreeds in a US referral caseload

(Zur *et al.*, 2002; Bellumori *et al.*, 2013)

Endocrine conditions

Diabetes mellitus

- Familial and inherited
- Older entire females are predisposed
- Tibetan Terrier comprised 5.3% of cases, compared with 0.3% of the overall population of insured dogs in the UK

(Davison *et al.*, 2005)

Haematological/immunological conditions

Haemophagocytic syndrome

- Benign proliferative disorder of activated macrophages associated with multiple blood cytopenias
- Tibetan Terriers were over-represented, comprising 12.5% of a US referral caseload

(Weiss, 2007)

Musculoskeletal conditions

Patellar luxation

- 5.2% of US referred Tibetan Terriers affected
- Mainly medial luxation observed, often bilateral

(Orthopedic Foundation for Animals, 2015)

Neurological conditions

Neuronal ceroid lipofuscinosis

- Only nyctalopia (night blindness) noted until 5/6 years of age and then personality and learning changes develop afterwards
- Autosomal recessive inheritance of a truncating 376 mutation in canine *ATP13A2* identified in the Tibetan Terrier in the USA
- Application of DNA testing was associated with a drop in mutant allele frequencies from 0.20–0.28 before the introduction to 0.09–0.14 two years after the introduction

(Riis *et al.*, 1992; Farias *et al.*, 2011; Wöhlke *et al.*, 2011; Kluth *et al.*, 2014)

Ocular conditions

Cataract

- 28% of cataracts reported as breed-related in France
- Tibetan Terrier had 4.71% prevalence and 13% heritability for non-congenital cataracts in Germany
- Prevalence of primary cataract 5.92%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)
- Tibetan Terrier had 18.92% prevalence, compared with 4.04% for crossbreeds, in a US referral study

(Ketteritzsch *et al.*, 2004; Gelatt & MacKay, 2005; Bellumori *et al.*, 2013; Donzel *et al.*, 2016)

Distichiasis

- Tibetan Terrier had 4.3% heritability and 11.4% prevalence in Germany

(Ketteritzsch *et al.*, 2004)

Lens luxation – primary

- *ADAMTS17* mutation has been identified, with a simple autosomal recessive hypothesis
- Tibetan Terrier had 99.3% heritability and 1.29% prevalence in Germany
- Tibetan Terrier had relative risks (RR) of 4.94 (95% CI 1.87–13.04) and 3.69 (95% CI 1.75–7.80) compared with overall referral dogs in two US studies

(Willis *et al.*, 1979; Ketteritzsch *et al.*, 2004; Sargan *et al.*, 2007; Gould *et al.*, 2011)

Persistent pupillary membranes

- Tibetan Terrier had 17.1% heritability and 12.8% prevalence in Germany

(Ketteritzsch *et al.*, 2004)

Progressive retinal atrophy (PRA)

- Simple autosomal recessive mode of inheritance suspected in Tibetan Terrier
- Tibetan Terrier had 49.1% heritability and 1.4% prevalence in Germany
- PRA mutation identified in Tibetan Terrier in the UK

(Millichamp *et al.*, 1988; Ketteritzsch *et al.*, 2004; Downs *et al.*, 2014a)

Renal and urinary conditions

Urolithiasis – calcium oxalate

- OR 2.3 (95% CI 1.6–3.4) compared with all dogs in the UK

(Roe *et al.*, 2012)

Urolithiasis – struvite (magnesium ammonium phosphate)

- OR 2.0 (95% CI 1.4–2.8) compared with all dogs in the UK

(Roe *et al.*, 2012)

TOSA

See *Japanese Tosa*

TREEING WALKER COONHOUND

See *Coonhound*

TURKISH SHEPHERD DOG (AKBASH, KANGAL AND KARS)

Ocular conditions

Retinal dysplasia

- 17.1% of Akbash and 5.4% of Kangal dogs from breeding or referral dogs in Turkey affected

(Saroğlu *et al.*, 2005)

Physiological conditions

Blood group

- DEA 1.1 is highly immunogenic and causes acute haemolytic transfusion reactions in sensitized dogs
- The frequency of positivity for DEA 1.1 was 71.2% in Kars, 67.9% in Kangal and 60.0% in Akbash

- 14.4–35.6% probability of sensitizing a DEA 1.1-negative recipient at the first transfusion with blood from a DEA 1.1-positive donor of any of the three Turkish Shepherd breeds

(Arikan *et al.*, 2009; Ergul Ekiz *et al.*, 2011)

VALLHUND

See *Swedish Vallhund*

VIZSLA

See *Hungarian Vizsla*

VORSTEHHUND

See *Weimaraner*

WACHTELHUND (GERMAN SPANIEL, DEUTSCHER WACHTELHUND)

Dermatological conditions

Atopic dermatitis (atopy)

- Wachtelhund had the tenth-highest incidence in insured dogs in Sweden: 4.2 cases per 1000 DYAR (95% CI 3.3–5.1)

(Nødtvedt *et al.*, 2006)

Endocrine conditions

Hypoadrenocorticism (Addison's disease)

- Complex inheritance pattern likely: estimated heritability 0.49 (±0.16)
- Wachtelhund had an incidence of 4.93 (95% CI 2.54–9.72) cases per 10 000 DYAR, compared with 2.26 (95% CI 2.07–2.46) overall among insured dogs in Sweden

(Hanson *et al.*, 2016)

Haematological/immunological conditions

Phosphofructokinase deficiency

- Inherited as an autosomal recessive trait
- Deficiency causes haemolytic crises and exertional myopathy
- Missense point mutation (c.550C>T) for phosphofructokinase) identified in Wachtelhunds in Sweden

(Inal Gultekin *et al.*, 2012b)

Neoplastic conditions

Mammary neoplasia

- Wachtelhund had an incidence of 149 cases per 10 000 DYAR, compared with 116 per 10 000 DYAR in crossbreeds among insured entire bitches in Sweden

(Egenvall *et al.*, 2005)

WEIMARANER (VORSTEHHUND)

Cardiovascular conditions

Congenital heart disease

- Includes a range of congenital heart disorders
- Weimaraner had an OR of 9.4 compared with all referral dogs in Italy

(Oliveira *et al.*, 2011)

Pulmonary artery dissection

- Weimaraner comprised 37.5% of a UK/US referral caseload and was suggested as predisposed

(Scansen *et al.*, 2015)

Dermatological conditions

Blastomycosis

See under *Infectious conditions*

Canine follicular dysplasia (seasonal flank alopecia)

- Familial tendency with early age at onset suggests an inherited basis
- Group of similar hair disorders
- Described in Weimaraners in France

(Laffort-Dassot *et al.*, 2002)

Drug reactions

Anaesthetic-related complications

- Weimaraner had the equal-highest incidence (25%) among general small animal practices in Canada

(Dyson *et al.*, 1998)

Metaphyseal osteopathy

See under *Musculoskeletal conditions*

Gastrointestinal conditions

Gastric dilatation/volvulus (bloat, GDV)

- 11.6% of UK pedigree Weimaraners died of the condition
- Weimaraner had sixth-highest pedigree prevalence (5.0%) in the UK and was highly represented in a referral study in Israel

- Weimaraner had an incidence of 21 cases per 1000 DYAR (95% CI 0–42) in the USA

(Glickman *et al.*, 2000a; Evans & Adams, 2010b;; Israeli *et al.*, 2012)

Inflammatory bowel disease

- Mode of inheritance is incompletely understood and may differ between breeds
- Weimaraner had an OR of 3.68 (95% CI 2.02–6.71) compared with referred crossbreeds in the UK

(Kathrani *et al.*, 2011)

Haematological/immunological conditions

Immunodeficiency syndrome

- Considered inherited in Weimaraner, but mode of inheritance unclear
- Median age at presentation of 4 months
- Clinical signs and low blood antibody levels often develop within 7 days of vaccination
- Described in Weimaraner in the UK

(Couto *et al.*, 1989; Foale *et al.*, 2003; Cuthbert *et al.*, 2016)

Infectious conditions

Blastomycosis

- Weimaraner was at increased risk compared with referral crossbred dogs in the USA

(Rudmann *et al.*, 1992; Arceneaux *et al.*, 1998)

Musculoskeletal conditions

Metaphyseal osteopathy

- Primarily young (2–6 months), rapidly growing large- and giant-breed dogs
- OR 21.4 (95% CI 8.2–55.8) compared to crossbreeds in the USA
- Some reports of a link with recent vaccination

(LaFond *et al.*, 2002; Crumlish *et al.*, 2006; Safra *et al.*, 2013)

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- OR 1.9 (95% CI 1.3–2.7) compared to crossbreeds in the USA

(LaFond *et al.*, 2002; Trostel *et al.*, 2003)

Neoplastic conditions

Mast cell tumour (MCT)

- Mean age at presentation between 7.5 and 9 years, but can occur at any age
- Three US studies showed Weimaraner had odds ratios of 16.26 (95% CI 3.22–82.22), 3.2 (95% CI 2.6–3.9) and 3.96 (95% CI 3.02–5.21) compared with crossbreeds
- OR 5.28 (95% CI 2.09–6.21) compared with crossbreeds in Austria

(Goldschmidt & Mcmanus, 2000; Villamil *et al.*, 2011; White *et al.*, 2011; Leidinger *et al.*, 2014)

Neurological conditions

Discospondylitis

- Males and older dogs predisposed
- OR 5.6 (95% CI 1.8–18.1) compared with referral crossbreeds in the USA

(Burkert *et al.*, 2005)

Hypomyelination syndrome

- Described in related Weimaraners in Spain
- Mutation in the folliculin-interacting protein 2 (FNIP2) gene reported in Weimaraner in the USA

(Kornegay *et al.*, 1987; Millán *et al.*, 2010; Pemberton *et al.*, 2014)

Spinal dysraphism

- Described in Weimaraners in the UK
- Inherited myelodysplasia possibly transmitted by a codominant lethal gene with variable expressivity

(van den Broek *et al.*, 1991)

Ocular conditions

Progressive retinal atrophy (PRA)

- PRA is highly heterogeneous, with autosomal dominant, recessive or X-linked modes of inheritance reported in dogs
- Large deletion of first four exons of the X-linked retinitis pigmentosa GTPase regulator (*RPGR*) gene identified in Weimaraner in Germany
- Represents a de novo mutation concerning only recent generations of the Weimaraner breed in Germany

(Kropatsch *et al.*, 2016)

Renal and urinary conditions

Hyperuricosuria

- The predisposing *SLC2A9* mutation in Dalmatians has also been described in Weimaraner
- Weimaraner has 25.41% prevalence of carriers for the mutation in the USA

(Karmi *et al.*, 2010a; Westropp *et al.*, 2014)

Urethral sphincter mechanism incompetence

- Larger breeds had an OR of 7.2 compared with smaller breeds in the USA
- Weimaraner over-represented in the UK

(Holt & Thrusfield, 1993; Bacon *et al.*, 2002; Forsee *et al.*, 2013)

Soft-tissue conditions

Peritoneopericardial diaphragmatic hernia (PPDH)

- Solely the result of congenital anomalies in the dog
- Weimaraner comprised 30.8% of affected dogs but only 1.1% of the hospital population in one study
- Weimaraner comprised 21.4% and 62.5% of cases in two US referral caseloads

(Evans & Biery, 1980; Banz & Gottfried, 2010; Burns *et al.*, 2013)

WELSH CORGI (PEMBROKE, CARDIGAN, UNSPECIFIED VARIANTS)

Behavioural conditions

Aggression

- A genetic basis for aggression has been described
- A survey of UK veterinarians classified Welsh Corgi as having high aggression

(Bradshaw & Goodwin, 1999)

Cardiovascular conditions

Patent ductus arteriosus

- Diagnosed at 12–24 weeks in Pembroke Welsh Corgi
- Described in related Pembroke Welsh Corgis
- Strong genetic predisposition reported

(Oswald & Orton, 1993)

Metabolic conditions

Exercise-induced collapse

- Many potential underlying causes of weakness and collapse associated with exercise exist in dogs
- The mutation causing dynamin 1 (*DNM1*)-associated exercise-induced collapse (d-EIC) has been identified in Pembroke Welsh Corgi

(Minor *et al.*, 2011)

Musculoskeletal conditions

Elbow dysplasia

- Pembroke Welsh Corgi had 6.7% prevalence, compared with 0.7% in the overall population, among radiographed dogs in Poland

(Narojek *et al.*, 2008; Michelsen, 2013)

Immune-mediated inflammatory myopathy with severe tongue muscular atrophy

- Characterized in Pembroke Welsh Corgis in Japan
- Mean age at diagnosis 3.4 years
- Many muscles affected, but tongue lesions most severe

(Toyoda *et al.*, 2010)

Short tail (bobtail)

- Characterized in Pembroke Welsh Corgi in Norway

(Haworth *et al.*, 2001; Indrebø *et al.*, 2008; Hytönen *et al.*, 2009)

Neoplastic conditions

Histiocytic sarcoma

- Pembroke Welsh Corgi had an OR of 9.7 (95% CI 5.6–17.0) compared with a referral population in Japan
- Median survival time was 43 days

(Takahashi *et al.*, 2014)

Lymphoma

- Pembroke Welsh Corgi had an OR of 2.1 (95% CI 1.6–2.8) compared with a US referral population

(Villamil *et al.*, 2009)

Neurological conditions

Degenerative myelopathy

- Cardigan Welsh Corgi had 1.51% prevalence and Pembroke Welsh Corgi had 0.58% prevalence, compared with 0.15% in referral crossbreeds in the USA
- Homozygosity for the A allele of the canine *SOD1* gene associated with degenerative myelopathy in Pembroke Welsh Corgi
- Prevalence of the mutant A allele was 69.7% in Pembroke Welsh Corgis in Japan, but only a small percentage may become clinically affected

(Coates *et al.*, 2007; Awano *et al.*, 2009; March *et al.*, 2009; Shelton *et al.*, 2012; Chang *et al.*, 2013)

Intervertebral disc disease (IVDD)

- Pembroke Welsh Corgi had 15.11% prevalence, compared with 4.43% for crossbreeds in a US referral caseload
- Welsh Corgi had RR 2.3 ($p < 0.01$) compared with an overall referral population in the USA

(Priester, 1976; Bellumori *et al.*, 2013)

Ocular conditions

Cataract

- 28% of cataracts reported as breed-related in France
- Prevalence of primary cataract 3.05% in Pembroke Welsh Corgi and 2.53% in Cardigan Welsh Corgi, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005; Donzel *et al.*, 2016)

Progressive retinal atrophy (PRA)

- Autosomal recessive inheritance: point mutation identified in Cardigan Welsh Corgi
- DNA-based test designed for detection of the codon 616 mutation in the alpha cyclic GMP phosphodiesterase gene in the Cardigan Welsh Corgi

(Petersen-Jones *et al.*, 1999; Petersen-Jones & Entz, 2002)

Renal and urinary conditions

Familial renal disease (familial nephropathy)

- Described in related Pembroke Welsh Corgis in the USA

(McKay *et al.*, 2004)

Telangiectasia

- Possibly congenital or hereditary
- Described in unrelated Pembroke Welsh Corgis in the USA
- May show marked haematuria and die from renal failure or anaemia

(Moore & Thornton, 1983)

Urolithiasis – cystine

- Small breeds and males are predisposed
- Males are strongly predisposed
- Welsh Corgi had OR 5.0 (95% CI 2.0–12.7) compared with crossbred dogs in the USA

(Low *et al.*, 2010)

Urolithiasis – struvite (magnesium ammonium phosphate)

- Small breeds and females are predisposed
- Welsh Corgi comprised 16.2% of a referral caseload in New Zealand

(Jones *et al.*, 1998)

Reproductive conditions

Dystocia

- 35.7% of Pembroke Welsh Corgi litters born by caesarean section in the UK

(Evans & Adams, 2010a)

High perinatal mortality

- Older dams and increasing litter size associated with increased perinatal mortality
- Overall perinatal mortality risk in Norway was 8.0%
- Pembroke Welsh Corgi had the fifth-highest perinatal mortality (16.9%) among registered purebred litters in Norway

(Tønnessen *et al.*, 2012)

WELSH SPRINGER SPANIEL

See *Springer Spaniel*

WELSH TERRIER

Dermatological conditions

Atopic dermatitis (atopy)

- Welsh Terrier had the second-highest incidence in insured dogs in Sweden: 13.4 cases per 1000 DYAR (95% CI 9.4–17.4)

(Nødtvedt *et al.*, 2006)

Musculoskeletal conditions

Pectus excavatum (funnel chest)

- Brachycephalic breeds are over-represented
- Atypical form that resolves spontaneously described in Welsh Terriers in the USA

(Ellison & Halling, 2004)

Neoplastic conditions

Mammary neoplasia

- 37% of insured Welsh Terrier bitches in Sweden develop the condition by 10 years of age, compared with 13% for bitches overall

(Jitpean *et al.*, 2012)

Neoplasia – overall

- Welsh Terrier had the ninth-highest proportional mortality from cancer among pedigree breeds in the UK: 43.5% (95% CI 23.3–63.7)

(Adams *et al.*, 2010)

Ocular conditions

Cataract

- 28% of cataracts reported as breed-related in France
- Prevalence of primary cataract 5.14%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005; Donzel *et al.*, 2016)

Lens luxation – primary

- *ADAMTS17* mutation has been identified: 35.9% of US Welsh Terriers were carriers
- Welsh Terrier had 5.74 (95% CI 2.76–11.93) RR compared with overall referral dogs in the USA

(Sargan *et al.*, 2007; Gould *et al.*, 2011)

WEST HIGHLAND WHITE TERRIER (WHWT)

Behavioural conditions

Aggression

- A genetic basis for aggression has been described
- A survey of UK veterinarians classified WHWT as having high aggression

(Bradshaw *et al.*, 1996; Bradshaw & Goodwin, 1999; Zapata *et al.*, 2016)

Victim of dog-to-dog aggression

- WHWT was over-represented as the victim in dog–dog conflict in Germany, representing 2.4% of victims and 1.5% of the general population

(Roll & Unshelm, 1997)

Cardiovascular conditions

Atrioventricular (AV) block

- WHWT had the highest prevalence (37.5%) of second-degree atrioventricular blocks among referred cardiology cases in Poland

(Noszczyk-Nowak *et al.*, 2017)

Congenital heart disease

- Includes a range of congenital heart disorders
- WHWT had an OR of 1.8 compared with all referral dogs in Italy

(Oliveira *et al.*, 2011)

Pulmonic stenosis

- WHWT comprised 12.3% of a UK referral caseload

(Johnson *et al.*, 2004)

Sick sinus syndrome

- Describes disturbed cardiac rhythm affecting the function of the sinus node
- Characterized in WHWTs in the UK
- Mean age of 10.5 years

(Moneva-Jordan *et al.*, 2001)

Dermatological conditions

Atopic dermatitis (atopy)

- OR 10.3 (95% CI 3.6–29.3) compared with a referral population in Australia
- WHWT was over-represented in a worldwide study and also in Switzerland, Hungary and the USA
- Fourth-highest incidence in insured dogs in Sweden: 8.4 cases per 1000 DYAR (95% CI 7.2–9.6)
- 8.58% prevalence for WHWT, compared with 1.08% for crossbreds, in a US referral caseload
- WHWT comprised 3.8% (95% CI 1.8–6.8) of an atopic caseload, compared with 0.6% of the overall hospital population, in a US referral study

(Zur *et al.*, 2002; Nødtvedt *et al.*, 2006; Tarpataki *et al.*, 2006; Picco *et al.*, 2008; Favrot *et al.*, 2010; Jaeger *et al.*, 2010; Bellumori *et al.*, 2013)

Demodicosis

- WHWT was over-represented in the UK: 16.1% of laboratory diagnoses, versus 3.6% of normal clinic population
- Described as a predilected breed in a Swedish referral study
- Third most commonly affected breed (6.9%) in a pan-European study

(Day, 1997a; Holm, 2003; Mueller *et al.*, 2009)

Malassezia dermatitis

- WHWT had the highest prevalence (16.4%) among a dermatology referral caseload in Romania
- WHWT had RR 7.82 compared to a general laboratory population in the USA

(Mauldin *et al.*, 1997; Mircean *et al.*, 2010)

Superficial necrolytic dermatitis
- Males and older dogs may be predisposed
- WHWT suggested as predisposed and comprised 16.7% of a US referral caseload

(Outerbridge *et al.*, 2002)

Drug reactions

Anaesthetic-related complications
- WHWT had 8% incidence among general small animal practices in Canada

(Dyson *et al.*, 1998)

Endocrine conditions

Diabetes mellitus
- OR 1.99 (95% CI 0.89–4.42) compared with crossbreeds in the UK
- Eighth-highest breed incidence in Sweden: 33 cases per 10 000 DYAR (95% CI 20–46)
- WHWT comprised 6.6% of cases, compared with 4.3% of the overall population of insured dogs in the UK

(Davison *et al.*, 2005; Fall *et al.*, 2007; Catchpole *et al.*, 2008; Mattin *et al.*, 2014)

Hypoadrenocorticism (Addison's disease)
- Complex inheritance pattern likely
- Females predisposed
- OR 11.42 (95% CI 4.69–26.97) compared with an overall US referral population
- WHWT comprised 19.5% of a US referral caseload

(Melián & Peterson, 1996; Peterson *et al.*, 1996)

Gastrointestinal conditions

Chronic hepatitis
- WHWT was 9 times over-represented ($p < 0.001$) in laboratory samples in Sweden
- Clinical liver disease in WHWTs caused by many etiologic agents in the USA
- Associated with hereditary copper toxicosis in WHWT in the USA

(Thornburg *et al.*, 1986, 1996; Andersson & Sevelius, 1991)

Congenital portosystemic shunt
- Referred WHWT (0.31% prevalence) had an OR of 6.0 (95% CI 2.6–12.2) compared with an overall US referral population
- WHWT comprised 14.3% of referral cases in the UK and were over-represented in another UK referral caseload

(Tobias & Rohrbach, 2003; Goodfellow *et al.*, 2008; Gow *et al.*, 2012)

Exocrine pancreatic insufficiency (EPI)
- Presumed inherited and autoimmune-mediated
- WHWT had 15.8% (95% CI 11.6–20.6) prevalence in a UK study

(Batchelor *et al.*, 2007)

Oesophageal and gastric foreign bodies
- Median age affected was 4 years
- OR 8.93 (95% CI 5.25–15.17) compared with an overall referral population in Switzerland
- WHWT had 21.4% prevalence in a UK referral study

(Sale & Williams, 2006; Gianella *et al.*, 2009)

Haematological/immunological conditions

Primary hepatitis
- Multiple causes including microorganisms, toxins and drugs, immune-mediated reactions and breed-associated metabolic errors
- Females predisposed ($p < 0.01$)
- WHWT was over-represented in a referral population in the Netherlands

(Poldervaart *et al.*, 2009)

Pyruvate kinase deficiency
- Affected dogs have abnormal red blood cells with a lifespan of about 20 days
- A 6 base-pair insertion in the C domain of the *R-PK* gene was identified in WHWT
- Genetic test developed

(Skelly *et al.*, 1999)

Musculoskeletal conditions

Avascular necrosis of the femoral head (Legg–Calvé–Perthes disease)
- Inherited as an autosomal recessive trait
- OR 33.2 (95% CI 15.7–70.4) compared to crossbreeds in the USA
- 26.2% of WHWT were affected in the UK

(Robinson, 1992; Brenig *et al.*, 1999; LaFond *et al.*, 2002)

Cranial cruciate ligament (CCL) disease
- Females and older dogs predisposed
- OR 2.6 (95% CI 1.4–4.8) compared with an overall UK referral population

(Adams *et al.*, 2011)

Craniomandibular osteopathy (lion jaw)
- Inherited as an autosomal recessive trait
- Usually affects dogs aged 3–8 months

- OR 1313 (95% CI 219–7874) compared to crossbreeds in the USA

(LaFond *et al.*, 2002; Macedo *et al.*, 2015)

Chondrodysplasia (short-limbed or disproportional dwarfism)

- Part of the WHWT breed conformation description
- An *fgf4* retrogene identified as a cause of chondrodysplasia

(Israel *et al.*, 2009; Parker *et al.*, 2009)

Panosteitis (enostosis, eosinophilic panosteitis)

- Young males predisposed
- OR 1.7 (95% CI 1.2–2.4) compared to crossbreeds in the USA

(LaFond *et al.*, 2002; Trostel *et al.*, 2003)

Patellar luxation

- 2.5% of UK and 3.6% of US WHWTs affected
- Mainly medial luxation observed, often bilateral
- Compared to crossbreeds, WHWT had odds ratios of 2.0 (95% CI 1.4–2.8) in the UK and 1.8 (95% CI 1.1–2.9) in the USA

(LaFond *et al.*, 2002; Orthopedic Foundation for Animals, 2015; O'Neill *et al.*, 2016c)

Neoplastic conditions

Adenoma/adenocarcinoma

- WHWT had an OR significantly above 1.0 ($p < 0.05$) compared with crossbreeds from a cancer registry in Switzerland

(Grüntzig *et al.*, 2016)

Canine cutaneous histiocytoma

- OR 2.60 (95% CI 2.27–2.99) compared to crossbreeds in the USA

(Goldschmidt & Mcmanus, 2000; Fulmer & Mauldin, 2007)

Lower urinary tract neoplasia

- WHWT was over-represented in the UK, comprising 11.4% of a referral caseload

(Burnie & Weaver, 1983)

Neurological conditions

Globoid cell leucodystrophy (Krabbe disease)

- Autosomal recessive inheritance
- Deficiency of galactocerebrosidase (GALC) activity that is responsible for lysosomal catabolism of certain galactolipids
- Disease-causing mutation of GALC cDNA identified in the WHWT
- Genetic test developed

(Victoria *et al.*, 1996)

Acute canine polyradiculoneuritis

- The most common form of acute polyneuropathy in dogs
- Diagnosis more common in autumn and winter
- WHWT had an OR of 8.56 (95% CI 1.39–52.90) compared with other referral dogs in the UK

(Laws *et al.*, 2017)

Ocular conditions

Cataract

- 28% of cataracts reported as breed-related in France
- Prevalence of primary cataract 2.71%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005; Donzel *et al.*, 2016)

Corneal ulceration (ulcerative keratitis)

- OR 2.05 (95% CI 1.34–3.15) compared with crossbreeds in the UK

(O'Neill *et al.*, 2017b)

Keratoconjunctivitis sicca

- WHWT was the third most common breed in a 2007 UK referral study, and accounted for 35% of cases in a 1985 UK referral study
- WHWT was the most common breed in a European multicentre study, comprising 18% of the cases

(Sansom & Barnett, 1985; Sanchez *et al.*, 2007; Ofri *et al.*, 2009)

Physiological conditions

Abnormal mediodistal location of medial fabella

- Medial fabella abnormally placed in 70% of WHWTs in the UK
- Considered as an incidental finding, and these dogs are not clinically affected

(Störk *et al.*, 2009)

High allergen-specific serum immunoglobulin E levels

- Non-atopic WHWTs had statistically significantly higher positive ELISA results than atopic WHWTs for 44 of 48 allergens tested

that are commonly regarded as significant in canine atopic dermatitis in Australia
(Roque *et al.*, 2011)

Renal and urinary conditions

Ectopic ureter

- WHWT bitches had relative risks (RR) of 6.9 (95% CI 2.5–17.5) and 16.71 (95% CI 4.38–59.12) compared with overall referral populations in two US studies
(Hayes, 1974b, 1984)

Urolithiasis

- WHWT was the fifth most common breed for uroliths overall submitted for laboratory testing in the UK (4.4%)
(Rogers *et al.*, 2011)

Urolithiasis – calcium oxalate

- OR 3.28 compared with crossbreeds in the USA
(Lekcharoensuk *et al.*, 2000a)

Reproductive conditions

Dystocia

- WHWT had an incidence of 15.2 per 1000 DYAR, compared with 5.7 per 1000 DYAR in insured bitches overall in Sweden
- OR 2.5 (95% CI 1.3–4.9) compared with first-opinion emergency-care crossbred bitches in the UK
(Bergström *et al.*, 2006; O'Neill *et al.*, 2017c)

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- RR 2.5 (95% CI 1.4–3.5) compared with all bitches insured by Agria for veterinary care in Sweden
(Egenvall *et al.*, 2001; Smith, 2006)

Respiratory conditions

Bronchiectasis

- OR 4.45 (95% CI 2.20–8.99) compared with an overall US referral population
(Hawkins *et al.*, 2003)

Chronic pulmonary disease (CPD)

- May be analogous to idiopathic pulmonary fibrosis in humans
- Associated with pulmonary hypertension in WHWT
- CPD in WHWTs results from aberrant collagen regulation
- Mean age 10.9 years
- Characterized in WHWTs in the USA, the UK and Finland
(Norris *et al.*, 2005a; Schober & Baade, 2006; Corcoran *et al.*, 2011; Syrjä *et al.*, 2013)

WETTERHOUN (DUTCH SPANIEL, FRISIAN WATER DOG)

Haematological/immunological conditions

Severe combined immunodeficiency

- Unexplained pup mortality reported in 10% of all litters of Wetterhoun
- Nonsense mutation in the gene coding for V(D)J recombination factor RAG1 identified
(Verfuurden *et al.*, 2011)

Metabolic conditions

Overweight/obesity

- Wetterhoun had significantly higher body condition score (5.38) than other show dogs in Holland
(Courcier *et al.*, 2010; Corbee, 2013; Raffan *et al.*, 2016)

WHIPPET

Cardiovascular conditions

Mitral valve disease

- OR 5.3 (95% CI 2.2–12.5) compared with crossbreeds in a UK primary-care veterinary population
(Parker & Kilroy-Glynn, 2012; Mattin *et al.*, 2015a, 2015b)

Drug reactions

Multiple drug sensitivity

- High doses of many drugs (e.g. ivermectin or milbemycin) cause neurological signs
- Associated with the nt230(del4) *MDR1* mutation
- Long-haired Whippet had a 24.3% allelic frequency with 0.7% recessive mutant allele frequency in Europe, and had a 45% allelic frequency in Germany
- 58.3% of referral Long-haired Whippets in the USA were carriers for the mutated *ABCB1–1* allele

- Whippet had a 0% allelic frequency in Brazil

(Dowling, 2006; Mealey & Meurs, 2008; Gramer *et al.*, 2011; Monobe *et al.*, 2015; Firdova *et al.*, 2016)

Haematological/immunological conditions

Eccentrocytosis

- Young dogs predisposed
- Whippet was the most strongly over-represented breed among a referral population in Italy, with 30.0% of Whippets affected

(Caldin *et al.*, 2005)

Phosphofructokinase deficiency

- Inherited as an autosomal recessive trait
- Present at 1 year of age
- Described in Whippets in the UK

(Gerber *et al.*, 2009)

Musculoskeletal conditions

Double muscling

- Heavily muscled dogs, often called 'bully' whippets
- Associated with muscle cramping and a distinctive overbite
- US 'bully' whippets are homozygous for a deletion mutation in the myostatin gene (*MSTN*)
- The 'bully' phenotype displays a simple autosomal recessive mode of inheritance

(Mosher *et al.*, 2007; Stinckens *et al.*, 2011)

Neoplastic conditions

Canine cutaneous histiocytoma

- OR 1.94 (95% CI 1.14–3.32) compared with crossbreeds in the USA

(Goldschmidt & Mcmanus, 2000; Fulmer & Mauldin, 2007)

Haemangiosarcoma

- Two US studies reported that Whippet had odds ratios of 31.76 (95% CI 7.86–128.33) and 7.3 (95% CI 3.0–17.9) compared with crossbreeds

(Hargis *et al.*, 1992; Goldschmidt & Mcmanus, 2000)

Ocular conditions

Cataract

- 28% of cataracts reported as breed-related in France
- Prevalence of primary cataract 2.01%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005; Donzel *et al.*, 2016)

Lens luxation – primary

- Whippet had relative risks (RR) of 3.28 (95% CI 1.65–6.54) and 4.57 (95% CI 2.57–8.12) compared with overall referral dogs in the USA

(Sargan *et al.*, 2007)

Progressive retinal atrophy (PRA)

- Autosomal recessive inheritance suspected
- Whippet had a 31.37% prevalence in a primary-care veterinary caseload in Brazil

(Somma *et al.*, 2017)

Physiological conditions

Innocent systolic heart murmur

- Associated with athletic training
- 58.1% of Whippets in Belgium had systolic murmurs in the absence of structural abnormalities

(Bavegems *et al.*, 2011)

Large heart size

- Whippets in Belgium had larger echocardiographic heart size and radiographic vertebral heart size than other breeds of comparable body weight

(Bavegems *et al.*, 2005, 2007)

Reduced thyroxine levels

- Healthy Whippets had significantly lower mean values for total T_4 (20.74 ± 1.35 nmol/l) than healthy control dogs of a variety of general breeds (mean total T_4 of 29.00 ± 1.91 nmol/l) ($p = 0.0007$) in Belgium

(van Geffen *et al.*, 2006)

WHITE SWISS SHEPHERD DOG (BERGER BLANC SUISSE)

Drug reactions

Multiple drug sensitivity

- High doses of many drugs (e.g. ivermectin or milbemycin) cause neurological signs
- Associated with the nt230(del4) *MDR1* mutation

- White Swiss Shepherd had a 16.2% allelic frequency with 0.8% recessive mutant allele frequency in Europe, and had a 14% allelic frequency in Germany

(Dowling, 2006; Geyer *et al.*, 2007; Gramer *et al.*, 2011; Firdova *et al.*, 2016)

Musculoskeletal conditions

Degenerative lumbosacral stenosis

- Involves soft and bony tissue alterations of the spine coupled with suspected instability of the L7–S1 intervertebral disk
- White Swiss Shepherd comprised 15% of a referral caseload in Germany and Switzerland

(Gödde & Steffen, 2007)

Lumbosacral transitional vertebrae

- Large breeds predisposed
- White Swiss Shepherd had 13.5% prevalence, compared with an overall 10.0% prevalence among dogs screened for pelvic problems in the Czech Republic

(Fialová *et al.*, 2014)

WOLFHOUND – IRISH

See *Irish Wolfhound*

WOLFSPITZ

See *Keeshond*

YORKSHIRE TERRIER

Behavioural conditions

Aggression

- A genetic basis for aggression has been described
- Yorkshire Terrier was reported to have a high tendency to aggression in Italy

(Notari & Goodwin, 2007; Zapata *et al.*, 2016)

Victim of dog-to-dog aggression

- Yorkshire Terrier was over-represented as the victim in dog–dog conflict in Germany, representing 2.9% of victims and 2.1% of the general population

(Roll & Unshelm, 1997)

Cardiovascular conditions

Arrhythmia

- Yorkshire Terrier had the highest prevalence (23.0%) of sinus tachycardia among referred cardiology cases in Poland

(Noszczyk-Nowak *et al.*, 2017)

Mitral valve disease

- OR 3.1 (95% CI 1.9–5.0) compared with crossbreeds in a UK primary-care veterinary population
- Yorkshire Terrier comprised 10.4% of a referral caseload in Italy
- Yorkshire Terrier comprised 12% of an affected caseload, compared with 8% of healthy controls from a general population in France

(Borgarelli *et al.*, 2008; Serres *et al.*, 2008; Parker & Kilroy-Glynn, 2012; Mattin *et al.*, 2015a, 2015b)

Patent ductus arteriosus

- Median age at presentation was 4 months
- Small breeds and females appear predisposed
- Yorkshire Terrier comprised 8.6% of a referral caseload in the USA

(Selmic *et al.*, 2013)

Ruptured chordae tendineae

- Recorded among dogs diagnosed with mitral valve disease
- Yorkshire Terrier comprised 8.8% of a referral caseload in France

(Serres *et al.*, 2007)

Dental conditions

Periodontal disease

- Yorkshire Terrier had prevalence of 25.2% (95% CI 18.6–33.4), compared with crossbreeds at 9.2% (95% CI 7.4–11.0) in the UK
- Yorkshire Terrier comprised 22.7% of a dental referral caseload of small breeds in South Korea

(Kim *et al.*, 2013; O'Neill *et al.*, 2014b)

Dermatological conditions

Atopic dermatitis (atopy)

- OR 8.85 ($p < 0.0001$) compared with a referral population in Greece

(Saridomichelakis *et al.*, 1999)

Colour dilution alopecia

- Described in a series of 10 Yorkshire Terriers

(Roperto *et al.*, 1995)

Dermatophytosis (ringworm)
- Animals aged < 1 year predisposed
- Zoonosis
- Yorkshire Terriers were over-represented for positive cultures in the UK and Brazil
- Yorkshire Terrier had the highest prevalence (46.4%) of breeds tested in Italy

(Sparkes et al., 1993; Brilhante *et al.*, 2003; Cafarchia *et al.*, 2004; Cerundolo, 2004)

Drug reactions

Vaccine-associated adverse effect
- Smaller breeds predisposed
- Yorkshire Terrier had the tenth-highest incidence (47.3 per 10 000 dogs within 3 days of vaccine administration; 95% CI 40.3–55.3), which was significantly higher than in an overall US primary-care population (38.2 per 10 000; 95% CI 37.1–39.3)

(Moore *et al.*, 2005)

Endocrine conditions

Diabetes mellitus
- Familial and inherited
- Peak incidence age of 7–9 years and older entire females predisposed
- Yorkshire Terrier comprised 4.0% of cases, compared with 1.7% of the overall population of insured dogs in the UK
- OR 2.62 ($p < 0.001$) compared with a referral population in Italy

(Fracassi *et al.*, 2004; Davison *et al.*, 2005)

Diabetic ketoacidosis
- Yorkshire Terrier comprised 16.1% of a referral caseload in Belgium

(De Causmaecker *et al.*, 2009)

Hyperadrenocorticism (Cushing's syndrome)
- Yorkshire Terrier was the most common breed, comprising 17.5% of a referral caseload in Austria
- Yorkshire Terrier comprised 13.6% of a referral caseload of pituitary-dependent hyperadrenocorticism in Spain

(Alenza *et al.*, 2006; Zeugswetter *et al.*, 2008)

Gastrointestinal conditions

Chronic hepatitis
- Familial
- OR 4.6 (95% CI 1.9–11.2) compared with overall unselected dogs from first-opinion practices in the UK
- RR 4.6 (95% CI 1.9–11.2) among referral post-mortem cases in the UK

(Watson *et al.*, 2007, 2010)

Cleft lip and/or palate
- Birth defect, small breeds predisposed
- RR 6.2 compared with all referral dogs in the USA

(Mulvihill *et al.*, 1980)

Congenital portosystemic shunt
- Small breeds predisposed
- Suspected to be hereditary in Yorkshire Terriers
- Yorkshire Terrier had 10.86% prevalence for portosystemic shunt, compared with 0.35% for crossbreeds in a US referral study
- Referred Yorkshire Terriers (2.9% prevalence) had OR 58.7 (95% CI 42.9–80.2) compared with an overall US referral population
- Yorkshire Terriers comprised 20.0% and 21.9% of two US referral caseloads and were over-represented in a UK referral caseload

(Tobias, 2003; Tobias & Rohrbach, 2003; Winkler *et al.*, 2003; Toulza *et al.*, 2006; Goodfellow *et al.*, 2008; Bellumori *et al.*, 2013)

Inflammatory bowel disease
- Mode of inheritance is incompletely understood and may differ between breeds
- Yorkshire Terrier comprised 19.2% of a referral caseload in Spain

(Luckschander *et al.*, 2006; Kathrani *et al.*, 2011)

Lymphangiectasia (resulting in protein-losing enteropathy)
- Mean age 7–8 years, females over-represented
- Associated with hypocobalaminaemia in Yorkshire Terrier
- OR 10.1 (95% CI 5.2–18.8) compared with an overall US referral population
- Yorkshire Terrier comprised 17.6% of a US referral caseload

(Kimmel *et al.*, 2000; Kull *et al.*, 2001; Grützner *et al.*, 2013; Simmerson *et al.*, 2014)

Oesophageal and gastric foreign bodies
- Median age affected was 4 years
- OR 3.13 (95% CI 1.63–6.03) compared with an overall referral population in Switzerland

(Gianella *et al.*, 2009)

Pancreatitis

- Middle- to older-aged, overweight and dogs with hyperlipidaemia and diabetes mellitus predisposed
- OR 4.3 (95% CI 1.2–15.3) compared with an overall referral population in the USA

(Hess *et al.*, 1999; Lem *et al.*, 2008)

Portal vein hypoplasia

- May occur in conjunction with portosystemic shunt (PSS)
- Cases present from 6 months 6 six years
- Yorkshire Terrier was the most commonly affected breed, comprising 28.6% of a US referral caseload

(Christiansen *et al.*, 2000)

Musculoskeletal conditions

Avascular necrosis of the femoral head (Legg–Calvé–Perthes disease)

- Inherited as an autosomal recessive trait
- A study showed 60% of cases were Yorkshire Terriers in Holland
- OR 35.8 (95% CI 20.0–63.9) compared to crossbreeds in the USA
- 34.0% of Yorkshire Terriers were affected in the UK

(Robinson, 1992; Piek *et al.*, 1996; Brenig *et al.*, 1999; LaFond *et al.*, 2002)

Cranial cruciate ligament (CCL) disease

- Females and older dogs predisposed
- OR 2.84 (95% CI 1.46–5.55) compared with an overall UK referral population

(Adams *et al.*, 2011)

Patellar luxation

- 5.4% of UK Yorkshire Terriers affected
- Mainly medial luxation observed, often bilateral
- Yorkshire Terrier had odds ratios of 5.5 (95% CI 4.3–7.1) in the UK and 8.3 (95% CI 6.4–10.8) in the USA compared to crossbreeds, and was over-represented in Korea
- Yorkshire Terrier comprised 10.0% of a US caseload and 10.9% of a caseload in Thailand

(LaFond *et al.*, 2002; Alam *et al.*, 2007; Campbell *et al.*, 2010; Nganvongpanit & Yano, 2011; Orthopedic Foundation for Animals, 2015; O'Neill *et al.*, 2016c)

Neoplastic conditions

Adenoma/adenocarcinoma

- Yorkshire Terrier had an OR significantly above 1.0 ($p < 0.05$) compared with crossbreeds from a cancer registry in Switzerland

(Grüntzig *et al.*, 2016)

Mammary neoplasia

- Yorkshire Terrier had an incidence of 188 cases per 10 000 DYAR, compared with 116 per 10 000 DYAR in crossbreeds among insured entire bitches in Sweden
- 25% of insured Yorkshire Terrier bitches in Sweden develop the condition by 10 years of age, compared with 13% for bitches overall

(Egenvall *et al.*, 2005; Jitpean *et al.*, 2012)

Neurological conditions

Atlantoaxial subluxation/instability

- Congenital or developmental condition
- Young small-breed dogs affected
- Yorkshire Terrier comprised 21.3% of a Japanese case study, 46.7% of a UK case study, and 21.1%, 32.6% and 41.7% of three US case study populations

(Denny *et al.*, 1988; Beaver *et al.*, 2000; Platt *et al.*, 2004; Sanders *et al.*, 2004; Aikawa *et al.*, 2013)

Idiopathic epilepsy

- Hereditary basis established in several breeds
- Yorkshire Terrier had an incidence of 25.4 per 10 000 DYAR (95% CI 18.6–32.1) among insured dogs in Sweden, compared with 16.1 (95% CI 14.7–17.4) for crossbreeds
- Yorkshire Terrier comprised 6.7% of epilepsy cases and 8.1% of idiopathic epilepsy cases among referred dogs in Japan

(Heske *et al.*, 2014; Hamamoto *et al.*, 2016)

Intervertebral disc disease (IVDD)

- Yorkshire Terrier comprised 6.1% of a cervical IVDD caseload and 0.6% of a thoracolumbar IVDD caseload at a Japanese referral hospital

(Itoh *et al.*, 2008)

Necrotizing meningoencephalitis

- Young adult dogs affected in Switzerland
- Yorkshire Terrier predisposed in Switzerland

(Tipold *et al.*, 1993; Tipold, 1995; Kuwamura *et al.*, 2002)

Ocular conditions

Cataract

- 28% of cataracts reported as breed-related in France
- OR 1.6 for all cataracts in France
- Prevalence of primary cataract 4.33%, compared to 1.61% in mixed-breed dogs, in a retrospective study of dogs presenting at North American teaching hospitals (VMDB, 1964–2003)

(Gelatt & MacKay, 2005; Donzel *et al.*, 2016)

Congenital alacrima (congenital keratoconjunctivitis sicca)

- RR 22.7 compared with an overall US referral population
- Yorkshire Terrier was suggested as predisposed in a study from Argentina and Spain

(Herrera, 2007; Westermeyer *et al.*, 2009)

Corneal ulceration (ulcerative keratitis)

- Yorkshire Terrier was the third commonest breed, comprising 16% of a referral caseload in South Korea
- OR 1.78 (95% CI 1.13–2.80) compared with crossbreeds in the UK

(Kim *et al.*, 2009; O'Neill *et al.*, 2017b)

Glaucoma

- 4.5% of Yorkshire Terriers referred for eye or neurological conditions in Japan were affected

(Kato *et al.*, 2006)

Physiological conditions

Litter size

- Smaller litters associated with older bitches and smaller breeds
- Yorkshire Terrier had the twelfth smallest mean litter size (3.5 puppies) among registered breeds in Norway

(Borge *et al.*, 2011)

Renal and urinary conditions

Kidney disease

- Yorkshire Terrier had an incidence of 34 (95% CI 26–42) cases per 10 000 DYAR, compared with 15.8 per 10 000 DYAR overall among insured dogs in Sweden

(Pelander *et al.*, 2015)

Renal calculi

- May be associated with urinary tract infections
- Yorkshire Terrier had odds ratios of 4.29 ($p < 0.001$) in females and 11.39 ($p < 0.001$) in males compared with crossbreeds in a US referral study

(Ling *et al.*, 1998c)

Urolithiasis

- Yorkshire Terrier was the most common breed submitted for urolith analysis in both the Benelux countries (8.5%) and Spain and Portugal (17.5%) and was the second most common in both the UK (7.4%) and Germany (9.4%)

(Hesse, 1990; Picavet *et al.*, 2007; Rogers *et al.*, 2011; Vrabelova *et al.*, 2011)

Urolithiasis – calcium oxalate

- Small breeds and males are predisposed
- Yorkshire Terrier was the fifth most common breed with submissions for calcium oxalate uroliths in Canada
- Yorkshire Terrier had odds ratios of 7.2 (95% CI 6.3–8.2) and 9.85 compared with crossbred dogs in two US studies, and 13.0 (95% CI 11.7–14.4) compared with all dogs in the UK

(Lekcharoensuk *et al.*, 2000a; Houston & Moore, 2009; Low *et al.*, 2010; Roe *et al.*, 2012; Okafor *et al.*, 2014)

Urolithiasis – silica

- OR 2.7 ($p < 0.001$) compared with all dogs in a US study

(Aldrich *et al.*, 1997)

Urolithiasis – struvite (magnesium ammonium phosphate)

- OR 3.6 (95% CI 3.2–4.0) compared with all dogs in the UK
- Small breeds and females are predisposed

(Houston & Moore, 2009; Roe *et al.*, 2012)

Urolithiasis – urate

- Yorkshire Terrier had 4.5 OR (95% CI 3.6–5.6) compared with all dogs in the UK
- Younger and female animals predisposed

(Roe *et al.*, 2012)

Reproductive conditions

Cryptorchidism

- Yorkshire Terrier had relative risks (RR) of 2.9 (95% CI 2.2–4.0) and 3.0 (95% CI 1.76–5.06) compared with overall referral populations in two US studies
- Yorkshire Terrier had a 7.6% prevalence in the UK, which was significantly higher than for crossbreeds ($p = 0.0018$)

(Pendergrass & Hayes, 1975; Hayes *et al.*, 1985; Yates *et al.*, 2003)

Dystocia

- OR 2.7 (95% CI 1.6–4.6) compared with first-opinion emergency-care crossbred bitches in the UK

(O'Neill *et al.*, 2017c)

Respiratory conditions

Tracheal collapse

- Common cause of cough in mature, small-breed dogs
- Yorkshire Terrier comprised 16% and 30% of two US referral caseloads, 50% and 65% of two UK referral caseloads, and 17.6% of a referral caseload in Korea

(White & Williams, 1994; Macready *et al.*, 2007; Marolf *et al.*, 2007; Eom *et al.*, 2008; Fonfara *et al.*, 2011)

Soft-tissue conditions

Perineal herniation

- Yorkshire Terrier comprised 13.6% of a UK caseload

(Raffan, 1993)

PART II

CAT BREEDS

ABYSSINIAN

Behavioural conditions

General behavioural traits

- In a study of 574 single-breed registered cats, based on owner-completed questionnaires, Abyssinians were found to have increased scores for sociability with people and cat aggression, but lower scores for restraint resistance and vocalization and lower likelihood of fear of noises

(Wilhelmy *et al.*, 2016)

Cardiovascular conditions

Aortic thromboembolism

- Breed at increased risk in retrospective series of 127 cases in the USA: OR 6.03 ($p = 0.0019$) compared to the general hospital population
- Males at increased risk: OR 1.75 ($p = 0.003$)

(Smith *et al.*, 2003)

Dermatological conditions

Atopic dermatitis (atopy)

- Breed at increased risk in case series
- In a retrospective study based at an Australian dermatology referral practice the Abyssinian was over-represented compared to the general hospital population
- Cases diagnosed with flea-bite hypersensitivity and adverse food reactions were excluded from the study

(Ravens *et al.*, 2014)

Endocrine conditions

Diabetes mellitus

- Breed at risk in a retrospective case series based on Swedish insurance data 2009–2013. Abyssinians had an increased incidence rate ratio (IRR) of 1.8 (95% CI 1.0–3.2) compared to all other breeds
- Males at increased risk: IRR 2.0 (95% CI 1.8–2.3) across all breeds
- Mean age at diagnosis: 10.7 years across all breeds

(Öhlund *et al.*, 2015)

Haematological/immunological conditions

Increased osmotic fragility of erythrocytes

- Results in haemolytic anaemia
- Inheritance suspected
- Affected cats have chronic intermittent severe anaemia and splenomegaly

(Kohn *et al.*, 2000; Tritschler *et al.*, 2016)

Breed Predispositions to Disease in Dogs and Cats, Third Edition. Alex Gough, Alison Thomas and Dan O'Neill.

Pyruvate kinase deficiency

- Results in haemolytic anaemia
- Autosomal recessive inheritance, mutations identified
- Breed at increased risk in a study of DNA samples from 14 179 cats

(Grahn *et al.*, 2012)

Infectious conditions

Feline infectious peritonitis (FIP)

- Breed at increased risk in a retrospective series of 60 cases from the patient records of a North American veterinary medicine teaching hospital 1986–2002: OR 8.98 (95% CI 2.71–29.77) compared to all cats
- Also found to be at increased risk in a study of 382 cases in Australia. Observed frequency in the FIP cohort was 4.4%, compared to an expected frequency 1.5%
- Increased risk from 3 months to 3 years of age (all breeds)
- Males and sexually intact cats predisposed (all breeds)
- Cats in a multi-cat environment at increased risk (all breeds)

(Pesteanu-Somogyi *et al.*, 2006; Worthing *et al.*, 2012)

Mycobacterium avium complex infection

- Very rare
- 10/12 cases were Abyssinians in a case series in Australia and the USA
- It is believed that some lines may suffer from familial immunodeficiency which predisposes them to infection

(Baral *et al.*, 2006)

Urinary tract infections (UTI)

See under *Renal and urinary conditions*

Musculoskeletal conditions

Acquired myasthenia gravis

See under *Neurological conditions*

Patellar luxation

- In a study of cases in the USA and Europe, 26/69 Abyssinian cats (38%) were found to be affected, compared to 1/84 cats of other breeds (1.2%)
- Dominant, possibly polygenic inheritance suspected

(Engvall & Bushnell, 1990)

Neurological conditions

Acquired myasthenia gravis

- Breed at increased risk in a retrospective study of 235 cases in the USA 2001–2012: OR 4.97 compared to all other breeds
- Bimodal age of presentation: 2–3 years and 9–10 years

(Hague *et al.*, 2015)

Ocular conditions

Progressive retinal atrophy (PRA) – early-onset

- Early-onset rod–cone dysplasia (PRA-Rdy), which is inherited dominantly
- Rarely seen
- Presents with retinal changes at 8–12 weeks; progresses rapidly to blindness at 1 year
- Mutation identified

(Curtis *et al.*, 1987; Bedford, 1989)

Progressive retinal atrophy (PRA) – late-onset

- Late-onset rod–cone degeneration (PRA-rdAc), which is inherited recessively
- More common than PRA-Rdy in the Abyssinian
- Clinical onset 1.5–2 years; progresses to blindness over 2–4 years
- Mutation identified

(Narfström, 1985; Bedford, 1989; Menotti-Raymond *et al.*, 2010)

Physiological conditions

Blood group

- In an Australian study, 89% of this breed were type A, 11% were type B and none were type AB
- In an American study of 230 Abyssinians, 13.5% were found to be type B

(Giger *et al.*, 1991b; Malik *et al.*, 2005)

Kitten birth weight

- In a UK questionnaire-based study of 1056 litters, Abyssinians produced larger kittens (mean 100.1 g) than the mean of all breeds (93.5 g)

(Sparkes *et al.*, 2006)

Litter size

- In a UK questionnaire-based study of 1056 litters, Abyssinians produced smaller litters (mean 3.9 kittens) than the mean of all breeds (4.6 kittens)

(Sparkes *et al.*, 2006)

Renal and urinary conditions

Renal amyloidosis

- Usually seen as part of reactive systemic amyloidosis
- Familial
- Clinical presentation is variable – only those cats with moderate or severe disease develop symptoms
- Renal amyloid deposits are found principally in the medulla; glomerular involvement is less common. Amyloid deposits may also be found in adrenal and thyroid glands, spleen, stomach, small intestine, heart, liver, pancreas and colon. These deposits often do not contribute to the clinical signs, which are principally due to chronic renal failure

(Boyce *et al.*, 1984; DiBartola *et al.*, 1986a, 1986b)

Urinary tract infections (UTI)

- Breed at increased risk in a retrospective case series of 784 cases from the VMDB (1980–1997): OR 3.4 compared to all breeds
- Increased risk was seen for spayed female cats and those > 10 years of age (all breeds)
- In a more recent study of 155 cases, no breed predilection was found

(Lekcharoensuk *et al.*, 2001; Martinez-Ruzafa *et al.*, 2012)

Reproductive conditions

Dystocia

- Breed at increased risk in a study based on Swedish insurance data, 1999–2006
- Incidence rates (IR) were 22 cases per 10 000 CYAR for all cats, and 100 cases per 10 000 CYAR for the Abyssinian group of cats (which included Somalis)
- Incidence rate ratio (IRR) in the Abyssinian group was 1.5 compared to all other purebred cats

(Holst *et al.*, 2017)

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- Breed at increased risk based on Swedish insurance data, 1999–2006
- IR for the Abyssinian group of cats (which included Somalis) was 27 cases per 10 000 CYAR, compared to 17 cases for all breeds combined

(Hagman *et al.*, 2014)

AMERICAN SHORTHAIR

Physiological conditions

Blood group

- In a US study, all cats of this breed were type A

(Giger *et al.*, 1991a)

ASIAN

Physiological conditions

Kitten birth weight

- In a UK questionnaire-based study of 1056 litters, Asian cats produced smaller kittens (mean 84.7 g) than the mean of all breeds (93.5 g)

(Sparkes *et al.*, 2006)

Litter size

- In a UK questionnaire-based study of 1056 litters, Asian cats produced larger litters (mean 6.5 kittens) than the mean of all breeds (4.6 kittens)

(Sparkes *et al.*, 2006)

AUSTRALIAN MIST

Infectious conditions

Feline infectious peritonitis (FIP)

- In an Australian series of 42 cases (1990–2002) Australian Mist cats were considered over-represented, numbering 5 of the 42 cases
- Increased risk 3 months to 3 years (all breeds)
- Males and sexually intact cats predisposed (all breeds)
- Cats in a multi-cat environment were at increased risk (all breeds)
- This breed is predisposed to the effusive form

(Norris *et al.*, 2005b)

BALINESE

Ocular conditions

Progressive retinal atrophy (PRA)

See under *Siamese*

Reproductive conditions

Dystocia

See under *Siamese*

Pyometra (cystic endometrial hyperplasia–pyometra complex)

See under *Siamese*

BENGAL

Behavioural conditions

General behavioural traits

- In a study of 574 single-breed registered cats, based on owner-completed questionnaires, Bengals were found to have increased scores for predatory behaviour and inappropriate elimination

(Wilhelmy *et al.*, 2016)

Gastrointestinal conditions

Tritrichomonas foetus infection

See under *Infectious conditions*

Haematological/immunological conditions

Blood group

- In a UK study of 100 Bengal cats, all were found to be type A

(Gunn-Moore *et al.*, 2009)

Pyruvate kinase deficiency

- Results in haemolytic anaemia
- Autosomal recessive inheritance, mutations identified
- Breed at increased risk in a study of DNA samples from 14 179 cats
- Carriers are asymptomatic
- Variable onset and severity of symptoms

(Grahn *et al.*, 2012)

Infectious conditions

Feline infectious peritonitis (FIP)

- Breed at increased risk in a retrospective series of 60 cases from the patient records of a North American veterinary medicine teaching hospital 1986–2002: OR 41.03 (95% CI 4.91–342.85) compared to all cats
- Increased risk from 3 months to 3 years of age (all breeds)
- Males and sexually intact cats predisposed (all breeds)
- Cats in a multi-cat environment at increased risk (all breeds)

(Pesteanu-Somogyi *et al.*, 2006)

Tritrichomonas foetus infection

- Breed at increased risk in a UK study
- Cats < 1 year old predisposed

(Gunn-Moore *et al.*, 2007)

Musculoskeletal conditions

Thoracic wall abnormalities

- In a study of thoracic wall defects in kittens presented for vaccination at a single UK practice, 12/244 Bengal kitten were affected, compared to none of 1748 domestic short-haired kittens
- Defects included pectus excavatum, unilateral thoracic wall concavity and scoliosis
- Familial basis suspected

(Charlesworth & Strugess, 2012)

Neurological conditions

Polyneuropathy

- Characterized by recurrent myelination and demyelination
- 37 cases reported; all were Bengal cats
- 65% were male
- Mean age at onset 10.6 ± 7.9 months

(Bensfield *et al.*, 2011)

Ocular conditions

Cataract

- Cataracts were diagnosed in 45% of 51 Bengal cats recruited in an observational study to assess the national prevalence of ocular disease in France, October 2014 to November 2016
- Pedigree analysis suggested inheritance
- No visual impairment was reported

(Bourguet *et al.*, 2017)

Renal and urinary conditions

Urolithiasis – urate

- Breed at increased risk in a retrospective study of uroliths examined at the Minnesota Urolith Center, 1981–2008, compared to a control population of cats without urinary tract disease derived from the VMDB over the same period
- Bengal cats had an OR of 5.6 (95% CI 2.83–10.98)
- Mean age 6.2 years (all breeds)
- Males were at increased risk: OR 1.1 (all breeds)

(Albasan *et al.*, 2012)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- Breed at increased risk based on Swedish insurance data, 1999–2006

- IR for the Bengal was 64 cases per 10 000, CYAR compared to 17 cases for all breeds combined

(Hagman *et al.*, 2014)

BIRMAN

Behavioural conditions

General behavioural traits

- In a study of 574 single-breed registered cats, based on owner-completed questionnaires, Birmans were found to have increased scores for fear-related aggression to familiar people and inappropriate elimination, but lower scores for activity and playfulness, vocalization, trainability and predatory behaviour

(Wilhelmy *et al.*, 2016)

Wool-sucking (compulsive)

- Breed at increased risk
- Early weaning and small litter size were found to be additional risk factors in Birman cats in one study
- Affected cats had an abnormally intense appetite

(Borns-Weil *et al.*, 2015)

Cardiovascular conditions

Aortic thromboembolism

- Breed at increased risk in a retrospective series of 127 cases in the USA: OR 10.52 ($p = 0.0001$) compared to the general hospital population
- Males at increased risk: OR 1.75 ($p = 0.003$)

(Smith *et al.*, 2003)

Dermatological conditions

Congenital hypotrichosis

- Autosomal recessive inheritance, mutation identified
- May be associated with thymic aplasia and short life expectancy

(Casal *et al.*, 1994; Abitbol *et al.*, 2015)

Gastrointestinal conditions

Tritrichomonas foetus infection

See under *Infectious conditions*

Haematological/immunological conditions

Atypical granulation of neutrophils

- Inherited as an autosomal recessive trait
- Common, with 46% of Birman cats studied affected
- Neutrophils have prominent eosinophilic granules
- No abnormalities of neutrophil function detected

(Hirsch & Cunningham, 1984)

Infectious conditions

Chlamydophilosis

- Breed at increased risk in a survey of cats in Britain
- Prevalence highest from 5 weeks to 9 months of age (all breeds)
- Males predisposed (all breeds)

(Wills *et al.*, 1988)

Cryptococcosis

- Breed at significantly increased risk ($p = 0.011$) in a retrospective series of 155 feline cases in Australia 1981–2001
- Across all breeds median age 6 years (range 1–16) with a peak at 2–3 years

(O'Brien *et al.*, 2004)

Feline infectious peritonitis (FIP)

- Breed at increased risk in retrospective series of 60 cases from the patient records of a North American Veterinary medicine teaching hospital 1986–2002: OR 82.06 (95% CI 26.66–262.44) compared to all cats
- Inheritance of susceptibility is suspected to be polygenic, and heritability has been found to be high in Birmans
- Increased risk from 3 months to 3 years of age (all breeds)
- Males and sexually intact cats predisposed (all breeds)
- Cats in a multi-cat environment are at increased risk (all breeds)

(Foley & Pedersen, 1996; Pesteanu-Somogyi *et al.*, 2006)

Tritrichomonas foetus infection

- Breed at increased risk in a study in Germany

(Kuehner *et al.*, 2011)

Neurological conditions

Audiogenic reflex seizures

- Birmans were strongly represented (31% of cases) in a study of 96 cases in the UK recruited by questionnaire, September 2013 to March 2014
- Mean age of all cases was 15 years (10–19 years)

(Lowrie *et al.*, 2015a)

Ocular conditions

Chlamydophila psittaci conjunctivitis

See under *Infectious conditions*

Physiological conditions

Azotaemia

- One study showed that 82% of healthy Birman cats < 6 months of age had creatinine levels above the reference range. The significance of this was unknown
- In a separate study of 91 healthy Birman cats, new higher reference intervals of 97.2–221.0 mmol/l were established for Birman cats (compared to a general feline reference range of 70.7–159.1 mmol/l)

(Gunn-Moore *et al.*, 2002; Paltrinieri *et al.*, 2014)

Blood group

- In a US study, 82% of Birman cats were type A and 18% type B
- In a UK study (1995–1998) in a population of 24 Birmans 15 (62.5%) were type A, 7 (29.2%) were type B and 2 (8.3%) were type AB

(Giger *et al.*, 1991a; Knottenbelt *et al.*, 1999)

Kitten birth weight

- In a UK questionnaire-based study of 1056 litters, Birman cats produced larger kittens (mean 101 g) than the mean of all breeds (93.5 g)

(Sparkes *et al.*, 2006)

Litter size

- In a UK questionnaire-based study of 1056 litters, Birman cats produced smaller litters (mean 3.6 kittens) compared to the mean of all breeds (4.6 kittens)

(Sparkes *et al.*, 2006)

Renal and urinary conditions

Urolithiasis – urate

- Breed at increased risk in a retrospective study of uroliths examined at the Minnesota Urolith Center, 1981–2008, compared to a control population of cats without urinary tract disease derived from the VMDB over the same period
- Birman cats had an OR of 6.77 (95% CI 5.01–9.15)
- Mean age (all breeds) 6.2 years
- Males were at increased risk (all breeds): OR 1.1
- In a separate study of 21 426 bladder uroliths, Birmans had an OR of 9.45 (95% CI 3.91–20.8) compared to domestic shorthaired cats

(Albasan *et al.*, 2012; Houston *et al.*, 2016)

Reproductive conditions

Dystocia

- Breed at increased risk in a study based on Swedish insurance data, 1999–2006
- Incidence rates (IR) were 22 cases per 10 000 CYAR for all purebred cats combined and 101 cases per 10 000 CYAR for Birman cats
- Incidence rate ratio (IRR) in the Birman was 1.7 compared to all other purebred cats

(Holst *et al.*, 2017)

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- Breed at increased risk based on Swedish insurance data, 1999–2006
- IR for the Birman was 35 cases per 10 000 CYAR compared to 17 cases for all breeds combined

(Hagman *et al.*, 2014)

BRITISH SHORTHAIR (BSH)

Cardiovascular conditions

Hypertrophic cardiomyopathy (HCM)

- Familial
- In a Danish study of 329 BSH cats screened by echocardiography for HCM, 8.5% were positive and 4.3% equivocal for the condition
- Median age at diagnosis 2.7 years
- Male cats at increased risk: OR 7.89 (95% CI 2.54–28.08)

(Granström *et al.*, 2011)

Gastrointestinal conditions

Tritrichomonas foetus infection

See under *Infectious conditions*

Haematological/immunological conditions

Haemophilia B

- Uncommon condition, occurs in this breed

(Littlewood, 1989)

Lymphoproliferative disease

- Novel disease recognized in multiple closely related BSH kittens in New Zealand

- Inheritance suspected
- Non-neoplastic proliferation of T cells

(Aberdein *et al.*, 2015)

Infectious conditions

Feline infectious peritonitis (FIP)

- Breed at increased risk in a retrospective Australian series of 382 cases
- Observed frequency of BSH cats in the FIP cohort was 15.5%, compared to an expected frequency of 2.4%
- Susceptibility to FIP may be partially inherited polygenically, as suggested in one study of purebred catteries in the USA
- Increased risk 3 months to 3 years (all breeds)
- Males and sexually intact cats predisposed (all breeds)
- Cats in a multi-cat environment at increased risk (all breeds)

(Foley & Pedersen, 1996; Norris *et al.*, 2005b; Worthing *et al.*, 2012)

Tritrichomonas foetus infection

- Breed at increased risk in a study in Germany

(Kuehner *et al.*, 2011)

Neurological conditions

Intervertebral disc disease (IVDD)

- In a UK retrospective study of the medical records of cats diagnosed with thoracolumbar intervertebral disc disease, 2008–2014, BSH cats were found to be at significantly increased risk ($p < 0.0001$) compared with the general hospital population

(De Decker *et al.*, 2017)

Physiological conditions

Blood group

- In an Australian study including 8 BSH cats, 3 (38%) were type A, 5 (62%) were type B and none were type AB
- In a UK study (1995–1998), in a population of 121 BSH cats 48 (39.7%) were type A, 71 (58.7%) were type B and 2 (1.6%) were type AB
- In a small study including 5 BSH cats in England, 2 (40%) were type A and 3 (60%) were type B
- In a US study, 41% were type A and 59% type B

(Giger *et al.*, 1991a; Knottenbelt *et al.*, 1999; Malik *et al.*, 2005; Forcada *et al.*, 2007)

Kitten birth weight

- In a UK questionnaire-based study of 1056 litters, BSH cats produced larger kittens (mean 104.4 g) compared to the mean of all breeds (93.5 g)

(Sparkes *et al.*, 2006)

Renal and urinary conditions

Polycystic kidney disease (PKD)

- Most common inherited disease in cats
- Some BSH cats with the condition share the same genetic mutation as Persians
- Autosomal dominant inheritance

(Nivy *et al.*, 2015)

Urolithiasis – calcium oxalate

- Breed at increased risk in case series
- In a study of 7934 calcium oxalate uroliths submitted to the Minnesota Urolith Center, 1981–1997, BSH cats had an OR of 7.8 (95% CI 4.87–34.82) compared to a control population of cats from the VMDB over the same period
- Males at increased risk: OR 1.5 (all breeds)
- Mean age 90 ± 41 months across all breeds

(Lekcharoensuk *et al.*, 2000b)

Reproductive conditions

Dystocia

- Breed at increased risk in a study based on Swedish insurance data, 1999–2006
- Incidence rates (IR) were 22 cases per 10 000 CYAR for all cats and 157 cases per 10 000 CYAR for BSH cats
- Incidence rate ratio (IRR) in the BSH was 2.5 compared to all other purebred cats

(Holst *et al.*, 2017)

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- Breed at increased risk based on Swedish insurance data, 1999–2006
- Incidence rate (IR) for the British Shorthair was 32 cases per 10 000 CYAR compared to 17 cases for all breeds combined

(Hagman *et al.*, 2014)

BURMESE

Behavioural conditions

General behavioural traits

- In a study of 574 single-breed registered cats, based on owner-completed questionnaires,

Burmese were found to have increased scores for dog aggression, prey interest, sleeping in elevated/warm/hidden locations and separation anxiety

(Wilhelmy *et al.*, 2016)

Cardiovascular conditions

Endocardial fibroelastosis

- Inherited congenital anomaly
- Age of onset 3 weeks to 4 months
- Short illness in many cases, sudden death possible
- Cats with mild forms survive to adulthood

(Zook & Paasch, 1982; Darke, 1989)

Dermatological conditions

Cutaneous asthenia (Ehlers–Danlos-like syndrome)

- Inherited

(Hansen *et al.*, 2015)

Cutaneous food allergy

- Burmese cats were over-represented in a study of 48 cases

(Scott & Miller, 2013)

Cutaneous neoplasia

See under *Neoplastic conditions*

Endocrine conditions

Diabetes mellitus

- Breed at increased risk in many studies (UK, Australia, Sweden)
- In a cohort of 193 563 cats in primary-care practice in England, 2009–2014 (VetCompass data), there were 1128 cases of diabetes mellitus (period prevalence 0.58%). Burmese were at increased risk: OR 3.0 (95% CI 2.0–4.4) compared to the overall population. Both being > 4 kg body weight and > 6 years of age were risk factors across all breeds ($p < 0.001$)
- Breed at increased risk in a retrospective series based on Swedish insurance data 2009–2013. Burmese had an increased incidence rate ratio (IRR) of 4.3 (95% CI 2.9–6.0) compared to all other breeds. Males at increased risk: IRR 2.0 (95% CI 1.8–2.3) across all breeds. Mean age at diagnosis 10.7 years across all breeds
- Inheritance suspected

(O'Leary *et al.*, 2013; Öhlund *et al.*, 2015; O'Neill *et al.*, 2016b)

Infectious conditions

Feline infectious peritonitis (FIP)

- Breed at increased risk in Australian series of 42 cases. In this study male Burmese cats were over-represented, and 7/10 cases in Burmese cats were the non-effusive form
- In another study in the USA, Burmese were not found to be at increased risk compared to mixed-breed cats

(Norris *et al.*, 2005b; Pesteanu-Somogyi, 2006)

Musculoskeletal conditions

Flat-chested kittens

- Reported to affect 3–4% of Burmese kittens in the UK

(Sturgess *et al.*, 1997)

Frontonasal dysplasia (Burmese head defect)

- Multiple congenital abnormalities of the head. Most kittens do not survive
- Inherited as autosomal recessive
- Created by selective breeding from a lineage with a more brachycephalic head shape (known as the Contemporary Burmese)
- Cats with shorter faces may be carriers
- Seen mainly in the USA

(Sponenberg & Graf-Webster, 1986; Lyons *et al.*, 2016a)

Hypokalaemic polymyopathy

- Autosomal recessive inheritance. Mutation identified
- Seen in Burmese cats and closely related breeds
- Signs are often episodic and seen as muscle weakness and pain in the first year of life

(Malik *et al.*, 2015)

Neoplastic conditions

Mast cell tumour (MCT) – cutaneous

- Breed at increased risk
- In a UK study of 287 records of feline MCTs, Burmese cats represented 2.4% of the study population, but only 1.1% of the control population
- Median age 11 years (range 5 months to 19 years) across all breeds

(Melville *et al.*, 2015)

Neurological conditions

Feline orofacial pain syndrome

- Predominantly seen in Burmese cats. In a UK study of 113 cases, 100 were Burmese

- Suspected to be a neuropathic condition, may be triggered by oral/dental disease
- Symptoms of acute oral pain and self-mutilation are initially episodic but may become unremitting with time

(Rusbridge *et al.*, 2010)

Hereditary meningoencephalocele

- Seen as part of frontonasal dysplasia (see under *Musculoskeletal conditions*)

Lysosomal storage disease – GM_2 gangliosidosis

- Inherited, mutation identified
- Signs from 1–2 months of age include intention tremors, progressing to ataxia, hindlimb weakness and inability to stand by 4–5 months of age

(Bradbury *et al.*, 2009, 2105)

Ocular conditions

Corneal sequestrum

- In a retrospective review of 97 cases, 17 cats were Burmese
- Mean age 6.8 years

(Graham *et al.*, 2016)

Glaucoma – primary

- A retrospective study (1996–2001) of 6 affected Burmese cats led to a suggestion of a predisposition to primary narrow-angle glaucoma in this breed
- Affected cats were aged 7–10.5 years

(Hampson *et al.*, 2002)

Lipaemia of the aqueous humour

- Young cats (5 months to 1 year) affected
- Seen in the UK, Australia and New Zealand

(Gunn-Moore & Crispin, 1998)

Prolapse of the gland of the nictitating membrane ('cherry eye')

- Uncommon condition in the cat, reported most frequently in this breed

(Chahory *et al.*, 2004)

Uveal cysts

- Breed at increased risk
- In a retrospective study conducted in the UK and Australia, 36/5017 cats had uveal cysts (prevalence 0.72%), and 21 of these were Burmese (total of 516 Burmese cats; incidence 4.1%)
- Only 2 cats had concurrent intraocular disease

(Blacklock *et al.*, 2016)

Physiological conditions

Blood group

- In a UK study (1995–1998), 9/10 Burmese cats (90%) were type A and 1 (10%) was type B
- In an Australian study (1992–2003) of 30 Burmese cats, 28 (93%) were type A, 1 (3%) was type B and 1 (3%) was type AB
- In a UK study of 5 Burmese, all were found to be type A

(Knottenbelt *et al.*, 1999; Malik *et al.*, 2005; Forcada *et al.*, 2007)

Kitten birth weight

- In a UK questionnaire-based study of 1056 litters, Burmese cats produced smaller kittens (mean 86.2 g) than the mean of all breeds (93.5 g)

(Sparkes *et al.*, 2006)

Litter size

- In a UK questionnaire-based study of 1056 litters, Burmese cats produced larger litters (mean 5.7 kittens) than the mean of all breeds (4.6 kittens)

(Sparkes *et al.*, 2006)

Triglyceridaemia

- A proportion of Burmese cats in Sydney, Australia, were found to have a more exaggerated and long-lasting triglyceridaemia than other cats, following a high-fat meal
- It has been suggested that this may result in increased insulin resistance and therefore risk of diabetes mellitus

(Kluger *et al.*, 2009)

Renal and urinary conditions

Urolithiasis – calcium oxalate

- Breed at increased risk in a retrospective study of 21 426 bladder uroliths submitted to the Canadian Veterinary Urolith Centre, 1998–2014
- Burmese cats had an OR of 3.74 (95% CI 2.08–7.22) compared to domestic short-haired cats
- Males were found to be at increased risk in all breeds combined: OR 1.73 (95% CI 1.63–1.82)
- Also found to be at risk in a US study

(Thumchai *et al.*, 1996; Houston *et al.*, 2016)

Respiratory conditions

Agenesis of the nares

- Seen as part of frontonasal dysplasia (see under *Musculoskeletal conditions*)

(Noden & Evans, 1986)

CHARTREUX

Renal and urinary conditions

Urolithiasis – struvite (magnesium ammonium phosphate)

- Breed at increased risk in case series
- In a study of 7456 uroliths submitted to the Minnesota Urolith Center, 1981–1997, Chartreux cats had an OR of 4.51 (95% CI 1.66–21.51) compared to a control population of cats from the VMDB over the same period
- Males reported to be at reduced risk: OR 0.7 (all breeds)
- Mean age 69 ± 38 months (all breeds)

(Lekcharoensuk *et al.*, 2000b)

CHINCHILLA

Pyometra (cystic endometrial hyperplasia–pyometra complex)

See under *Persian*

COLOURPOINT PERSIAN

Pyometra (cystic endometrial hyperplasia–pyometra complex)

See under *Persian*

CORNISH REX

Infectious conditions

Feline infectious peritonitis (FIP)

- Cornish and Devon Rex combined were found to be at increased risk in a retrospective series of 60 cases from the patient records of a North American veterinary medicine teaching hospital, 1986–2002: OR 38.29 (95% CI 8.42–174.15) compared to all other cats
- Increased risk from 3 months to 3 years of age (all breeds)
- Males and sexually intact cats predisposed (all breeds)
- Cats in a multi-cat environment at increased risk (all breeds)

(Foley & Pedersen, 1996; Norris *et al.*, 2005b; Pesteanu-Somogyi *et al.*, 2006)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- Breed at increased risk based on Swedish insurance data, 1999–2006
- IR for the Cornish Rex was 50 cases per 10 000 CYAR, compared to 17 cases per 10 000 CYAR for all breeds combined

(Hagman *et al.*, 2014)

DEVON REX

Behavioural conditions

General behavioural traits

- In a study of 574 single-breed registered cats, based on owner-completed questionnaires, Devon Rex were found to have increased scores for playfulness, sociability with people and sleeping in elevated/warm/hidden locations

(Wilhelmy *et al.*, 2016)

Dermatological conditions

Malassezia dermatitis

- Increased numbers of *Malassezia* organisms are isolated in this breed from both seborrhoeic and healthy cats, compared to domestic short-haired and Cornish Rex cats

(Ahman *et al.*, 2007; Bond *et al.*, 2008)

Urticaria pigmentosa-like dermatosis

- Reported in Devon Rex cats

(Noli *et al.*, 2004; Colombo *et al.*, 2012)

Haematological/immunological conditions

Vitamin-K-dependent coagulopathy

- There are a number of reports suggesting the presence of this condition in Devon Rex cats in the UK and Australia

(Soute *et al.*, 1992)

Infectious conditions

Feline infectious peritonitis (FIP)

See under *Cornish Rex*

Infectious skin diseases
See under *Dermatological conditions*

Musculoskeletal conditions

Hereditary myopathy of Sphynx and Devon Rex cats

- Autosomal recessive inheritance
- Variably progressive
- Seen in the Devon Rex and the related Sphynx
- May represent a form of congenital myasthenia gravis

(Martin *et al.*, 2008; Gandolfi *et al.*, 2015)

Physiological conditions

Blood group

- In an Australian study including 71 Devon Rex cats, 32 cats (45%) were type A, 38 (54%) were type B and 1 (1.4%) was type AB

(Malik *et al.*, 2005)

Renal and urinary conditions

Urolithiasis – calcium oxalate

- Breed at increased risk in a retrospective study of 21 426 bladder uroliths submitted to the Canadian Veterinary Urolith Centre, 1998–2014
- Devon Rex cats had an OR of 2.4 (95% CI 1.21–5.09) compared to domestic shorthaired cats
- Males were found to be at increased risk in all breeds combined: OR 1.73 (95% CI 1.63–1.82)

(Houston *et al.*, 2016)

Reproductive conditions

Dystocia

- Breed at increased risk
- In a survey of cat breeders reporting on 2928 litters, dystocia occurred in 5.8% of all litters, but in 18.2% of Devon Rex litters

(Gunn-Moore & Thrusfield, 1995)

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- Breed at increased risk based on Swedish insurance data, 1999–2006
- IR for the Devon Rex was 59 cases per 10 000 CYAR, compared to 17 cases per 10 000 CYAR for all breeds combined

(Hagman *et al.*, 2014)

EGYPTIAN MAU

Haematological/immunological conditions

Pyruvate kinase deficiency

- Results in haemolytic anaemia
- Autosomal recessive inheritance, mutations identified
- Breed at increased risk in a study of DNA samples from 14 179 cats
- Carriers are asymptomatic
- Variable onset and severity of symptoms

(Grahn *et al.*, 2012)

Renal and urinary conditions

Urolithiasis – urate

- Breed at increased risk in a retrospective study of uroliths examined at the Minnesota Urolith Center, 1981–2008, compared to a control population of cats without urinary tract disease derived from the VMDB over the same period
- Egyptian Mau cats had an OR of 44.41 (95% CI 32.95–59.86)
- Mean age was 6.2 years (all breeds)
- Males were at increased risk: OR 1.1 (all breeds)
- In a separate study of 21 426 bladder uroliths submitted to the Canadian Veterinary Urolith Centre, 1998–2014, Egyptian Maus had an OR of 94.5 (95% CI 38.2–285)

(Albasan *et al.*, 2012; Houston *et al.*, 2016)

EUROPEAN SHORTHAIR

Renal and urinary conditions

Urolithiasis – urate

- Breed at increased risk in a retrospective study of uroliths examined at the Minnesota Urolith Center, 1981–2008, compared to a control population of cats without urinary tract disease derived from the VMDB over the same period
- European Shorthair cats had an OR of 61.28 (95% CI 43.17–86.98)
- Mean age 6.2 years (all breeds)
- Males were at increased risk: OR 1.1 (all breeds)

(Albasan *et al.*, 2012)

EXOTIC SHORTHAIR

Ocular conditions

Epiphora

- Brachycephalia affects the course of the nasolacrimal duct and the efficiency of tear drainage. All 4 Exotic Shorthair cats were classified as severely brachycephalic in one study

(Schlueter *et al.*, 2009)

Renal and urinary conditions

Polycystic kidney disease (PKD)

- Autosomal dominant inheritance, mutation identified
- Affected cases may present with renal failure from 2 to 3 years of age
- In a French study of 64 Exotic Shorthair cats, 39.1% were found to be affected when screened with ultrasound
- Studies have demonstrated similar prevalences in USA, Australia and Italy

(Barrs *et al.*, 2001; Barthez *et al.*, 2003; Bonazzi *et al.*, 2009)

Urolithiasis – calcium oxalate

- Breed at increased risk in case series
- In a study of 7934 calcium oxalate uroliths submitted to the Minnesota Urolith Center, 1981–1997, Exotic Shorthair cats had an OR of 2.9 (95% CI 1.68–6.81) compared to a control population of cats from the VMDB over the same period
- Males reported to be at increased risk: OR 1.5 (all breeds)
- Mean age 90 ± 41 months across all breeds

(Lekcharoensuk *et al.*, 2000b)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)

See under *Persian*

Stillborn kittens

- In a UK questionnaire-based study of 1056 litters, Exotic Shorthair cats had a significantly higher prevalence of stillbirths (12.5%) than that of all breeds combined (7.2%)

(Sparkes *et al.*, 2006)

FOREIGN SHORTHAIR

Renal and urinary conditions

Urolithiasis – calcium oxalate

- Breed at increased risk in case series
- In a study of 7934 calcium oxalate uroliths submitted to the Minnesota Urolith Center, 1981–1997, Foreign Shorthair cats had an OR of 7.15 (95% CI 3.75–11.77) compared to a control population of cats from the VMDB over the same period
- Males reported to be at increased risk: OR 1.5 across all breeds
- Mean age 90 ± 41 months (all breeds)

(Lekcharoensuk *et al.*, 2000b)

Urolithiasis – struvite (magnesium ammonium phosphate)

- Breed at increased risk in case series
- In a study of 7456 uroliths submitted to the Minnesota Urolith Center, 1981–1997, Foreign Shorthair cats had an OR of 18.46 (95% CI 11.12–25.74) compared to a control population of cats from the VMDB over the same period
- Males reported to be at reduced risk: OR 0.7 across all breeds
- Mean age 69 ± 38 months (all breeds)

(Lekcharoensuk *et al.*, 2000b)

FOREIGN WHITE

Pyometra (cystic endometrial hyperplasia–pyometra complex)

See under *Siamese*

HAVANA BROWN

Renal and urinary conditions

Urolithiasis – calcium oxalate

- Breed at increased risk in case series
- In a study of 7934 calcium oxalate uroliths submitted to the Minnesota Urolith Center, 1981–1997, Havana Brown cats had an OR of 5.47 (95% CI 2.49–18.38) compared to a control population of cats from the VMDB over the same period

- Males reported to be at increased risk: OR 1.5 across all breeds
- Mean age 90 ± 41 months (all breeds)

(Lekcharoensuk *et al.*, 2000b)

HIMALAYAN

Cardiovascular conditions

Peritoneopericardial diaphragmatic hernia (PPDH)

- In a USA study of 67 cases 1987–2002, Himalayans were found to be significantly over-represented compared to the hospital population (prevalence of 1.45% in the Himalayan compared to 0.25% in the hospital population)
- Median age at presentation: 54 months (range 1.5–204 months)

(Reimer *et al.*, 2004)

Dermatological conditions

Cheyletiellosis

- Himalayan cats were over-represented in a Canadian study of 111 cats with skin disease, accounting for 50% of the cases of cheyletiellosis, but only 6.9% of the hospital population

(Scott & Paradis, 1990)

Cutaneous food allergy

- Himalayan cats were over-represented in a study of 48 cases

(Scott & Miller, 2013)

Cutaneous neoplasia

See under *Neoplastic conditions*

Idiopathic facial dermatitis in Persians and Himalayans

- Breed at increased risk

(Chung *et al.*, 2009)

Gastrointestinal conditions

Congenital portosystemic shunt

- In an Australian retrospective study of 9 cats, Himalayan cats were over-represented, with an OR 30.6 ($p < 0.001$) compared to the general hospital population
- Males may be predisposed
- High rate of cryptorchidism in affected males (24%)
- Both intra- and extrahepatic shunts can occur; extrahepatic are more common

(Tillson & Winkler, 2002; Hunt, 2004)

Periodontal disease

- In a US study of 16 374 cats > 5 years of age with a diagnosis of periodontal disease, Himalayans had an RR of 1.6 (95% CI 1.3–2.0) of being represented in the periodontal disease group compared to being represented in a hospital population of cats of similar age but without periodontal disease

(Lund, 2012)

Infectious conditions

Aspergillosis

- Persian and Himalayan cats seem to be over-represented in a number of case reports

(Barrs & Talbot, 2014)

Feline infectious peritonitis (FIP)

- Breed at increased risk in a retrospective series of 60 cases from the patient records of a North American veterinary medicine teaching hospital 1986–2002: OR 3.19 (95% CI 1.12–9.06) compared to all cats
- Increased risk from 3 months to 3 years of age (all breeds)
- Males and sexually intact cats predisposed (all breeds)
- Cats in multi-cat environment at increased risk (all breeds)

(Foley & Pedersen, 1996; Pesteanu-Somogyi *et al.*, 2006)

Neoplastic conditions

Basal cell tumour

- Breed at increased risk in a series of 124 cases
- Risk increases with increasing age

(Diters & Walsh, 1984)

Ocular conditions

Corneal sequestrum

- In a retrospective review of 97 cases, 18 cats were Himalayan
- Mean age 6.8 years (all breeds combined)
- Predisposition suggested in other studies

(Morgan, 1994; Graham *et al.*, 2016)

Physiological conditions

Blood group

- In a US study, 80% were type A and 20% type B

(Giger *et al.*, 1991a)

Renal and urinary conditions

Polycystic kidney disease (PKD)

- Autosomal dominant inheritance
- In an Australian study of 48 Himalayan cats which were screened by renal ultrasound, 42% were found to be affected

(Barrs *et al.*, 2001)

Urolithiasis – calcium oxalate

- Breed at increased risk in a retrospective study of 21 426 bladder uroliths submitted to the Canadian Veterinary Urolith Centre, 1998–2014
- Himalayan cats had an OR of 2.7 (95% CI 2.02–2.81) compared to domestic short-haired cats
- Males were found to be at increased risk in all breeds combined: OR 1.73 (95% CI 1.63–1.82)
- In a study of 7934 calcium oxalate uroliths submitted to the Minnesota Urolith Center, 1981–1997, Himalayan cats had an OR of 7.86 (95% CI 7.15–8.65) compared to a control population of cats from the VMDB over the same period

(Lekcharoensuk *et al.*, 2000b; Houston *et al.*, 2016)

Urolithiasis – struvite (magnesium ammonium phosphate)

- Breed at increased risk in a case series
- In a study of 7456 uroliths submitted to the Minnesota Urolith Center, 1981–1997, Himalayan cats had an OR of 2.01 (95% CI 1.85–2.49) compared to a control population of cats from the VMDB over the same period
- Males reported to be at reduced risk: OR 0.7, across all breeds
- Mean age 69 ± 38 months across all breeds

(Lekcharoensuk *et al.*, 2000b)

Respiratory conditions

Aspergillosis

- Persian and Himalayan cats seem to be over-represented in a number of case reports

(Barrs & Talbot, 2014)

Brachycephalic obstructive airway syndrome (BOAS)

- Likely a consequence of selective breeding for certain facial characteristics

(Ginn *et al.*, 2008; Meola, 2013)

JAPANESE BOBTAIL

Musculoskeletal conditions

Vertebral anomalies

- Japanese Bobtail cats feature variations of tail morphology caused by transitional vertebrae, changes in the numbers of vertebrae and hemivertebrae
- Simple autosomal dominant inheritance (with variable expression of tail length and kink placement)

(Pollard *et al.*, 2015)

JAVANESE

Ocular conditions

Progressive retinal atrophy (PRA)

See under *Siamese*

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)

See under *Siamese*

KORAT

Neurological conditions

Lysosomal storage disease – GM_1 gangliosidosis

- Autosomal recessive inheritance, mutation identified
- Rare
- Signs seen at 3–6 months

(De Maria *et al.*, 1998)

Lysosomal storage disease – GM_2 gangliosidosis

- Autosomal recessive inheritance, mutation identified
- Rare
- Signs seen at 3–6 months

(Muldoon *et al.*, 1994)

Physiological conditions

Gestation length

- In a UK questionnaire-based study of 1056 litters, Korats had shorter gestation (mean 63 days) than the mean of all breeds (65.1 days)

(Sparkes *et al.*, 2006)

Kitten birth weight

- In a UK questionnaire-based study of 1056 litters, Korats produced smaller kittens (mean 72.7 g) than the mean of all breeds (93.5 g)

(Sparkes *et al.*, 2006)

LA PERM

Haematological/immunological conditions

Pyruvate kinase deficiency

- Results in haemolytic anaemia
- Autosomal recessive inheritance, mutations identified
- Breed at increased risk in a study of DNA samples from 14 179 cats
- Carriers are asymptomatic
- Variable onset and severity of symptoms

(Grahn *et al.*, 2012)

MAINE COON

Behavioural conditions

General behavioural traits

- In a study of 574 single-breed registered cats, based on owner-completed questionnaires, Maine Coons were found to have increased scores for owner directed aggression and prey interest, but lower scores for attention-seeking behaviours, separation anxiety, sleeping in elevated/warm/hidden positions and inappropriate elimination

(Wilhelmy *et al.*, 2016)

Cardiovascular conditions

Hypertrophic cardiomyopathy (HCM)

- Inherited as an autosomal dominant trait, mutation identified
- Homozygosity for the mutation has been found to increase the risk of developing HCM compared to unaffected Maine Coon cats: OR 21.6 (95% CI 7.01–66.2). Heterozygosity did not increase the risk in this study
- In a UK-based study including 742 Maine Coon cats, the prevalence of the mutation was 39.4%
- Prevalence of the mutation has been described as 22% in Germany, 46% in Australia/New Zealand, and 34% worldwide
- Most affected cats developed HCM by 6 years of age, and males are at more risk of developing the disease

(Godiksen *et al.*, 2011; Casamián-Sorrosal *et al.*, 2014)

Peritoneopericardial diaphragmatic hernia (PPDH)

- Congenital defect
- Breed at increased risk in a study of 31 feline cases, 2000–2007
- Maine Coons represented 4 of the 31 cases (12.9%), but only 2.2% of the hospital population

(Banz & Gottfried, 2010)

Dermatological conditions

Cutaneous food allergy

- Maine Coon cats were over-represented in a study of 48 cases

(Scott & Miller, 2013)

Gastrointestinal conditions

Intussusception

- Breed at increased risk in case series. Maine Coon cats represented 19/25 cases in a study, 2000–2012

(Vershoof *et al.*, 2015)

Tritrichomonas foetus infection

See under *Infectious conditions*

Haematological/immunological conditions

Pyruvate kinase deficiency

- Results in haemolytic anaemia
- Autosomal recessive inheritance, mutations identified
- Breed at increased risk in a study of DNA samples from 14 179 cats
- Carriers are asymptomatic
- Variable onset and severity of symptoms

(Grahn *et al.*, 2012)

Infectious conditions

Tritrichomonas foetus infection

- Breed at increased risk in a study in Germany

(Kuehner *et al.*, 2011)

Musculoskeletal conditions

Hip dysplasia

- In a retrospective US study of data recorded at the Orthopedic Foundation for Animals the prevalence of hip dysplasia was found to be 24.9% in Maine Coon cats
- There was a slightly higher prevalence in males (27.3%) than females (23.3%)
- 56% of cases were bilateral

(Loder & Todhunter, 2017)

Peritoneopericardial diaphragmatic hernia (PPDH)

See under *Cardiovascular conditions*

Polydactyly

- Inherited in some lines of Maine Coons
- Variability in digit number and conformation
- Conformation of tarsus and carpus are also affected in some cases

(Hamelin *et al.*, 2017)

Slipped capital femoral epiphysis (SCFE)

- In a retrospective study of cases presented to a first-opinion and referral practice in Austria, 2009–2015, 17/208 (8.17%) Maine Coon cats were diagnosed with SCFE, compared to 29/4348 (0.67%) cats of all breeds

(Borak *et al.*, 2017)

Neoplastic conditions

Middle ear polyps

- In a study of 62 cases (2004–2014) Maine Coons were over-represented, with 23 cases (37%)
- Mean age (all breeds): 3.9 years (range 0.5–14 years)

(Janssens *et al.*, 2017)

Physiological conditions

Blood group

- In a study of 357 blood donor cats in Italy, 21% were Maine Coon cats and all were type A

(Spada *et al.*, 2014)

Haematological and biochemical differences

- In a retrospective study of 81 healthy Maine Coon cats presented as blood donors in Italy, 2011–2014, significant variations (from published reference intervals in the general cat population) were found in a number of haematological and biochemical parameters. Breed-specific reference intervals have been created for Maine Coon cats

(Spada *et al.*, 2015)

Kitten birth weight

- In a UK questionnaire-based study of 1056 litters, Maine Coon cats produced larger kittens (mean 116.1 g) than the mean of all breeds (93.5 g)

(Sparkes *et al.*, 2006)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- Breed at increased risk based on Swedish insurance data, 1999–2006
- IR for the Maine Coon was 68 cases per 10 000 CYAR, compared to 17 cases per 10 000 CYAR for all breeds combined

(Hagman *et al.*, 2014)

MANX

Gastrointestinal conditions

Faecal incontinence (part of Manx syndrome)

See under *Musculoskeletal conditions*

Megacolon and constipation (part of Manx syndrome)

See under *Musculoskeletal conditions*

Rectal prolapse (part of Manx syndrome)

See under *Musculoskeletal conditions*

Musculoskeletal conditions

Manx syndrome

- Autosomal dominant inheritance
- The mutation causes a shortened or absent tail
- May also affect the spine and spinal cord, resulting in spina bifida; symptoms can include problems with the control of urination and defecation, rectal prolapse and paresis of the hindlegs
- Homozygosity for the mutation is lethal
- Variation in penetrance of the mutation results in variation of both tail length and severity of the spinal signs

(Leipold *et al.*, 1974; Deforest & Basrur, 1979; Song *et al.*, 2016)

Neurological conditions

Spina bifida (part of Manx syndrome)

See under *Musculoskeletal conditions*

Renal and urinary conditions

Urinary incontinence (part of Manx syndrome)

See under *Musculoskeletal conditions*

Urolithiasis – struvite (magnesium ammonium phosphate)

- Breed at increased risk in case series
- Across all breeds, females reported to be more at risk than males, and neutered cats at greater risk than entire

(Cannon *et al.*, 2007)

NORWEGIAN FOREST CAT (NFC)

Cardiovascular conditions

Hypertrophic cardiomyopathy (HCM) and restrictive cardiomyopathy (RCM)

- Familial
- In a UK-based prospective study of 53 Norwegian Forest Cats screened for cardiomyopathy by echocardiogram, 13 were found to have signs of HCM
- As part of the same study, post-mortem results for 8 NFCs which died of cardiac-related problems were reviewed retrospectively. Pathological findings of both HCM and RCM were found in 7 cases

(März *et al.*, 2015)

Endocrine conditions

Diabetes mellitus

- Breed at increased risk in several case series (UK, Sweden)
- In a cohort of 193 563 cats in primary-care practice in England, 2009–2014 (VetCompass data), there were 1128 cases of diabetes mellitus (period prevalence 0.58%). Norwegian Forest Cats were at increased risk: OR 3.5 (95% CI 1.3–9.6) compared to the overall population. Both being > 4 kg body weight and > 6 years of age were risk factors across all breeds ($p < 0.001$)
- Breed at risk in retrospective series based on Swedish insurance data 2009–2013. NFCs had an increased incidence rate ratio (IRR) of 1.9 (95% CI 1.5–2.3) compared to all other breeds
- Males at increased risk: IRR 2.0 (95% CI 1.8–2.3) across all breeds
- Mean age at diagnosis: 10.7 years across all breeds

(Öhlund *et al.*, 2015; O'Neill *et al.*, 2016b)

Gastrointestinal conditions

Tritrichomonas foetus infection

See under *Infectious conditions*

Haematological/immunological conditions

Pyruvate kinase deficiency

- Results in haemolytic anaemia
- Autosomal recessive inheritance, mutations identified
- Breed at increased risk in a study of DNA samples from 14 179 cats
- Carriers are asymptomatic
- Variable onset and severity of symptoms

(Grahn *et al.*, 2012)

Infectious conditions

Tritrichomonas foetus infection

- Breed at increased risk in a study in Germany

(Kuehner *et al.*, 2011)

Neurological conditions

Lysosomal storage disease – glycogen storage disease type IV

- Autosomal recessive inheritance
- Many affected kittens die perinatally (from hypoglycaemia). Survivors develop neuromuscular degeneration around 5 months of age
- In a US study screening 402 Norwegian Forest Cats, 58 were carriers and 4 were affected

(Fyfe *et al.*, 2007)

Physiological conditions

Blood group

- In a US study, 100% of Norwegian Forest Cats were type A

(Giger *et al.*, 1991a)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- Breed at increased risk based on Swedish insurance data, 1999–2006
- IR for the Norwegian Forest Cat was 39 cases per 10 000 CYAR, compared to 17 cases per 10 000 CYAR for all breeds combined

(Hagman *et al.*, 2014)

OCICAT

Renal and urinary conditions

Urolithiasis – urate

- Breed at increased risk in a retrospective study of uroliths examined at the Minnesota Urolith Center, 1981–2008, compared to a control population of cats without urinary tract disease derived from the VMDB over the same period
- Ocicats had an OR of 16.80 (95% CI 11.37–24.84)
- Mean age (all breeds) 6.2 years
- Males were at increased risk (all breeds): OR 1.1
- In a separate study of 21 426 bladder uroliths submitted to the Canadian Veterinary Urolith Centre, 1998–2014, Ocicats had an OR of 18.4 (95% CI 6.55–49.5)

(Albasan *et al.*, 2012; Houston *et al.*, 2016)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- Breed at increased risk based on Swedish insurance data, 1999–2006
- IR for the Ocicat was 105 cases per 10 000 CYAR, compared to 17 cases per 10 000 CYAR for all breeds combined

(Hagman *et al.*, 2014)

ORIENTAL SHORTHAIR

Behavioural conditions

General behavioural traits

- In a study of 574 single-breed registered cats, based on owner-completed questionnaires, Orientals were found to have increased scores for compulsive (non-grooming) behaviours and cat aggression

(Wilhelmy *et al.*, 2016)

Gastrointestinal conditions

Systemic amyloidosis

- Familial
- At increased risk
- Primarily involves the liver. May result in hepatic dysfunction or spontaneous hepatic haemorrhage

(Piirsalu *et al.*, 1994; van der Linde-Sipman *et al.*, 1997)

Ocular conditions

Progressive retinal atrophy (PRA)

See under *Siamese*

Physiological conditions

Blood group

- In an Australian study, 100% of the Oriental/Siamese breed were type A

(Malik *et al.*, 2005)

Gestation length

- In a UK questionnaire-based study of 1056 litters, Oriental Shorthair cats had longer gestation (mean 66.2 days) than the mean of all breeds (65.1 days)

(Sparkes *et al.*, 2006)

Renal and urinary conditions

Urolithiasis – struvite (magnesium ammonium phosphate)

- Breed at increased risk in case series
- In a study of 7456 uroliths submitted to the Minnesota Urolith Center, 1981–1997, Oriental Shorthair cats had an OR of 3.22 (1.21–10.18) compared to a control population of cats from the VMDB over the same period
- Males reported to be at reduced risk: OR 0.7 across all breeds
- Mean age 69 ± 38 months across all breeds

(Lekcharoensuk *et al.*, 2000b)

Urolithiasis – urate

- Breed at increased risk in a retrospective study of uroliths examined at the Minnesota Urolith Center, 1981–2008, compared to a control population of cats without urinary tract disease derived from the VMDB over the same period
- Oriental cats had an OR of 3.81 (95% CI 1.68–8.63)
- Mean age (all breeds): 6.2 years
- Males were at increased risk (all breeds): OR 1.1

(Albasan *et al.*, 2012)

Reproductive conditions

Dystocia

See under *Siamese*

Pyometra (cystic endometrial hyperplasia–pyometra complex)

See under *Siamese*

PERSIAN

Behavioural conditions

General behavioural traits

- In a study of 574 single-breed registered cats, based on owner-completed questionnaires, Persians were found to have lower scores for playfulness, predatory behaviour, prey interest and fear-related aggression

(Wilhelmy *et al.*, 2016)

House-soiling

- Over-represented for soiling outside the litter box in a US retrospective series of 736 behaviour cases, 1991–2001

(Bamberger & Houpt, 2006)

Cardiovascular conditions

Hypertrophic cardiomyopathy (HCM)

- Breed at increased risk
- In a French retrospective study of 344 cats with HCM (2001–2011), there were 41 Persians
- Male Persians were significantly predisposed: 25/41 (61%)
- Median age was 7 years (0.5–19 years) across all breeds

(Trehiou-Sechi *et al.*, 2012)

Dermatological conditions

Dermatophytosis (ringworm)

- Breed at increased risk. In a French retrospective study Persians represented 75% of diagnosed cases but only 7.9% of the hospital population
- This breed may develop dermatophytic pseudomycetoma, characterized by one or more ulcerated and discharging nodules over the dorsal trunk or tail base

(Scott & Paradis, 1990; Nuttall *et al.*, 2008)

Idiopathic facial dermatitis in Persians and Himalayans

- Breed at increased risk
- Unknown cause; possibly genetic basis

(Bond *et al.*, 2000; Chung *et al.*, 2009)

Gastrointestinal conditions

Periodontal disease

- In a US study of 16 374 cats > 5 years of age with a diagnosis of periodontal disease, Persians had an RR of 1.3 (95% CI 1.1–1.6) of being represented in the periodontal disease group compared to being represented in a hospital population of cats of similar age but without periodontal disease

(Lund, 2012)

Polycystic liver disease

- Autosomal dominant inheritance, mutation identified
- Associated with polycystic kidney disease (see under *Renal and urinary conditions*)
- In one study of 27 cases of polycystic liver and/or kidney disease in cats, 21 were Persians or their crosses

(Eaton *et al.*, 1997; Bosie *et al.*, 1998)

Haematological/immunological conditions

Chédiak–Higashi syndrome

- Seen in blue-smoke Persians with yellow eyes
- Autosomal recessive inheritance
- Multi-systemic condition

See also under *Ocular conditions*

(Kramer *et al.*, 1977)

Infectious conditions

Aspergillosis

- Persian and Himalayan cats seem to be over-represented in a number of case reports

(Barrs & Talbot, 2014)

Dermatophytosis (ringworm)

See under *Dermatological conditions*

Neurological conditions

Intervertebral disc disease (IVDD)

- In a UK retrospective study of the medical records of cats diagnosed with thoracolumbar intervertebral disc disease, 2008–2014, Persian cats were found to be at significantly increased risk ($p < 0.0006$) compared to the general hospital population

(De Decker *et al.*, 2017)

Lysosomal storage disease – α-mannosidosis

- Inherited, mutation identified
- Signs, seen at 2–4 months, include cerebellar ataxia, corneal and lenticular opacities, skeletal abnormalities, hepatomegaly, thymic aplasia, gingival hyperplasia and polycystic kidneys
- Most cases are euthanized around 4–6 months

(Berg *et al.*, 1997; Bradbury *et al.*, 2015)

Ocular conditions

Cataract

- Seen with Chédiak–Higashi syndrome
- Autosomal recessive inheritance

(Collier *et al.*, 1979)

Chédiak–Higashi syndrome

- Seen in blue-smoke Persians with yellow eyes
- Ocular signs include hypopigmentation of the fundus and iris, lack of a visible tapetum, nystagmus and cataracts

See also under *Haematological/immunological conditions*

(Collier *et al.*, 1979)

Corneal sequestrum

- In one retrospective review of 97 cases, 20 cats were Persians. In another (UK-based) study 31/64 cases were Persians
- Most seen at 2–7 years of age
- May be bilateral

(Featherstone & Sansom, 2004; Graham *et al.*, 2016)

Entropion

- Breed at increased risk of primary entropion
- Inheritance suspected

(Narfström, 1999b)

Epiphora

- Brachycephalia affects the course of the nasolacrimal duct and the efficiency of tear drainage. 23/31 Persians were classified as moderately or severely brachycephalic in one study, predisposing them to epiphora

(Schlueter *et al.*, 2009)

Lysosomal storage disease – α-mannosidosis

- Inherited, mutation identified
- Ocular symptoms include corneal and lenticular opacities

See also under *Neurological conditions*

(Berg *et al.*, 1997; Bradbury *et al.*, 2015)

Progressive retinal atrophy (PRA)

- Early-onset retinal degeneration
- Autosomal recessive inheritance, mutation identified
- Clinical signs at 2–3 weeks, blindness at 16 weeks

(Rah *et al.*, 2005; Alhaddad *et al.*, 2014)

Physiological conditions

Blood group

- In an Australian study, 67% of this breed were type A, 22% were type B and 11% were type AB
- In an English study, 88.2% of this breed were type A, 11.8% were type B and none were type AB

(Knottenbelt *et al.*, 1999; Malik *et al.*, 2005)

Litter size

- In a UK questionnaire-based study of 1056 litters, Persian cats produced smaller litters (mean 3.8 kittens) than the mean of all breeds (4.6 kittens)

(Sparkes *et al.*, 2006)

Renal and urinary conditions

Feline idiopathic cystitis

- Breed at increased risk in case series. In a prospective study of 55 cases, Persians represented 13% of affected cats but only 2% of the control population
- Neutered males at greater risk
- Mean age 4 years 11 months

(Gunn-Moore, 2003; Cameron *et al.*, 2004)

Polycystic kidney disease (PKD)

- Autosomal dominant inheritance
- It is estimated that 38% of Persian cats are affected worldwide
- In an Australian study of 230 Persian cats screened by renal ultrasound, 47% were found to be affected
- In a French study of 220 Persian cats screened by renal ultrasound, 41.8% were found to be affected
- Affected cases may present with renal failure from 2–3 years of age
- Some cases have liver cysts

(Barrs *et al.*, 2001; Barthez *et al.*, 2003; Young *et al.*, 2005)

Urolithiasis – calcium oxalate

- Breed at increased risk in a retrospective study of 21 426 bladder uroliths submitted to the Canadian Veterinary Urolith Centre, 1998–2014
- Persian cats had an OR of 2.21 (95% CI 1.82–2.69) compared to domestic short-haired cats
- Males were found to be at increased risk in all breeds combined: OR 1.73 (95% CI 1.63–1.82)

- In a study of 7934 calcium oxalate uroliths submitted to the Minnesota Urolith Center, 1981–1997, Persian cats had an OR of 3.30 compared to a control population of cats from the VMDB over the same period. Mean age 90 ± 41 months across all breeds

(Lekcharoensuk *et al.*, 2000b; Houston *et al.*, 2016)

Reproductive conditions

Cryptorchidism

- Polygenic inheritance suspected

(Millis *et al.*, 1992)

Dystocia

- In a study based on Swedish insurance data, 1999–2006, incidence rates (IR) were 22 cases per 10 000 CYAR for all cats, and 38 cases per 10 000 CYAR for Persian cats. However, the Persian cat was found to be at reduced risk compared to all purebred cats (67 cases per 10 000 CYAR)
- In a separate Swedish retrospective study, 1986–1990, the Persian cat represented 37.4% of cases, by far the highest of all purebred cats
- In a study of data based on questionnaires completed by cat breeders, Persians were found to have high levels of dystocia

(Ekstrand & Linde-Forsburg, 1994; Gunn-Moore & Thrusfield, 1995; Holst *et al.*, 2017)

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- Breed at increased risk based on Swedish insurance data, 1999–2006
- IR for the Persian group (which included Persians, Chinchillas, Colourpoint Persians, Exotic Shorthairs) was 34 cases per 10 000 CYAR, compared to 17 cases per 10 000 CYAR for all breeds combined

(Hagman *et al.*, 2014)

Stillborn kittens

- In a UK questionnaire-based study of 1056 litters, Persian cats had a significantly higher prevalence of stillbirths (10.8%) than that of all breeds combined (7.2%)
- Persians also have a higher number of kitten deaths in the first 8 weeks of life

(Sparkes *et al.*, 2006)

Respiratory conditions

Aspergillosis

- Persian and Himalayan cats seem to be over-represented in a number of case reports

(Barrs & Talbot, 2014)

Pulmonary carcinoma

- Breed at increased risk in case series
- In a USA-based retrospective study of 39 feline cases, Persians were represented at least 4 times more frequently than any other breed ($p < 0.0001$)
- Average age 12.3 years (range 6–18 years)

(D'Costa *et al.*, 2012)

RAGDOLL

Behavioural conditions

General behavioural traits

- In a study of 574 single-breed registered cats, based on owner-completed questionnaires, Ragdolls were found to have lower scores for attention-seeking, trainability and sleeping in elevated/warm/hidden locations

(Wilhelmy *et al.*, 2016)

Cardiovascular conditions

Aortic thromboembolism

- Breed at increased risk in a retrospective series of 127 cases in the USA: OR 14.40 ($p = 0.0016$) compared to the general hospital population
- Males at increased risk: OR 1.75 ($p = 0.003$)

(Smith *et al.*, 2003)

Hypertrophic cardiomyopathy (HCM)

- Inherited as an autosomal dominant trait, mutation identified
- In a UK-based study including 2018 Ragdoll cats, the prevalence of the mutation was 27%
- Prevalence has been described as 17% in Italy and 23% in the USA
- It is suspected that cats homozygous for the mutation have a shorter lifespan and are more likely to suffer cardiac death
- In a UK study of 127 cats with HCM, 1997–2005, Ragdolls with HCM were found to be younger and have a shorter survival time than other HCM cats
- Males predisposed

(Payne *et al.*, 2010; Borgeat *et al.*, 2014; Casamián-Sorrosal *et al.*, 2014)

Dermatological conditions

Cutaneous neoplasia

See under *Neoplastic conditions*

Gastrointestinal conditions

Feline gastrointestinal eosinophilic sclerosing fibroplasia

- Breed at increased risk. In a retrospective study of 13 cases (from Australia and UK) Ragdolls (7/13 cases) and males (9/13 cases) were over-represented

(Linton *et al.*, 2015)

Infectious conditions

Cryptococcosis

- Breed at significantly increased risk ($p < 0.001$) in a retrospective series of 155 feline cases in Australia, 1981–2001
- Across all breeds, median age was 6 years (range 1–16) with a peak at 2–3 years

(O'Brien *et al.*, 2004)

Feline infectious peritonitis (FIP)

- Breed at increased risk in a retrospective series of 60 cases from the patient records of a North American veterinary medicine teaching hospital, 1986–2002: OR 52.22 (95% CI 11.14–244.79) compared to all cats
- Increased risk from 3 months to 3 years of age (all breeds)
- Males and sexually intact cats predisposed (all breeds)
- Cats in multi-cat environment at increased risk (all breeds)

(Foley & Pedersen, 1996; Pesteanu-Somogyi *et al.*, 2006)

Neoplastic conditions

Mast cell tumour (MCT) – cutaneous

- Breed at increased risk
- In a UK study of 287 records of feline MCTs, Ragdoll cats represented 2.1% of the study population, compared to 0.7% of the control population
- Median age 11 years (range 5 months to 19 years)

(Melville *et al.*, 2015)

Physiological conditions

Blood group

- In an Italian study of 61 Ragdoll cats, 77.1% were type A, 4.9% type B, and 18% type AB

(Proverbio *et al.*, 2013)

Renal and urinary conditions

Urolithiasis – calcium oxalate

- Breed at increased risk in case series
- In a study of 7934 calcium oxalate uroliths submitted to the Minnesota Urolith Center, 1981–1997, Ragdoll cats had an OR 7.85 (95% CI 4.74–26.56) compared to a control population of cats from the VMDB over the same period
- Males reported to be at increased risk: OR 1.5 across all breeds
- Mean age 90 ± 41 months across all breeds

(Lekcharoensuk *et al.*, 2000b)

Urolithiasis – struvite (magnesium ammonium phosphate)

- Breed at increased risk in case series
- In a study of 7456 uroliths submitted to the Minnesota Urolith Center, 1981–97, Ragdoll cats had an OR 4.9 (95% CI 1.98–14.35) compared to a control population of cats from the VMDB over the same period
- Males reported to be at reduced risk: OR 0.7 across all breeds
- Mean age 69 ± 38 months across all breeds

(Lekcharoensuk *et al.*, 2000b)

Urolithiasis – urate

- Breed at increased risk in a retrospective study of uroliths examined at the Minnesota Urolith Center, 1981–2008, compared to a control population of cats without urinary tract disease derived from the VMDB over the same period
- Ragdoll cats had an OR of 5.14 (95% CI 3.15–8.40)
- Mean age (all breeds): 6.2 years
- Males were at increased risk (all breeds): OR 1.1

(Albasan *et al.*, 2012)

Reproductive conditions

Dystocia

- Breed at increased risk in a study based on Swedish insurance data, 1999–2006
- Incidence rates (IR) were 22 cases per 10 000 CYAR for all cats, and 102 cases per 10 000 CYAR for Ragdoll cats
- Incidence rate ratio (IRR) in the Ragdoll cat was 1.5 compared to all other purebred cats

(Holst *et al.*, 2017)

Pyometra (cystic endometrial hyperplasia–pyometra complex)
- Breed at increased risk based on Swedish insurance data, 1999–2006
- IR for the Ragdoll was 80 cases per 10 000 CYAR, compared to 17 cases per 10 000 CYAR for all breeds combined

(Hagman *et al.*, 2014)

RUSSIAN BLUE

Dermatological conditions
Cutaneous neoplasia
See under *Neoplastic conditions*

Endocrine conditions
Diabetes mellitus
- Breed at increased risk in a retrospective series based on Swedish insurance data 2009–2013. Russian Blues had an increased incidence rate ratio (IRR) of 3.8 (95% CI 2.1–6.4) compared to all other breeds
- Males at increased risk: IRR 2.0 (95% CI 1.8–2.3) across all breeds
- Mean age at diagnosis: 10.7 years across all breeds

(Öhlund *et al.*, 2015)

Neoplastic conditions
Mast cell tumour (MCT) – cutaneous
- Breed at increased risk
- In a UK study of 287 records of feline MCTs, Russian Blue cats represented 2.1% of the study population, compared to 0.1% of the control population
- Median age 11 years (range 5 months to 19 years)

(Melville *et al.*, 2015)

Renal and urinary conditions
Urolithiasis
- Breed at risk in case series
- Type of urolith not specified

(Lekcharoensuk *et al.*, 2000b)

SAVANNAH

Haematological/immunological conditions
Pyruvate kinase deficiency
- Results in haemolytic anaemia
- Autosomal recessive inheritance, mutation identified
- Breed at increased risk in a study of DNA samples from 14 179 cats
- Carriers are asymptomatic
- Variable onset and severity of symptoms

(Grahn *et al.*, 2012)

SCOTTISH FOLD

Musculoskeletal conditions
Osteochondrodysplasia
- Autosomal dominant inheritance with incomplete penetrance

(Takanosu *et al.*, 2008)

Physiological conditions
Blood group
- In a US study, 85% reported as type A, 15% as type B

(Giger *et al.*, 1991a)

Renal and urinary conditions
Urolithiasis – calcium oxalate
- Breed at increased risk in case series
- In a study of 7934 calcium oxalate uroliths submitted to the Minnesota Urolith Center, 1981–97, Scottish fold cats had an OR 5.21 (95% CI 3.53–10.52) compared to a control population of cats from the VMDB over the same period
- Males reported to be at increased risk: OR 1.5 across all breeds
- Mean age 90 ± 41 months across all breeds

(Lekcharoensuk *et al.*, 2000b)

SEYCHELLOIS

Reproductive conditions
Dystocia
See under *Siamese*

Pyometra (cystic endometrial hyperplasia–pyometra complex)
See under *Siamese*

SIAMESE

Behavioural conditions
General behavioural traits
- In a study of 574 single-breed registered cats, based on owner-completed questionnaires,

Siamese were found to have increased scores for stranger-directed aggression, but lower scores for sociability and fear-related aggression

(Wilhelmy *et al.*, 2016)

Wool-sucking (compulsive)

- Breed at increased risk
- The presence of a medical condition was found to be an increased risk factor for wool-sucking in Siamese cats in one study
- Affected cats had an abnormally intense appetite

(Borns-Weil *et al.*, 2015)

Cardiovascular conditions

Endocardial fibroelastosis

- Inherited congenital anomaly
- Age of onset 3 weeks to 4 months
- Short illness in many cases, sudden death possible
- Cats with mild forms survive to adulthood

(Zook & Paasch, 1982)

Mitral stenosis

- Breed at increased risk in US retrospective case series
- Males over-represented across all breeds
- May present as an asymptomatic murmur, or as respiratory distress due to congestive heart failure and/or hindlimb paralysis due to aortic thromboembolism

(Campbell & Thomas, 2012)

Dermatological conditions

Blastomycosis

See under *Infectious conditions*

Cryptococcosis

See under *Infectious conditions*

Cutaneous neoplasia

See under *Neoplastic conditions*

Endocrine conditions

Diabetic ketoacidosis

- Breed at increased risk

(Cooper *et al.*, 2015)

Primary hyperparathyroidism

- Breed at increased risk in retrospective case series
- Siamese represented 5/7 cats with primary hyperparathyroidism
- 5 of the cats were female
- Ages ranged from 8 to 15 years, mean 12.9 years

(Richter *et al.*, 1990)

Gastrointestinal conditions

Intestinal neoplasia

- Breed at increased risk in case series
- In a retrospective study of VMDB records of 1129 cases of feline intestinal tumours, 1964–2004, Siamese cats had an OR of 1.79 compared to other breeds
- Cats of all breeds > 7 years old were at significantly increased risk
- Siamese were found to be at increased risk of both intestinal adenocarcinoma and lymphoma
- In a separate study, 6/11 cases of intestinal adenocarcinoma were found to be in the Siamese. Males were at increased risk

(Cribb, 1988; Rissetto *et al.*, 2011)

Megaoesophagus and pyloric dysfunction

- Breed at increased risk in case series. In a study of 13 cases of pyloric dysfunction, 12 cats were Siamese; 8 cases had concurrent oesophageal dilatation
- Inheritance suspected
- Vomiting started soon after weaning

(Pearson *et al.*, 1974)

Pancreatitis

- Breed at increased risk in a retrospective review of 40 cases, 1976–1989

(Hill & Van Winkle, 1993)

Periodontal disease

- In a US study of 16 374 cats > 5 years of age with a diagnosis of periodontal disease, Siamese had an RR of 1.3 (95% CI 1.1–1.5) of being represented in the periodontal disease group compared to being represented in a hospital population of cats of similar age but without periodontal disease
- In a Japanese study of 323 cats, 7.1% were affected by gingivostomatitis, but among the Siamese the incidence was 40%

(Fujitu & Sakai, 1999; Lund, 2012)

Pyloric dysfunction
See *Megaoesophagus and pyloric dysfunction*

Salivary gland neoplasia
- Siamese cats were over-represented in a study of 30 cats
- Most were adenocarcinomas

(Hammer *et al.*, 2001)

Systemic amyloidosis
- Familial
- Primarily involves the liver. May result in hepatic dysfunction or spontaneous hepatic haemorrhage

(van der Linde-Sipman *et al.*, 1997; Niewold *et al.*, 1999)

Tritrichomonas foetus infection
See under *Infectious conditions*

Haematological/immunological conditions
Haemophilia B
- Factor IX deficiency occurs in this breed

(Littlewood, 1989)

Infectious conditions
Blastomycosis
- In a literature review of cases, 1961–1988, 9/23 cases were in the Siamese cat
- 70% of cases across all breeds were male
- 75% of cases across all breeds were < 4 years old

(Miller *et al.*, 1990)

Cryptococcosis
- Breed at significantly increased risk ($p = 0.013$) in a retrospective series of 155 feline cases in Australia, 1981–2001
- Across all breeds, the median age was 6 years (range 1–16) with a peak at 2–3 years

(O'Brien *et al.*, 2004)

Mycobacterial infections
- In a UK study of 339 cases of feline mycobacterial infections, 39 cases were seen in pedigree cats, of which 18 were Siamese
- Cutaneous lesions were the most common presenting signs
- Siamese may also be predisposed to disseminated *Mycobacterium avium* complex infection

(Baral *et al.*, 2006; Gunn-Moore *et al.*, 2011)

Sporotrichosis
- Breed at increased risk in a US case series
- Young males predisposed

(Davies & Troy, 1996)

Tritrichomonas foetus infection
- Breed at increased risk in a UK study
- Cats < 1 year old predisposed

(Gunn-Moore *et al.*, 2007)

Musculoskeletal conditions
Mucopolysaccharidosis VI
- Autosomal recessive inheritance
- Causes dwarfism, facial dysmorphism, multiple skeletal, neurological and retinal deficits
- Two mutations identified: D520N (which causes a very mild phenotype) and L476P (which causes a more severe phenotype)

(Crawley *et al.*, 2003; Lyons *et al.*, 2016b)

Slipped capital femoral epiphysis (SCFE)
- Siamese were over-represented (23% of cases) in a study of 13 cases
- Across all breeds, males were over-represented (85%)
- 90% of the male cases were overweight
- Age range 4.5–24 months across all breeds

(Craig, 2001)

Neoplastic conditions
Mast cell tumour (MCT) – cutaneous
- Breed at increased risk in some case series
- In one study the head was the most commonly affected site
- In a UK study of 287 records of feline MCTs, Siamese cats represented 5.2% of the study population, compared to 1.8% of the control population
- Median age 11 years (range 5 months to 19 years)
- Histiocytic mast cell tumours, which are multicentric and regress spontaneously, are found in young Siamese cats (<1 year old)

(Chastain *et al.*, 1988; Miller *et al.*, 1991; Melville *et al.*, 2015)

Intestinal neoplasia
See under *Gastrointestinal conditions*

Lymphoma
- Breed at increased risk in several case series
- Males over-represented (3.2:1 in one study)

- Siamese cats are at increased risk of mediastinal lymphoma, tending to present at a younger age than other breeds and being feline leukaemia virus-negative

(Louwerens *et al.*, 2005; Fabrizio *et al.*, 2014)

Mammary neoplasia

- Breed at increased risk
- Generally seen in older cats, but may occur at an earlier age in this breed
- Primarily a disease of female cats, but occasionally seen in males

(Hayes *et al.*, 1981)

Salivary gland neoplasia

See under *Gastrointestinal conditions*

Neurological conditions

Feline hyperaesthesia syndrome

- Unknown aetiology
- May be due to a myopathy

(Tuttle, 1980)

Lysosomal storage disease

- Autosomal recessive inheritance
- Types seen in the Siamese are GM_1 and GM_2 gangliosidosis, ceroid lipofuscinosis, mucopolysaccharidosis type VI, sphingomyelinosis (Niemann–Pick disease)

See also under *Musculoskeletal conditions* and *Ocular conditions*

(Skelly & Franklin, 2002)

Ocular conditions

Congenital glaucoma and microphakia

- Autosomal recessive inheritance
- Additionally, Siamese cats may be predisposed to primary open-angle glaucoma

(McLellan *et al.*, 2004; McLellan & Teixeira, 2015)

Convergent strabismus and nystagmus

- Congenital; breed at increased risk

(Johnson, 1991)

Lens luxation

- Breed at increased risk in series of 345 cases
- Most common age at presentation 7–9 years
- Males were over-represented

(Olivera *et al.*, 1991)

Lysosomal storage disease

- Autosomal recessive inheritance
- Ocular signs include visual deficits and corneal opacities

See also under *Neurological conditions*

(Skelly & Franklin, 2002)

Progressive retinal atrophy (PRA)

- Late-onset rod–cone degeneration (PRA-rdAc), which is inherited recessively
- Siamese group (including, Oriental Shorthair, Balinese and Javanese) are at increased risk
- Clinical onset 1.5–2 years, progressing to blindness over 2–4 years
- Mutation identified

(Menotti-Raymond *et al.*, 2010)

Physiological conditions

Blood group

- In Portuguese, English, Australian and American studies, 100% of purebred Siamese cats were type A

(Giger *et al.*, 1991a; Silvestre-Ferreira *et al.*, 2004; Malik *et al.*, 2005; Forcada *et al.*, 2007)

Gestation length

- In a UK questionnaire-based study of 1056 litters, Siamese cats had longer gestation (mean 66.1 days) than the mean of all breeds (65.1 days)

(Sparkes *et al.*, 2006)

Litter size

- In a UK questionnaire-based study of 1056 litters, Siamese cats produced larger litters (mean 4.9 kittens) than the mean of all breeds (4.6 kittens)

(Sparkes *et al.*, 2006)

Renal and urinary conditions

Urolithiasis – calcium oxalate

- Breed at increased risk in a retrospective study of 21 426 bladder uroliths submitted to the Canadian Veterinary Urolith Centre, 1998–2014
- Siamese cats had an OR of 1.53 (95% CI 1.25–1.89) compared to domestic short-haired cats
- Males were found to be at increased risk in all breeds combined: OR 1.73 (95% CI 1.63–1.82)

(Houston *et al.*, 2016)

Urolithiasis – urate

- Breed at increased risk in a retrospective study of 21 426 bladder uroliths submitted to the Canadian Veterinary Urolith Centre 1998–2014

- Siamese cats had an OR of 4.52 (95% CI 3.37–5.96) compared to domestic short-haired cats
- Males were found to be at increased risk in all breeds combined: OR 1.3 (95% CI 1.16–1.54)

(Houston *et al.*, 2016)

Reproductive conditions

Dystocia

- Breed at increased risk in a study based on Swedish insurance data, 1999–2006
- Incidence rates (IR) were 22 cases per 10 000 CYAR for all cats, and 135 cases per 10 000 CYAR for the Oriental group (including the Siamese, Balinese, Seychellois and Oriental Shorthair)
- Incidence rate ratio (IRR) in the Oriental group was 2.2 compared to all other pure-bred cats
- In a study of data based on questionnaires completed by cat breeders, Siamese-type were found to have high levels of dystocia

(Gunn-Moore & Thrusfield, 1995; Holst *et al.*, 2017)

Mammary neoplasia

See under *Neoplastic conditions*

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- Breed at increased risk based on Swedish insurance data, 1999–2006
- IR for the Siamese group (which included Balinese, Foreign White, Javanese, Oriental Shorthair, Seychellois) was 84 cases per 10 000 CYAR, compared to 17 cases per 10 000 CYAR for all breeds combined

(Hagman *et al.*, 2014)

Respiratory conditions

Feline asthma

- Breed at increased risk in some (but not all) case series
- Siamese represented 12/22 cases in a Greek study
- Siamese were also over-represented in a study of 65 cases of feline bronchial disease, 1980–1986

(Moise *et al.*, 1989; Adamama-Moraitou *et al.*, 2004; Trzil & Reinero, 2014)

Mediastinal lymphoma

See under *Neoplastic conditions*

SIBERIAN FOREST CAT

Cardiovascular conditions

Hypertrophic cardiomyopathy (HCM)

- Believed to be inherited in Siberian Forest Cats

(Meurs *et al.*, 2009)

Haematological/immunological conditions

Pyruvate kinase deficiency

- Results in haemolytic anaemia
- Autosomal recessive inheritance, mutations identified
- Breed at increased risk in a study of DNA samples from 14 179 cats
- Carriers are asymptomatic
- Variable onset and severity of symptoms

(Grahn *et al.*, 2012)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- Breed at increased risk based on Swedish insurance data, 1999–2006
- IR for the Siberian cat was 125 cases per 10 000 CYAR, compared to 17 cases for all breeds combined

(Hagman *et al.*, 2014)

SINGAPURA

Haematological/immunological conditions

Pyruvate kinase deficiency

- Results in haemolytic anaemia
- Autosomal recessive inheritance, mutations identified
- Breed at increased risk in a study of DNA samples from 14 179 cats
- Carriers are asymptomatic
- Variable onset and severity of symptoms

(Grahn *et al.*, 2012)

SNOWSHOE

Renal and urinary conditions

Urolithiasis – urate

- Breed at increased risk in a retrospective study of uroliths examined at the Minnesota Urolith Center, 1981–2008, compared to a control

population of cats without urinary tract disease derived from the VMDB over the same period
- Snowshoe cats had an OR of 16.91 (95% CI 4.93–58.06)
- Mean age (all breeds): 6.2 years
- Males were at increased risk (all breeds): OR 1.1

(Albasan *et al.*, 2012)

SOMALI

Haematological/immunological conditions

Increased osmotic fragility of erythrocytes
- Results in haemolytic anaemia
- Inheritance suspected
- Affected cats have chronic intermittent severe anaemia and splenomegaly

(Kohn *et al.*, 2000; Tritschler *et al.*, 2016)

Pyruvate kinase deficiency
- Results in haemolytic anaemia
- Autosomal recessive inheritance, mutations identified
- Breed at increased risk in a study of DNA samples from 14 179 cats
- Carriers are asymptomatic
- Variable onset and severity of symptoms

(Kohn, 2000; Grahn *et al.*, 2012)

Musculoskeletal conditions

Acquired myasthenia gravis
See under *Neurological conditions*

Neurological conditions

Acquired myasthenia gravis
- Breed at increased risk in a retrospective study of 235 cases in the USA, 2001–2012: Somali cats had an OR of 11.60 compared to all other breeds
- Bimodal age of presentation, at 2–3 years and 9–10 years

(Hague *et al.*, 2015)

Ocular conditions

Progressive retinal atrophy (PRA)
- Late-onset rod–cone degeneration (PRA-rdAc), which is inherited recessively
- Clinical onset 1.5–2 years, progressing to blindness over 2–4 years
- Mutation identified

(Narfström, 1985; Bedford, 1989; Menotti-Raymond *et al.*, 2010)

Physiological conditions

Blood group
- In the USA, 78% reported as type A, 22% as type B

(Giger *et al.*, 1991a)

Litter size
- In a UK questionnaire-based study of 1056 litters, Somali cats produced smaller litters (mean 3.6 kittens) than the mean of all breeds (4.6 kittens)

(Sparkes *et al.*, 2006)

Renal and urinary conditions

Renal amyloidosis
- Breed at increased risk

(van Rossum *et al.*, 2004)

Reproductive conditions

Dystocia
See under *Abyssinian*

Pyometra (cystic endometrial hyperplasia–pyometra complex)
See under *Abyssinian*

SPHYNX

Cardiovascular conditions

Hypertrophic cardiomyopathy (HCM)
- Breed at increased risk. In a French prospective study of 114 healthy Sphynx cats examined by echocardiography, 2004–2011, 23 (20.2%) were found to have HCM
- Males and females were equally affected
- Autosomal dominant inheritance with incomplete penetrance proposed

(Chetboul *et al.*, 2012)

Mitral valve dysplasia
- Breed at increased risk. In a French prospective study of 114 healthy Sphynx cats examined by echocardiography, 2004–2011, 16 (14%) were found to have congenital heart disease. In most cases this was mitral valve dysplasia

(Chetboul *et al.*, 2012)

Dermatological conditions

Malassezia skin colonization
- Studies have demonstrated a high rate of *Malassezia* carriage in normal Sphynx cats

(Volk *et al.*, 2010)

Musculoskeletal conditions

Hereditary myopathy of Sphynx and Devon Rex cats

- Autosomal recessive inheritance
- Variably progressive
- Seen in Sphynx and the related Devon Rex
- May represent a congenital myasthenic condition

(Martin *et al.*, 2008; Gandolfi *et al.*, 2015)

Renal and urinary conditions

Urolithiasis – urate

- Breed at increased risk in a retrospective study of uroliths examined at the Minnesota Urolith Center, 1981–2008, compared to a control population of cats without urinary tract disease derived from the VMDB over the same period
- Sphynx cats had an OR of 12.88 (95% CI 4.52–36.75)
- Mean age (all breeds): 6.2 years
- Males were at increased risk (all breeds): OR 1.1

(Albasan *et al.*, 2012)

Reproductive conditions

Pyometra (cystic endometrial hyperplasia–pyometra complex)

- Breed at increased risk based on Swedish insurance data, 1999–2006
- IR for the Sphynx was 433 cases per 10 000 CYAR, compared to 17 cases per 10 000 CYAR for all breeds combined

(Hagman *et al.*, 2014)

TONKINESE

Behavioural conditions

General behavioural traits

- In a study of 574 single-breed registered cats, based on owner-completed questionnaires, Tonkinese were found to have increased scores for sociability with people, playfulness, vocalization, attention-seeking behaviour, separation anxiety and trainability, but lower scores for restraint resistance, owner-directed aggression, fear-related aggression and cat aggression

(Wilhelmy *et al.*, 2016)

Endocrine conditions

Diabetes mellitus

- Breed at increased risk in case series
- In a cohort of 193 563 cats in primary-care practice in England, 2009–2014 (VetCompass data), there were 1128 cases of diabetes mellitus (period prevalence 0.58%). Tonkinese were at increased risk, with an OR of 4.1 (95% CI 1.8–9.6) compared to the overall population. Both being >4 kg body weight and >6 years of age were risk factors across all breeds ($p < 0.001$)

(O'Neill *et al.*, 2016b)

Physiological conditions

Blood group

- In a study in the USA, 100% of Tonkinese cats tested were type A

(Giger *et al.*, 1991a)

Kitten birth weight

- In a UK questionnaire-based study of 1056 litters, Tonkinese cats produced smaller kittens (mean 84.1 g) than the mean of all breeds (93.5 g)

(Sparkes *et al.*, 2006)

Litter size

- In a UK questionnaire-based study of 1056 litters, Tonkinese cats produced larger litters (mean 5.3 kittens) than the mean of all breeds (4.6 kittens)

(Sparkes *et al.*, 2006)

Renal and urinary conditions

Urolithiasis – calcium oxalate

- Breed at increased risk in a retrospective study of 21 426 bladder uroliths submitted to the Canadian Veterinary Urolith Centre, 1998–2014
- Tonkinese cats had an OR 5.02 (95% CI 1.89–17.3) compared to domestic short-haired cats
- Males were found to be at increased risk in all breeds combined, OR 1.73 (95% CI 1.63–1.82)

(Houston *et al.*, 2016)

TURKISH ANGORA

Physiological conditions

Blood group

- In a study of 28 Turkish Angora cats in Turkey, 53.6% were type A and 46.4% were type B

(Arikan *et al.*, 2003)

TURKISH VAN

Physiological conditions

Blood group

- In a study of 85 Turkish Van cats in Turkey, 40% were type A and 60% were type B

(Arikan *et al.*, 2003)

PART III

DISEASE DESCRIPTIONS

Abnormal dentition

Dentition (teeth) may develop abnormally in several ways in dogs and cats. Possible abnormalities include persistent deciduous teeth, unerupted teeth, malformed or maldirected teeth, malocclusion, missing or supernumerary teeth (polyodontia). For example, missing incisors are seen in some Havanese dogs as part of a wider syndrome of multiple developmental abnormalities.

Abnormal heart sounds

These include murmurs, gallop rhythms and adventitious sounds.

Abnormal mediodistal location of medial fabella

The lateral and medial fabellae are sesamoid bones in the tendon of origin of each head of the gastrocnemius muscle, associated with the stifle (knee) joint.

Accessory pathway arrhythmia

Accessory pathways are abnormal cardiac muscle fibres which can conduct the electrical impulse that causes the heart to contract, bypassing the atrioventricular node which helps control heart rate. This can lead to arrhythmias such as Wolf–Parkinson–White syndrome.

Achilles tendon rupture

The Achilles tendon attaches to the calcaneus of the hock joint. Rupture will lead to lameness due to a loss of ability to extend the hock.

Acne

Also known as folliculitus, acne involves skin inflammation, often around the chin or face, with signs including redness, swelling, papules and pustules. It can be idiopathic or bacterial in origin.

Acquired megaoesophagus

A motility disorder resulting in flaccidity of the oesophagus. Affected animals suffer from regurgitation and are at increased risk of aspiration pneumonia.

Acquired myasthenia gravis

An autoimmune disorder affecting the receptors of the neurotransmitter acetylcholine resulting in muscular weakness. Signs may include fatigue

Breed Predispositions to Disease in Dogs and Cats, Third Edition. Alex Gough, Alison Thomas and Dan O'Neill.

on exercise and megaoesophagus. Myasthenia gravis may be primary, or secondary to another condition such as thymoma.

Acral mutilation and analgesia
A neurological or skin condition which results in mutilation of the distal extremities. Pups are often affected from between 3 and 5 months of age. Temperature and pain sensation of the toes is lost. The prognosis is often poor. See also *Sensory neuropathy*.

Acrodermatitis
Inherited condition of Bull Terriers causing coat, skin and footpad lesions. There may be respiratory and gastrointestinal signs, and the prognosis is poor. A defect in zinc metabolism may be involved in the pathogenesis.

Acromegaly
Acromegaly results from overproduction of growth hormone by the pituitary gland. In the cat, this most commonly results from a tumour of the pituitary gland, while in the dog it results from excess progesterone either in older intact bitches or following exogenous progesterone administration. Signs of acromegaly include enlargement of the paws, mandible and internal organs. Some cases present with diabetes mellitus.

Actinic (solar) keratosis
An inflammatory skin condition caused by prolonged exposure to the sun. It can lead to skin cancer.

Acute canine polyradiculoneuritis
An autoimmune disease of the peripheral nerves leading to paralysis. It is sometimes known as *coonhound paralysis*, although this more correctly only relates to the condition when it is caused by toxicity from a racoon bite.

Acute febrile neutrophilic vasculitis
An immune-mediated skin condition of unknown cause. Leads to multifocal areas of skin discoloration and oedema.

Acute non-compressive nucleus pulposus extrusion (type III disc extrusion)
This occurs when a small piece of disc material breaks off and impacts the spinal cord causing bruising. This can lead to paresis or paralysis, which may be reversible over time. This condition presents clinically in a similar way to a fibrocartilaginous embolism, although acute non-compressive nucleus pulposus extrusion is more commonly associated with spinal hyperaesthesia.

Adaptation to hypoxia
Certain breeds which have traditionally been kept and bred at high altitudes, such as Tibetan Mastiffs, show genetic adaptation to the low oxygen levels found at altitude.

Adenoma/adenocarcinoma
Adenomas are benign tumours of glandular tissue. Adenocarcinomas are malignant tumours of glandular tissue.

Adult-onset deafness
There can be various causes of deafness in later life, including infection, trauma, iatrogenic injury and degenerative processes.

Adult-onset hair loss
There are several causes of hair loss in adult dogs, such as hormonal disease, parasitism and self-trauma. Some cases are unexplained, but as they occur more commonly in certain breeds, there may be a genetic component.

Afghan myelopathy
A progressive disease of the white matter of the spinal cord. Signs include pelvic limb ataxia and paresis, progressing to thoracic limb involvement, tetraplegia and eventually death from respiratory paralysis.

Agenesis of the nares
This congenital condition can predispose to laryngeal collapse. Dyspnoea, mouth breathing and snoring are seen.

Aggression
Some dog breeds are noted in studies to be more prone to aggression than others. However, different types of aggression are recognized, including fear-related, aggression to owners, aggression to strangers, predatory aggression, protective aggression and aggression to other dogs. Aggression is a common reason for owners to seek euthanasia, and so is an important cause of mortality, as well as being a public health risk.

Alanine aminotransferase (ALT) levels
This enzyme is routinely tested in blood samples as a marker of liver damage.

Alaskan Malamute chondrodysplasia
This condition leads to short limbs with bowed front legs and laterally deviated paws. Haemolytic anaemia is often also seen.

Alexander disease
This rare neurodegenerative disorder causes neurological signs including ataxia, tremors and weakness, progressing over a few weeks to paralysis.

Alopecia X
Also known as adrenal hyperplasia-like syndrome, biopsy-responsive alopecia, castration-responsive alopecia, castration-responsive dermatosis, growth-hormone-responsive alopecia, pseudo-Cushing's syndrome. This is a poorly understood cosmetic condition affecting coat quality and colour in early adulthood. It is characterized by partial to complete alopecia that spares the head and forelimbs and the alopecic skin may become hyperpigmented. It is progressive and symmetrical but non-pruritic.

Amblyopia and quadriplegia
This is a lethal inherited condition of Irish Setters. Puppies are unable to walk, and progression to visual impairment, nystagmus and seizures occurs.

Anaesthetic-related complications
All general anaesthesia carries a degree of risk. Some breeds are more at risk of complications. This may be due to anatomical factors such as airway anatomy, or to individual tolerance of certain anaesthetics.

Anal furunculosis (perianal fistula)
Chronically infected and often deep tracts in the soft tissues around the anus. An immune-mediated basis is suspected.

Anal sac adenocarcinoma
Anal sac adenocarcinoma is a malignant tumour which is palpable as a discrete or infiltrative mass in the anal sac. These tumours are often associated with hypercalcaemia and metastasize early to the sublumbar lymph nodes, spleen and lung. They are rare in the cat.

Angiostrongylosis
Angiostrongylus vasorum, also known as lungworm or French heartworm, can cause respiratory disease, neurological disease, clotting disorders and hypercalcaemia. It has been increasing in geographical spread in the UK in recent years.

Antibiotic-responsive diarrhoea (small intestinal bacterial overgrowth)
This condition was previously known as small intestinal bacterial overgrowth. It is believed to result from abnormal interaction between the intestinal immune system and antigens derived from gastrointestinal bacteria.

Antral pyloric hypertrophy (pyloric stenosis, chronic hypertrophic pyloric gastropathy)
In this syndrome, gastric outlet obstruction is caused by hypertrophy of the pyloric muscle, hyperplasia of the antral mucosa or both, and results in persistent vomiting. Congenital hypertrophy of the pyloric muscle is seen in young Boxers and Boston Terriers and may be referred to as congenital pyloric stenosis.

Adult-onset antral pyloric hypertrophy syndrome is seen in older (> 6 years) small oriental canine breeds. In these cases, there may be antropyloric mucosal hyperplasia only or a combination of mucosal and muscular hypertrophy.

Aortic or cardiac mineralization
An incidental finding noted in some dogs during radiography or computed tomography.

Aortic stenosis – subaortic stenosis (SAS)
This condition accounts for up to a third of reported cases of congenital canine heart disease. It appears to be inherited, but not in a simple way, with more than one gene thought to be involved. The condition develops in the first 3–8 weeks of life, and may be first detected as a heart murmur at this age. If the condition is mild, clinical signs are minimal, but more severely affected animals may suffer from weakness, collapse and sudden death. Screening programmes allowing selective breeding may reduce the incidence of this defect.

Aortic thromboembolism
A blood clot that lodges in the caudal aorta, especially in cats but occasionally in dogs, causing signs of hindlimb paresis or paralysis, cold extremities and pain. It is often associated with

cardiac disease in cats, and many cases may present with concurrent heart failure.

Arachnoid cyst – spinal
Arachnoid cysts are a rare cause of focal spinal cord compression in young dogs. Neurological deficits depend on the site of the lesion.

Arrhythmogenic right ventricular cardiomyopathy (Boxer cardiomyopathy)
The condition is also seen in cats. Affected animals can present with syncope, weakness or congestive heart failure.

Arthrosis of cervical articular facet joints
Abnormalities of the facet joints in the neck resulting in severe pain.

Aspergillosis
Aspergillosis is an opportunist fungal infection caused by *Aspergillus* spp. In the dog, it generally presents as a nasal and frontal sinus infection, and dolichocephalic (long-nosed) breeds seem predisposed. Disseminated aspergillosis is a more serious and often fatal form presenting as a systemic disease with multiple organ involvement.

Aspiration pneumonia
Inhalation of foreign material leading to lung inflammation. This is a serious and often fatal disease.

Atherosclerosis
Thickening of arterial walls.

Atlantoaxial subluxation/instability
This is seen primarily in young dogs of toy breeds which present with neck pain and neurological deficits in all four limbs due to cervical spinal cord compression. A variety of congenital defects, including a lack of or hypoplasia of the dens and shortening of the axis, lead to instability of the atlantoaxial articulation. The condition may also be acquired in any breed as a result of fracture of the dens or damage to the ligamentous support.

Atopic dermatitis (atopy)
This is a common condition involving hypersensitivity reactions to environmental allergens, affecting around 10% of the canine population. It is thought to be inherited, but the exact mode of inheritance has not yet been determined. Signs include pruritus, erythema and self-trauma with secondary bacterial infection.

Atresia ani
Congenital lack of a patent anus. Atresia ani is a rare disease (0.007% cases in a review of 1.6 million dogs from the VMDB).

Atrial fibrillation (AF)
This arrhythmia is usually seen in conjunction with severe heart disease such as dilated cardiomyopathy. However, some large-breed dogs can show an asymptomatic atrial fibrillation in the absence of structural heart disease.

Atrial septal defect
This uncommon congenital condition involves a defect in the septum between the atria. Small defects may be asymptomatic, but larger lesions can lead to congestive heart failure.

Atrioventricular (AV) block
Arrhythmia due to a disruption of the conduction of the electrical impulse from the pacemaker in the atrium to the ventricles.

Atypical granulation of neutrophils
Fine eosinophilic granules are noted in the neutrophils. This does not appear to affect the function of the cells.

Audiogenic reflex seizures
Reflex seizures are fits consistently triggered by environmental factors. Audiogenic reflex seizures are triggered by high-pitched sounds.

Avascular necrosis of the femoral head (Legg–Calvé–Perthes disease)
This disorder of small-breed dogs involves an aseptic, avascular necrosis of the femoral head. Signs are usually seen from 5 months of age. Ischaemia of the femoral head leads to degeneration of the bone which presents as a progressive uni- or bilateral hindlimb lameness.

Avulsion of the tibial tuberosity
This is a fracture of the growth plate of the tibial tuberosity in young dogs, which is seen more commonly in dogs with large quadriceps muscles.

Azotaemia
Higher than normal levels of urea, creatinine and other nitrogen-containing compounds in the blood.

Babesiosis
A tickborne protozoal disease caused by *Babesia* species. Infection results primarily in haemolytic anaemia; however, complications in multiple organs may develop. Infection may be peracute, acute, chronic or subclinical. It has been proposed that the disease may also be transmitted between dogs by biting.

Bacterial cholecystitis and bactibilia
Bacterial infection of the gallbladder and biliary tree.

Bacterial folliculitis/furunculosis
Inflammation of the skin associated with bacteria.

Bacterial keratitis
Bacterial infection and resulting inflammation of the cornea.

Basal cell tumour
These common skin tumours arise from the basal epithelial cells which give rise to the epidermis. They are usually well circumscribed, firm, freely mobile masses found in the dermis and subcutis around the head and neck. They are generally slow growing and benign in behaviour, rarely metastasizing. Basal cell carcinoma has low-grade malignancy and is a more invasive form that is reasonably common in cats but uncommon in dogs and rarely metastasizes in either species. Some dermatopathologists now consider most basal cell tumours to be more accurately classified as trichoblastomas.

Benign familial hyperphosphatasaemia
A hereditary condition causing elevations in serum alkaline phosphatase.

Black hair follicular dysplasia
A rare disorder causing alopecia in areas of black hair. Thought to be inherited as an autosomal recessive trait.

Blastomycosis
Blastomycosis is a systemic fungal infection, caused by *Blastomyces dermatitidis* and seen primarily in North America. The lungs are the site of initial infection, and from there it may spread to the lymphatics, skin, eyes and bones. Dogs are more commonly infected than cats, young, male, large sporting-breed dogs living close to water being at greatest risk.

Blood group
Canine blood groups are classified according to the dog erythrocyte antigen (DEA). There are six main groups, DEA 1.1, 1.2, 3, 4, 5 and 7. DEA 1.1 and 1.2 are alleles so it is not possible to be positive for both. Since there are no naturally occurring autoantibodies to these two groups, an initial blood transfusion does not usually cause an acute transfusion reaction. However, if the donor and recipient are incompatible, an immune response will be mounted after the first transfusion, so subsequent incompatible transfusions are likely to cause a reaction. DEA 1.1 is inherited as an autosomal dominant. A DEA 1.1-negative female bred with a DEA 1.1-positive male may therefore have DEA 1.1-positive pups, and this can lead to neonatal isoerythrolysis.

Feline blood groups are classified into A, B and AB. A is dominant over B, but the inheritance of the rare AB blood group is determined by a different gene. There are high levels of naturally occurring antibodies against the other groups, so there are no universal donors, and crossmatching or typing is vital before transfusing.

Bone marrow necrosis
Necrosis of the bone marrow can be associated with toxins, neoplasia and infections. This leads to cytopenias such as anaemia, thrombocytopenia and neutropenia.

Bone tumour
Common bone tumours include osteosarcomas and chondrosarcomas. Signs of bone tumours include pain, swelling and pathological fractures.

Border Collie collapse
This condition occurs after strenuous exercise and can lead to ataxia, altered mentation and collapse. It is thought to be an episodic diffuse central nervous system disorder.

Borreliosis (Lyme disease)
This is caused by the tick-borne organism *Borrelia burgdoferi*, and causes signs including pyrexia and polyarthritis.

Brachycephalic obstructive airway syndrome (BOAS)
This term is used to describe a group of anatomical deformities which lead to respiratory compromise in brachycephalic breeds. An intronic, transposable element within the *SMOC2* gene is

associated with disruption of facial skeleton development in a dose-dependent manner. The deformities include stenotic nares, laryngeal deformities and hypoplastic trachea. The clinical signs are of upper airway obstruction and secondary complications; concurrent conditions such as laryngeal oedema and bronchopneumonia can occur in severely affected dogs.

Bradyarrhythmia
An abnormally slow heart rate, often associated with an irregular rhythm.

Bronchiectasis
Dilatation of the bronchi, often occurring as a complication of chronic bronchitis or bronchopneumonia. The changes are irreversible once present.

Calcinosis circumscripta
An uncommon condition, usually of unknown cause, although it may be associated with hyperadrenocorticism, or with tissue damage from mechanical, chemical, infectious or other factors. Calcinosis circumscripta involves localized deposition of mineral, causing a tumour-like nodule.

Calcinosis cutis
Calcinosis cutis involves localized or widespread mineralized deposits in the skin.

Calcium phosphate deposition
Calcium phosphate deposition can cause paraplegia in very young puppies, resulting from narrowing of the cervical vertebral canal. Soft-tissue deposition of mineral also occurs.

Cane toad toxicity
Exposure to the cane toad (*Bufo marinus*) commonly leads to hypersalivation and erythema of the mucous membranes. Seizures and arrhythmias are also seen.

Canine acanthomatous ameloblastoma (acanthomatous epulis)
An oral tumour which, while technically benign, can be locally invasive.

Canine autoinflammatory disease (AID)
This disease involves widespread systemic inflammation, leading to signs including fever, arthritis, dermatitis, otitis and amyloidosis.

Canine cutaneous histiocytoma
These skin tumours are commonly seen in young dogs (< 4 years old), and appear as solitary, firm, well-circumscribed intradermal nodules on the head, limbs or trunk. Occasionally the surface will ulcerate. They are benign, and most will regress spontaneously over a period of months. See also *Histiocytic diseases*.

Canine distemper
This disease is caused by the canine distemper virus, and causes gastrointestinal signs, respiratory signs and footpad hyperkeratosis. Neurological signs can also occur. The disease can be fatal but is reliably prevented by vaccination.

Canine ectodermal dysplasia (hairlessness)
A rare genetic fragile skin condition seen in puppies.

Canine epileptoid cramping syndrome (Spike's disease)
This is a paroxysmal dyskinesia or movement disorder which can resemble epilepsy. Most cases begin before the age of 3 years, with signs of tremor, dystonia and difficulty walking lasting from 2 to 30 minutes. Some cases are associated with gastrointestinal signs, and in some cases diet changes may improve the severity of signs.

Canine follicular dysplasia (seasonal flank alopecia)
This is a localized cyclic follicular dysplasia causing a symmetrical alopecia. Hair loss and hyperpigmentation are noted especially on the flanks. Some dogs lose their hair in spring and regrow it spontaneously in autumn, while for others the reverse occurs.

Canine juvenile cellulitis
This condition is also known as juvenile pyoderma, puppy strangles or juvenile sterile granulomatous dermatitis and lymphadenitis. It is an uncommon disorder causing pustules on the face and pinnae of puppies. The submandibular lymph nodes are often greatly enlarged.

Canine leproid granuloma
A mycobacterial disease causing nodules and papules, usually around the head, which may ulcerate.

Canine leucocyte adhesion deficiency (CLAD)
An inherited defect in the ability of neutrophils to bind to endothelial cells causes severe and recurrent bacterial infections. A molecular diagnostic test is available to diagnose this condition.

Canine multiple system degeneration (progressive neuronal abiotrophy)
A hereditary neurodegenerative disease causing degeneration of the cerebellum, caudate nucleus and substantia nigra. Signs start from 3 months of age and start with classic cerebellar signs, but progress to difficulty initiating movement and balance problems.

Canine odontogenic parakeratinized cyst
A number of subtypes have been recognized, including radicular (periapical) cysts, dentigerous (follicular) cysts and lateral periodontal cysts. Odontogenic cysts are pathological, epithelial-lined cavities containing fluid or semisolid material that are derived from odontogenic epithelium and can be developmental or the result of an inflammatory process. Odontogenic keratocysts are developmental cysts with an unusual propensity for recurrence.

Canine pigmented epidermal naevus
Some cases are considered to be an inherited disorder similar to that in humans, and some may be associated with canine papillomavirus infection.

Canine spongiform leucoencephalomyelopathy
A progressive neurological disease causing signs from 2–9 weeks of progressive neurological dysfunction including ataxia, paresis, paralysis and spasticity.

Cardiac hypertrophy
Thickening of the heart muscles can be present as a normal variation in athletic breeds, as a response to obstruction of outflow such as aortic stenosis, or as a primary myocardial disorder such as hypertrophic cardiomyopathy.

Cardiac tumour
Various tumours can affect the heart, including haemangiosarcomas, which are often found attached to the right atrium, and chemodectomas, which are often attached to the aorta.

Cardiomyopathy – X-linked muscular dystrophy (Golden Retriever muscular dystrophy)
In this rare inherited condition, skeletal muscle signs predominate, starting at about 8 weeks of age, but severe cardiac involvement may develop later. Few dogs affected with this condition survive past 5 years of age.

Carpal laxity syndrome
This condition involves either carpal (wrist) hyperextension or carpal hyperflexion. It occurs in puppies and is usually self-limiting.

Cataract
An opacity which may affect all or part of the lens or lens capsule, unilaterally or bilaterally. Cataracts may be primary (where a hereditary basis is suspected) or secondary, for example, to ocular inflammation, metabolic disease or congenital anomalies such as persistent pupillary membranes or persistent hyaloid artery.

Cataracts may be detected first in a variety of different areas of the lens and may progress at different rates. A complete cataract involves the whole lens and obscures the fundus, resulting in blindness in the affected eye.

Catechol-O-methyltransferase gene polymorphism
Alterations in this gene are associated with psychological problems in humans, and may be linked to behavioural abnormalities, including in territorial defence behaviours, in animals.

Central axonopathy
Several breeds have had central axonopathies described. These often have a very early age of onset, are progressive, and show signs of ataxia and tremor.

Central tarsal bone fracture
Fracture of one of the bones of the hock.

Central vestibular disease
Vestibular disease leads to signs of head tilt, nystagmus and ataxia. Central vestibular disease results from lesions in the brainstem and/or cerebellum.

Cerebellar ataxia
Ataxia related to the cerebellum is usually characterized by hypermetria, tremor, incoordination, but retention of conscious proprioception.

Cerebellar degeneration
Also known as cerebellar cortical abiotrophy, cerebellar cortical degeneration, hereditary cerebellar degeneration. Cerebellar cells can undergo premature ageing, degeneration and death (termed abiotrophy), leading to signs of cerebellar dysfunction (intention tremor, ataxia, hypermetria and menace deficits). In most cases the condition is believed to be hereditary.

Cerebellar hypoplasia
Congenital malformations of the cerebellum include hypoplasia and aplasia of the whole or part of the cerebellum. Some may have a genetic basis, while others result from a teratogen. Clinical signs are seen as soon as the animal becomes mobile and are non-progressive. They include hypermetria, head tremor and a wide-based stance. There is no treatment, but animals may make suitable pets if not severely affected.

Cerebellar Purkinje cell degeneration and coat colour dilution
Signs include growth retardation, progressive ataxia and dilution of the coat colour.

Cervical spondylomyelopathy (cervical vertebral malformation, wobbler syndrome)
A collection of abnormalities of the cervical vertebrae, including spinal canal stenosis, hypertrophy of the ligamentum flavosum and dorsal annulus, and disc herniation. Causes progressive signs of ataxia, starting in the hindlimbs and progressing to the forelimbs.

Chédiak–Higashi syndrome
A condition seen in the Persian cat. Affected cats have abnormal neutrophils and/or neutropenia, and may have increased susceptibility to disease. Platelet storage pool deficiency results in increased bleeding tendencies with normal coagulation profiles. Signs may include ocular and cutaneous albinism, cataracts, susceptibility to infection and bleeding tendencies.

Chemodectomas (aortic body and carotid body)
Chemodectomas are derived from the chemoreceptor cells of the aortic and carotid bodies which detect changes in the blood pH, oxygen and carbon dioxide levels. Chemodectoma of the aortic body arises at the heart base and is reported more frequently than carotid body tumours, which arise at the bifurcation of the carotid artery and present as a cervical mass. Both are relatively uncommon in the dog and cat, but brachycephalic dogs appear predisposed. Chemodectomas may be locally invasive and have the potential to metastasize.

Cheyletiellosis
A non-suppurative dermatitis caused by *Cheyletiella* spp. mites.

Chiari malformation/syringomyelia
This condition involves a fluid-filled dilatation in the cervical spinal cord, which may lead to clinical signs of neck pain, persistent scratching around the head and neck, and sometimes ataxia. It has become increasingly recognized because of the increased availability of MRI, which is necessary for the diagnosis. Syringomyelia is often associated with a malformation of the occipital bone of the skull, which is known as Chiari malformation, or caudal occipital malformation syndrome.

Chlamydophilosis
This zoonotic disease caused by *Chlamydophila psittaci* is more commonly seen in birds.

Chondrodysplasia (short-limbed or disproportional dwarfism)
Disproportionate growth in which the legs are shorter than expected for the head and body. This is considered normal in some breeds (e.g. Dachshunds), and abnormal in others.

Chondrosarcoma (skeletal)
This is the second most common primary bone tumour of dogs, accounting for 5–10% of cases. It generally grows slowly and metastasizes less frequently than the osteosarcomas.

Chronic atrophic gastritis
Chronic inflammation of the stomach leading to loss of glandular tissue.

Chronic hepatitis
Inflammatory liver disease which usually progresses to cirrhosis. There are many types of hepatitis, and classification remains controversial; however, certain breeds of dog may be predisposed, and individual breeds may demonstrate particular patterns of inflammation.

Chronic hepatitis (copper-associated)
Copper storage hepatopathy in the Bedlington Terrier results from a defect in biliary copper excretion leading to accumulation of copper in hepatocytes and hepatic necrosis. Copper-associated hepatopathy occurs in other breeds, but other mechanisms may be involved in the copper accumulation.

Chronic hypertrophic pyloric gastropathy
See *Antral pyloric hypertrophy*.

Chronic kidney disease (chronic renal failure, chronic renal insufficiency)
Many cases are idiopathic, but the disease may also be secondary to conditions such as amyloidosis, glomerulonephritis, neoplasia, renal dysplasia and pyelonephritis. The International Renal Interest Society (IRIS) grades severity on a scale of 1 to 4 based on serum creatinine, with subcategories based on proteinuria and hypertension. Chronic kidney disease causes signs such as polyuria–polydipsia, weight loss, inappetence, vomiting and anaemia. See also *Familial renal disease* and *Kidney disease*.

Chronic pulmonary disease (CPD)
A chronic respiratory illness, typified by inspiratory crackles and an increased interstitial pattern on thoracic radiography that is particularly prevalent in West Highland White Terriers. It has been suggested that this condition may be analogous to idiopathic pulmonary fibrosis (IPF) in humans.

Chronic superficial keratitis (pannus)
A bilateral progressive inflammatory disease of the cornea. A fleshy, vascular lesion spreads towards the central cornea from the temporal limbus. Corneal pigmentation follows and, if severe, vision loss occurs. It is suspected to have an immune-mediated basis and is influenced by ultraviolet radiation. The condition is more severe in dogs living at high altitude. May be seen with plasma cell infiltration of the nictitating membrane (plasmoma).

Chylothorax
An accumulation of chyle in the pleural space. This is often idiopathic, although it can be secondary to conditions such as heart failure and neoplasia. Signs are attributable to the pleural effusion, i.e. respiratory signs.

Cleft lip and/or palate
A congenital defect in the hard or soft palate allowing abnormal communication between the oral cavity and the nasal cavity/nasopharynx. Signs including failure to thrive and reflux from the nose during suckling are present from an early age.

Colitis
Inflammation of the lower intestine causing signs such as watery diarrhoea, fresh blood in the faeces and tenesmus.

Collie eye anomaly
A bilateral congenital condition characterized by abnormal development of the eye. The severity and effect on vision is variable. Mild cases may have only choroidal hypoplasia (inadequate development of the choroid). More severe cases may also have optic nerve colobomas, retinal detachment and intraocular haemorrhage. The condition is best diagnosed at 6–7 weeks, and it is advisable to remove affected dogs from a breeding programme.

Colorectal polyps
Polyps are more commonly found in the rectum than in the colon. They may be single or multiple, and while often benign, may have malignant characteristics.

Colour dilution alopecia
Hypotrichosis and recurrent bacterial folliculitis occur in colour dilute areas.

Cone degeneration (hemeralopia or day blindness)
Day blindness with no ophthalmoscopically visible abnormality. The condition results from selective degeneration of the cone photoreceptors of the retina. Dogs show severe loss of vision in daylight from 8–12 weeks but are able to see in dim light.

Congenital achromatopsia (rod monochromacy, day blindness)
Achromatopsia refers to lack of colour vision, which can be detected from 8 weeks using electroretinography.

Congenital alacrima (congenital keratoconjunctivitis sicca)
A lack of lacrimal tissue and tears causing dry eye.

Congenital deafness
This has been observed in numerous breeds (especially Dalmatians and blue-eyed white cats) and usually results from a partial or complete failure of development of the organ of Corti.

Congenital glaucoma and microphakia
High intraocular pressure with a small lens.

Congenital heart disease
A number of heart conditions can be caused by developmental defects, including septal defects, stenosis of major vessels, valve malformations and patent ductus arteriosus.

Congenital hypothyroidism
Can lead to disproportionate dwarfism, mental dullness and coat changes.

Congenital hypotrichosis
Animals affected with this condition are born without normal coats or lose their coats in the first few months of life.

Congenital megaoesophagus
A motility disorder which when congenital shows signs of regurgitation around the time of weaning.

Congenital myasthenia gravis
Clinical signs in dogs include muscle weakness on exercise which improves with rest, and megaoesophagus. The onset may be chronic or acute and the condition can be generalized or focal. Signs in cats include drooling, ventroflexion of the neck, regurgitation, weakness and lameness.

Congenital portosystemic shunt
Failure of fetal venous shunts to close after birth leads to persistent shunting of blood from the gastrointestinal tract to the systemic circulation without hepatic metabolism. Shunts may be single or multiple, intrahepatic or extrahepatic. Large breeds of dog are more likely to have intrahepatic shunts, small breeds and cats are more likely to have extrahepatic shunts.

Congenital umbilical hernia
A defect in the body wall at the umbilicus.

Conjunctival haemangiosarcoma
Malignant tumour of the conjunctiva.

Conjunctivitis
Inflammation of the conjunctiva.

Convergent strabismus and nystagmus
Results from abnormal visual pathway development associated with an absence of ocular pigment. Convergent strabismus is an abnormal deviation of the eyeballs medially. Nystagmus is a repetitive drift or flick of the eye. Other symptoms include decreased visual activity and loss of binocular vision.

Corneal and anterior segment foreign body trauma
Damage to the cornea from foreign bodies leading to penetration can cause glaucoma and blindness.

Corneal dystrophy
A primary, non-inflammatory bilateral (though not necessarily symmetrical) opacity of the cornea. The term *dystrophy* implies a hereditary condition. However, in many cases of corneal dystrophy, firm evidence of inheritance is lacking, although no underlying disease can be found. Different layers of the cornea may be affected, giving *epithelial*, *endothelial* and *stromal* dystrophies. The appearance, age of onset and rate of progression vary with the breed. Visual disturbance may occur if the lesion becomes extensive.

Corneal pigmentation (pigmentary keratopathy)
Occurs secondary to local irritation, e.g. from entropion or distichiasis.

Corneal sequestrum
A disease of the cornea seen in the cat, characterized by the development of a pigmented lesion in the centre of the cornea. In some cases, it is secondary to feline herpes virus keratitis, or chronic corneal irritation from entropion or trichiasis.

Corneal ulceration (ulcerative keratitis)
May occur secondary to dry eye, foreign bodies, chronic irritation such as entropion, or infection.

Corns (on the footpad)
Well-circumscribed regions of hyperkeratosis on the footpad.

Cranial cruciate ligament (CCL) disease
This common injury often presents as a severe, acute onset lameness. Diagnosis is by ascertaining the presence of a 'cranial drawer' motion in the stifle, by radiography, and by arthroscopy or arthrotomy.

Craniomandibular osteopathy (lion jaw)
This condition is inherited in some breeds, but other factors may be important in other breeds. Clinical signs include mandibular swelling, drooling and pain on opening the mouth. Irregular bone proliferation is seen on radiographs. The disorder is usually self-limiting, although in some cases hemimandibulectomy may be necessary.

Cricopharyngeal dysfunction
Difficulty in swallowing due to failure of the cricopharyngeal sphincter (the upper oesophageal sphincter) to relax.

Cryptococcosis
Cryptococcosis is a systemic fungal infection, caused by *Cryptococcus neoformans*, which is found worldwide and may be spread by pigeons. It infects a wide range of mammalian species but is most commonly seen in the cat. Clinical signs may reflect nasal, respiratory, central nervous system, ocular or cutaneous involvement.

Cryptorchidism
A failure of one or both testes to descend into the scrotum. The undescended testis may be found in the inguinal canal or abdomen. Cryptorchidism may be unilateral (in which case the right testis is more commonly affected in the dog) or bilateral. Smaller breeds of dog seem to have a higher risk. The risk of testicular neoplasia is higher in retained testes.

Cutaneous and renal glomerular vasculopathy (Alabama rot)
A disease of unknown cause, leading to skin ulceration and acute kidney injury. This was originally a disease of Greyhounds seen mainly in the USA; more recently a similar disease has been recognized in the UK, but without obvious breed predispositions.

Cutaneous asthenia (Ehlers–Danlos-like syndrome)
Causes skin hyperextensibility and alopecia.

Cutaneous food allergy
Allergic reaction to allergens within food causing skin signs.

Cutaneous haemangioma
Haemangiomas are benign tumours arising from the vascular endothelial cells of the dermis and subcutis. They are common in dogs but rare in cats. They appear as well-circumscribed blue/purple masses. It has been suggested that prolonged exposure to sunlight may be a predisposing factor, making light-skinned dogs with short coats more vulnerable.

Cutaneous haemangiosarcoma
Malignant tumours arising from the vascular endothelial cells of the dermis and subcutis. May be indistinguishable from haemangiomas or may be infiltrative with large areas of haemorrhage.

Cutaneous lupus erythematosus
Dogs typically develop clinical signs before 10 months of age, but age of onset has been reported as late as 2.75 years. Clinical signs consist of excessive scaling and crusting that first occur on the face, ears and back and then progress to a generalized form.

Cutaneous melanoma
Malignant skin tumour involving melanocytes.

Cutaneous mucinosis
Excessive mucin in the skin and subcutis, leading to signs of skin thickening and folding, with vesicles which may ooze fluid when squeezed.

Cutaneous soft-tissue sarcoma
A malignant skin tumour.

Dancing Dobermann disease
This is believed to be a neuromuscular disease of the gastrocnemius muscle; the underlying cause is not known. It has only been reported in Dobermann Pinschers. Affected dogs initially flex one pelvic limb while standing. As progression occurs to involve the other pelvic limb, the dog is seen to alternately flex and extend each pelvic limb in a dancing motion.

Deafness and vestibular disease
Hearing and balance are sensed in the ear and communicated to the brain via cranial nerve VIII. Lesions in any of these areas can lead to simultaneous deafness and balance disorders.

Deficiency of third component of complement
An immunodeficiency syndrome related to deficiencies in the complement system.

Degenerative encephalopathy
There are several neurodegenerative diseases reported in animals, including one affecting Nova Scotia Duck Tolling Retrievers which is associated with marked movements during sleep, anxiety and noise phobia, and gait abnormalities. It is seen from a young age and is progressive.

Degenerative lumbosacral stenosis
A disease of the lumbosacral space caused by conditions such as disc protrusion, instability of the vertebrae and foraminal stenosis. Causes signs of pain and lameness.

Degenerative myelopathy
A degenerative disease primarily seen in older dogs. Diffuse degeneration of the white matter of the thoracolumbar spinal cord results in progressive pelvic limb ataxia, paresis and loss of conscious proprioception. A DNA mutation that is a major risk factor for this condition has been identified.

Delivery by caesarean section
Some breeds have an increased frequency of delivery by the caesarean section. This may be due to dystocia, or may be elective.

Demodicosis
Generalized demodicosis is a severe skin disease caused by *Demodex* spp. mite. It can lead to pyoderma and deep folliculitis.

Dentigerous cyst
A cyst of the oral epithelium. May be incidental, or may be associated with gingival swelling, pain and anorexia.

Dermal arteritis of the nasal philtrum
Linear, well-circumscribed ulcers of nasal philtrum caused by arteritis. Mild arterial bleeding can result.

Dermatophyte pseudomycetoma
Subcutaneous fungal infections that cause nodules, ulcers and draining tracts.

Dermatophytosis (ringworm)
This fungal skin condition is particularly prevalent in long-haired cats.

Dermoid sinus
A dermoid sinus is a developmental defect arising from the incomplete separation of the skin and neural tube. It may be found midline in the cervical, cranial thoracic or sacrococcygeal regions. In cases where the sinus communicates with the dura mater, neurological signs may be seen. The condition is most commonly found in the Rhodesian Ridgeback, and it is believed to be hereditary in this breed.

Diabetes mellitus
Diabetes mellitus occurs where there is hyperglycaemia resulting from an absolute or relative lack of insulin. Where the blood glucose level exceeds the renal threshold, glycosuria results.

Diabetic ketoacidosis
A serious metabolic state caused by uncontrolled diabetes mellitus, in which ketones build up in the blood, and acidosis and usually hyperkalaemia are present. Older animals are predisposed.

Diffuse idiopathic skeletal hyperostosis (DISH)
Calcification and ossification of the ligaments. Can lead to spinal hyperaesthesia and stiffness, due to compression of the nerve roots.

Dilated cardiomyopathy (DCM)
This condition involves a dilatation of the heart causing larger chamber size, thinner heart walls and reduced strength of the heartbeat. It is thought that the majority of cases are genetic or familial, but it is not certain that all cases are genetic in origin. Nutritional abnormalities may also contribute, and it is possible that viral and immune-mediated causes may be involved in some cases.

Dirofilariasis (heartworm)
Infection by *Dirofilaria immitis* leading to a number of clinical signs, from asymptomatic infection to weight loss, dyspnoea and heart murmur. Some dogs develop pulmonary hypertension or pulmonary thromboembolism.

Discoid lupus erythematosus
Uncommon in dogs and very rare in cats. This condition is an immune-mediated dermatosis with no systemic involvement. Clinical signs include depigmentation, scaling, erosion and ulceration. The nose is primarily affected, but the pinnae, limbs and genitalia can be involved.

Discospondylitis
Infection of the intervertebral disc with osteomyelitis of adjoining vertebral bodies. Infection occurs secondarily to spinal surgery, foreign body migration or septic emboli from the skin or urinary/genital tract, or from a concurrent endocarditis. Clinical signs may include pyrexia, anorexia, spinal pain and paresis.

Disseminated aspergillosis
See *Aspergillosis*.

Disseminated histiocytoma
See *Histiocytic diseases*.

Distal limb fractures and dislocations
These fractures are common in racing Greyhounds, due to the stresses of racing.

Distal tibial valgus deformity
Angular limb deformity of the hindlimb.

Distichiasis
Abnormally positioned cilia (eyelashes) which emerge through or close to meibomian gland orifices. They are often of no clinical significance but in some cases may cause ocular irritation. Inheritance is suspected, given the high incidence in certain breeds, though the exact mode of transmission is unknown.

Dorsal ridge
The dorsal hair ridge is considered normal for Rhodesian Ridgebacks but can be associated with dermoid sinus.

Double muscling
Mutations in the gene for the myostatin protein augment muscle growth.

Dysmyelination of the central nervous system
A severe myelin deficiency of the central nervous system can lead to signs of tremors from a young age.

Dysplasia of the cerebellar cortex
An inherited malformation of the central nervous system characterized by hydrocephalus and an unusual dysplasia of the cerebellar cortex.

Dystocia
Dystocia can be defined as a difficulty or an inability in giving birth. It may result from a wide range of maternal or fetal factors. In dogs, brachycephalic breeds are predisposed because of a combination of a narrow maternal pelvis and a large fetal head and shoulders. Small nervous breeds may be predisposed owing to a tendency to psychological inhibition and primary uterine inertia. Purebred cats are at higher risk than mixed-breed cats, with dolicocephalic and brachycephalic types at greater risk than mesocephalic.

Eccentrocytosis
A red blood cell abnormality associated with oxidative stress. Eccentrocytes are red blood cells which when observed under a microscope look as if they have most of their haemoglobin on one side only. They have been associated with various conditions including onion/garlic ingestion and vitamin K antagonism.

Eclampsia (puerperal tetany)
Depletion of extracellular calcium resulting in hypocalcaemia. Signs include nervousness, panting, restlessness, tremors and finally seizures. It is most common within 6 weeks of parturition when demand for milk is great. It can affect any breed but is most common in small breeds.

Ectopic cilia
Cilia (eyelashes) which emerge directly through the palpebral conjunctiva to cause corneal irritation, ulceration and pain.

Ectopic ureter
A congenital anomaly involving one or both ureters. There is failure of the affected ureter to terminate in the trigone region of the bladder, opening instead into the urethra, vagina or uterus. Continuous or intermittent urinary incontinence may be seen as a result, usually in the juvenile bitch. Urinary incontinence is less commonly associated with ectopic ureters in the male because of the longer urethra and stronger urethral sphincter.

Ectropion
Eversion (rolling out) of all or part of the eyelid margin leading to exposure and subsequent irritation of the ocular tissues. In some cases ectropion is seen as part of *macroblepharon.*

Ehrlichiosis
Disease caused by the tick-borne parasite *Ehrlichia canis*. This can lead to ocular, haematological and central nervous system signs, such as uveitis, thrombocytopenia and seizures.

Elbow dysplasia
Genetics and rapid growth predispose to this disease complex, which includes an ununited anconeal process, medial coronoid process disease and osteochondritis dissecans of the medial humeral condyle. It may be that elbow dysplasia is caused by osteochondrosis, possibly relating to incongruities of the trochlear notch. In the UK and USA, there are screening schemes for elbow dysplasia in operation.

Electrocardiographic abnormalities
Abnormalities in the electrocardiogram include changes in the height and width of complexes, presence or absence of some of the components of the PQRST complex, and changes in the heart rhythm.

Enamel hypoplasia
Lack of tooth enamel.

Endocardial fibroelastosis
Severe thickening of the endocardium, sometimes involving the mitral valve leaflets. Heart murmur, failure to thrive and congestive heart failure are seen.

Endocrine alopecia
Loss of hair due to hormonal causes.

Entropion
An inward rolling of all or part of the eyelid margin resulting in irritation of the conjunctival and corneal surfaces. Entropion may occur alone, or as part of *macroblepharon*, where it may occur in the upper eyelid and/or lateral and medial to central ectropion in the lower eyelid. Where entropion occurs in the upper eyelid, trichiasis often results. In many cases, entropion arises as a result of conformation of the skull and orbit, and the amount of skin on the head. Most cases present in the first year; some severely affected cases present as early as 2–6 weeks of age. Some mild cases disappear as the dog matures.

Eosinophilia
Increased blood levels of the type of white blood cell known as an eosinophil.

Eosinophilic dermatitis and oedema
This rare condition presents as acute-onset erythematous macules which progress to form plaques. Variable oedema is seen.

Epidermal hyperkeratosis
A mild epidermolytic ichthyosis. Adult dogs with the disease show generalized, pigmented hyperkeratosis with epidermal fragility.

Epidermolysis bullosa acquisita
This is a group of inherited bullous diseases involving abnormal keratin production. Junctional epidermolysis bullosa causes bullae, vesicles and erosions in various locations. Dystrophic epidermolysis bullosa shows erosions in the mucocutaneous junctions. See also *Junctional epidermolysis bullosa*.

Epilepsy
Recurrent seizures caused by functional disorders of the brain. If no structural or metabolic cause can be found, the condition is termed idiopathic epilepsy, and this tends to have an age of onset in dogs of 6 months to 6 years. The high incidence in certain breeds of dog suggests an inherited basis.

Epiphora
Overflow of tears down the face.

Episodic falling (hypertonicity, collapsing Cavalier King Charles Spaniels)
This condition is poorly understood, but it is speculated that it is due to a disorder in GABA transmission. Extensor rigidity induced by exercise is seen, but mentation remains normal.

Erythema multiforme
An acute skin disorder resulting from a hypersensitivity reaction, causing erythematous macules, pustules and plaques.

Eversion of the cartilage of the nictitating membrane
Scrolling of the cartilage of the third eyelid which may result in chronic conjunctivitis. Seen most commonly in young large-breed dogs.

Exercise-induced collapse
Labradors are prone to a condition of collapse on exercise; extensive investigations have as yet failed to reveal a cause.

Exfoliative cutaneous lupus erythematosus (ECLE, lupoid dermatosis of the German Short-haired Pointer)
Hyperkeratosis and alopecia, mainly of the head, from 5–7 months of age.

Exocrine pancreatic insufficiency (EPI)
Lack of digestive enzymes that are produced by the pancreas, causing signs of diarrhoea and weight loss due to maldigestion.

Extraskeletal soft-tissue osteosarcomas
Most osteosarcomas affect the bone, but they sometimes arise from non-bony soft tissue.

Factor I deficiency
Deficiencies in factor I (fibrinogen) prolong the prothrombin time in tests and can cause bleeding disorders.

Factor II deficiency
Factor II deficiencies prolong prothrombin time and can cause bleeding disorders.

Factor VII deficiency
This condition leads to a mild clotting disorder. Prothrombin time (PT) is usually prolonged, but activated partial thromboplastin time (aPTT) is usually normal, as is consistent with a disorder of the extrinsic pathway.

Factor X deficiency
Factor X is part of the common pathway, so PT and aPTT are both prolonged. A specific factor X assay is used to confirm the diagnosis. The severity of bleeding is variable, and some affected dogs may survive into adulthood.

Factor XI deficiency
Factor XI is part of the intrinsic pathway of secondary haemostasis. Deficiency leads to prolongation of PT and aPTT. Affected animals can have prolonged bleeding after surgery or trauma but do not exhibit spontaneous haemorrhage.

Faecal incontinence (part of Manx syndrome)
See *Manx syndrome*.

Familial canine dermatomyositis
This is a hereditary disease causing skin lesions around the face, ear tips and digits.

Familial cutaneous lupus erythematosus (CLE)
An autoimmune skin disorder.

Familial renal disease (familial nephropathy)
Familial diseases include those that occur in related individuals with a greater frequency than chance alone would allow. Familial renal disease should be suspected whenever chronic renal failure occurs in an immature or young animal. If chronic renal failure develops before physical maturity, stunting will develop. Familial renal diseases vary in clinical signs and pathology depending on the breed.

- **Glomerular basement membrane disorder.** The main lesion in this condition is a thickening and splitting of the glomerular basement membrane, usually resulting in early-onset proteinuria and leading to renal failure.
- **Membranoproliferative glomerulonephritis.** Glomerulonephritis results from the presence of immune complexes in the glomerular capillary walls, leading to glomerular damage. In most cases, there is significant proteinuria leading to hypoalbuminaemia which, if severe, is manifest as peripheral oedema or ascites (nephrotic syndrome). The condition may progress to renal failure.
- **Periglomerular fibrosis.** Periglomerular fibrosis progresses to generalized interstitial fibrosis and results in renal failure.
- **Polycystic kidney disease**: see under separate heading.
- **Renal amyloidosis**: see under separate heading.
- **Renal cystadenocarcinoma**: see under separate heading.
- **Renal dysplasia**: see under separate heading.

Familial Shar Pei fever
A familial renal amyloidosis, which can also affect the liver. Females are predisposed, and the mean age of onset is 4 years. Signs include fever, joint swelling, vomiting, anorexia and jaundice.

Familial vasculopathy
This is a rare group of conditions which can cause dermatological and systemic signs. In some breeds the disease is inherited.

Familial vasculopathy of the nasal planum, nostrils and nasal mucosa
A presumably hereditary pyogranulomatous and vasculitic disorder of the nasal planum, nostrils and nasal mucosa. Clinical signs include bilateral nasal discharge or a bilateral ulcerative and

destructive process of the nasal planum, nostrils and nasal mucosa.

Fanconi syndrome
Fanconi syndrome results from generalized proximal renal tubular dysfunction resulting in abnormal reabsorption of many solutes, including glucose, amino acids and phosphate. Low blood levels of the solutes involved may result. Affected dogs are polyuric and polydipsic. The condition may progress to acute renal failure or pyelonephritis.

Feline asthma (feline bronchitis, allergic bronchitis)
This condition may be chronic or acute, and can present with mild or severe signs. Coughing and dyspnoea are seen.

Feline gastrointestinal eosinophilic sclerosing fibroplasia
A non-neoplastic gastrointestinal mass. The cause is unknown.

Feline hyperaesthesia syndrome
Cats with this condition show a combination of dermatological, neurological and behavioural signs including self-trauma, vocalization and apparent hallucinations. The cause is not known, but there can be a variety of trigger factors such as skin irritants and stress.

Feline idiopathic cystitis
Signs of cystitis with no obvious underlying cause. Cases present with dysuria, pollakiuria, haematuria and sometimes urethral obstruction. Predisposing factors are believed to include being male, neutered, overweight, using an indoor litter box, limited outside access, dry diet and living in a stressful relationship with one or more other cats.

Feline infectious peritonitis (FIP)
Caused by feline coronavirus. While many cats are seropositive for feline coronavirus, only 10% will go on to develop FIP. FIP can develop in two forms: 'dry' or non-effusive FIP where pyogranulomas develop in various organs throughout the body, and 'wet' or effusive FIP where ascites and pleural effusions develop.

Feline orofacial pain syndrome
In this condition, chewing motions and pawing at the face are seen. This can be episodic or continuous. Oral disease is often present.

Femoral artery occlusion
Femoral pulses are found to be weak or absent in these cases.

Fibroadnexal hamartoma
Non-inflammatory, non-neoplastic skin nodule.

Fibrocartilaginous embolic myelopathy (FCEM, fibrocartilaginous embolism (FCE), ischaemic myelopathy)
Fibrocartilage causes a focal obstruction of blood flow to the spinal cord. The exact mechanism is unknown, but signs often occur acutely at exercise, and lead to lateralized, usually non-painful signs of myelopathy such as paresis and paralysis. Large and giant breeds are more likely to be predisposed.

Fibroma/fibrosarcoma
A fibrosarcoma is a malignant tumour derived from fibrous tissues and may be found in many sites, including the bone, skin, spleen and oral cavity. Fibroma is the benign form. Tumour behaviour varies with the site and histological grade. In general, fibrosarcomas are locally invasive but have a relatively low rate of metastasis. Oral fibrosarcomas tend to be histologically low grade but biologically high grade with a tendency to aggressive local infiltration and a higher potential for local and distant metastasis. Cutaneous fibrosarcomas are more common in cats than in dogs. Tumours vary from slow-growing, well-circumscribed lesions which are more benign in behaviour to rapidly growing, poorly circumscribed lesions which may be more malignant.

Flank-sucking
A compulsive behaviour seen in some dogs, often just before they fall asleep. It may be associated with blanket-sucking and kneading of the paws.

Flat-chested kittens
A congenital thoracic wall defect.

Flea-bite hypersensitivity
Severe inflammatory reactions may occur due to hypersensitivity reactions to allergens in flea saliva.

Focal metatarsal fistulation (sterile idiopathic pedal panniculitis)
Causes sinus tracts in the metatarsi that can discharge a sterile exudate.

Folate – low serum level
Folate (vitamin B_9) levels in the blood may be low because of disease in the small intestine.

Follicular dysplasia
This is a group of conditions having alopecia and coat changes in common. They are suspected to be inherited in many breeds.

Folliculitis
Inflammation of the hair follicles.

Footpad hyperkeratosis
This condition is familial in some breeds. Signs of severe hyperkeratosis are usually seen by 6 months of age.

Frontonasal dysplasia (Burmese head defect)
This congenital defect is inherited and has been described as autosomal recessive or autosomal dominant with incomplete penetrance. Heterozygotes have a range of facial dimensions. The condition is fatal to homozygotes. It is seen in the eastern, 'new look' or contemporary strain of Burmese. The upper maxillary region is duplicated.

Gallbladder mucocoele
Distension of the gallbladder with mucus. The cause is unknown, but it can be associated with hypothyroidism and hyperadrenocorticism.

Gastric carcinoma
A primary, malignant stomach tumour derived from epithelial cells.

Gastric dilatation/volvulus (bloat, GDV)
Gastric distension due to the rapid accumulation of food, fluid or gas resulting in torsion of the stomach. Usually an acute and severe condition which is rapidly fatal without treatment. Large deep-chested dogs are predisposed. Mesenteric volvulus involves a twist of the small intestines, which is also acutely life-threatening.

Gastric neoplasia
Tumours of the stomach include adenocarcinoma, lymphoma, leiomyomas and leiomyosarcomas.

Gastrocnemius musculotendinopathy
A chronic strain injury which can lead to rupture of the gastrocnemius tendon.

Gastroduodenal perforation
Rupture of the upper gastrointestinal tract, secondary for example to ulceration, will cause life-threatening peritonitis.

Gastrointestinal changes seen with BOAS
There is a high prevalence of gastrointestinal disorders in dogs with brachycephalic obstructive airway syndrome (BOAS), diagnosed clinically, endoscopically and histologically. These changes improve following surgical management of the upper airway disease.

Gastrointestinal foreign bodies
Foreign bodies in the gastrointestinal tract can cause vomiting, and may cause obstruction, leading to dehydration, shock, rupture and peritonitis. See also *Oesophageal and gastric foreign bodies*.

Generalized sebaceous gland hyperplasia
Rare idiopathic disease causing greasy coat and hair clumping.

German Shepherd Dog pyoderma
This is an idiopathic deep pyoderma affecting German Shepherd Dogs. Probably an inherited immunodeficiency causes susceptibility to infection.

Gestation length
Gestation is generally shorter with larger litters, but breed seems to exert an independent effect.

Giant axonal neuropathy
A progressive peripheral neuropathy causing paresis, hyporeflexia and hypotonia and progressing to faecal incontinence and sensory deficits.

Giant platelets and thrombocytopenia
Some breeds have fewer but larger platelets, without a reduction in clotting function.

Giardiasis
Caused by *Giardia* spp. parasites that can cause signs of diarrhoea.

Gingival and oropharyngeal neoplasia
Cancer of the gums, oral cavity and throat.

Glaucoma
A group of diseases characterized by degeneration of the retinal ganglion cells and optic nerve resulting in progressive loss of vision. The condition is

associated with an increase in intraocular pressure. Primary glaucoma develops without the presence of other intraocular disease and may be hereditary, with potential for bilateral involvement. Primary glaucomas may be divided by the appearance of the iridocorneal filtration angle into *open-angle* and *closed-angle* glaucomas. Causes of secondary glaucomas include lens luxation, uveitis, neoplasia and cataracts.

Globoid cell leucodystrophy (Krabbe disease)
An enzyme deficiency that causes accumulation of galactocerebroside in oligodendrocytes and Schwann cells. Leads to paralysis hyper/dysmetria, tremors, blindness and death.

Gluten-sensitive enteropathy
An intolerance to gluten-containing foods, most commonly seen in Irish Setters. Weight loss and chronic diarrhoea due to malabsorption are seen.

Glycogen storage disease type III
Type III glycogen storage disease (Cori's disease) leads to poor growth, weakness and liver disease. This disease is rare and also has a poor prognosis.

Gracilis contracture (fibrotic myopathy)
This is usually seen in athletic dogs and leads to a gait alteration. This condition may be part of a complex with *fibrotic myopathy of semitendinosus muscle*. Surgery can help, but the condition can recur.

Granulomatous meningoencephalitis
See *Meningoencephalitis*.

Granulomatous sebaceous adenitis
See *Sebaceous adenitis*.

Granulosa-theca cell ovarian tumour
A type of sex cord stromal tumour of the ovary. This tumour is potentially malignant.

Grass awn migration
Grass awns are reported to comprise 61% of foreign bodies. Predilection sites include ears, eyes, interdigital web and nose.

Grey eosinophils
Eosinophils stain abnormally, which may lead to underestimating their numbers on automated counts.

Haemangioendothelioma
A group of vascular neoplasms.

Haemangioma
See *Cutaneous haemangioma*.

Haemangiosarcoma
This is a highly malignant tumour arising from vascular endothelial cells. Primary sites include the spleen (most common site in the dog), the right atrium of the heart, liver, skin, bone, nervous system, kidney, bladder and oral cavity. Metastasis to a wide variety of sites is common, and in many cases micrometastasis has occurred by the time of diagnosis.

Haematological differences
Some breeds differ in the normal range of their haematological parameters, possibly related to the purposes they have been bred for, such as racing Greyhounds.

Haemophilia A
This deficiency of factor VIII can cause moderate to severe bleeding. aPTT is prolonged, but PT is normal. Many cases may arise from new mutations. The condition is inherited as a sex-linked recessive.

Haemophilia B (factor IX deficiency, Christmas disease)
This clotting deficiency is caused by a deficiency in factor IX. This is a sex-linked condition, but because the gene for factor IX is smaller than for factor VIII, spontaneous mutations are less common for haemophilia B than for haemophilia A. aPTT is prolonged, but PT is normal.

Haemorrhagic gastroenteritis
An acute haemorrhagic vomiting and diarrhoea syndrome of unknown cause. Most commonly seen in middle-aged small-breed dogs.

Heart block
A slowing or failure of electrical conduction in the heart. First-degree heart block involves a prolongation of the PR interval, second-degree involves intermittent block of the conduction from sinoatrial node to ventricles, and third-degree involves a complete block. Can lead to signs of weakness, collapse and syncope, depending on severity.

Heart disease
Heart disease can be acquired, such as cardiomyopathies and valve degenerations, or congenital, such as stenosis or valve malformations.

Heart murmur
An abnormal heart sound. A murmur may be associated with heart disease or may be innocent.

Hemivertebrae (wedge-shaped vertebrae)
Among the most frequent vertebral malformations in dogs, hemivertebrae are congenitally malformed vertebrae most commonly seen at the level of thoracic vertebrae 7–9. Neurological signs, e.g., pelvic limb ataxia, paresis, faecal and urinary incontinence, may result from spinal cord compression.

Haemophagocytic syndrome
Proliferation of haemophagocytic histiocytes causes cytopenias. May be idiopathic or secondary to other disorders such as infectious diseases, immune-mediated disorders and neoplasia. Familial and acquired forms have been described in humans.

Hepatocerebellar degeneration
A syndrome causing progressive cerebellar and hepatic disease, leading to neurological signs from the age of 4–6 weeks.

Hereditary ataxia
Progressive ataxia results from degeneration of the white matter of the cervical and thoracic spinal cord in young Smooth-haired Fox Terriers and Jack Russell Terriers.

Hereditary lupoid dermatosis (exfoliative cutaneous lupus erythematosus)
This is a familial disease of unknown cause. Scaling begins on the head and progresses to become generalized. There may be systemic signs. No consistently successful treatment has been described.

Hereditary meningoencephalocoele
Herniation of the brain through the skull which is fatal. Is also associated with craniofacial abnormalities.

Hereditary myopathy of Sphynx and Devon Rex cats
A variably progressive myopathy causing signs of muscle weakness, megaoesophagus and fatigue.

Hereditary nasal parakeratosis in Labrador Retrievers
Hyperkeratosis and depigmentation of the nasal planum are seen in this condition. The dogs are otherwise healthy.

Hereditary necrotizing myelopathy
This disease causes hindlimb paresis in young dogs. It appears similar to Afghan myelopathy.

Hereditary polioencephalomyelopathy of the Australian Cattle dog
This is a degenerative condition primarily affecting the grey matter, causing focal malacia in the cerebellum, brainstem and spinal cord.

Hereditary retinal dystrophy of Briards (congenital stationary night blindness)
A retinal dystrophy causing congenital night blindness with a variable effect on day vision. The disease is slowly progressive, with no fundoscopic changes until 2–3 years of age. Nystagmus may be present. A defect in retinal polyunsaturated fatty acid metabolism may be involved.

Hereditary spectrin deficiency
Spectrin deficiency with increased red blood cell osmotic fragility is associated with hereditary spherocytosis and haemolytic anaemia in humans. Although spectrin deficiency was found to be common in a population of Golden Retrievers, it was unclear whether this was associated with haemolytic anaemia in these animals.

Hereditary thrombopathy (Glanzmann's thrombasthenia)
This condition affects platelets, leading to decreased platelet retention and absent platelet aggregation. This causes severe mucosal bleeding. Platelet count is usually normal or possibly slightly decreased. The buccal mucosal bleeding time is increased and clot retraction is abnormal. It is inherited as an autosomal recessive trait.

Hiatal hernia
Protrusion of part of the oesophagus and/or part of the stomach through the oesophageal hiatus into the thoracic space. Signs include vomiting, regurgitation and hypersalivation.

High allergen-specific serum immunoglobulin E levels

High levels of allergen-specific IgE are associated with atopy, but can be found in dogs of some breeds which do not have atopy.

Hip dysplasia

This very common condition occurs in a wide range of breeds, with large and giant breeds particularly affected. Various deformities in the hip lead to joint instability with the development of degenerative joint disease. Many affected dogs show no or minimal clinical signs. Genetics undoubtedly play a role, but environmental factors such as nutrition and exercise are also important. Various screening programmes are used around the world in an attempt to reduce the incidence of this condition. Estimates of heritability vary from 20% to 60%, depending on breed, population examined and methods applied.

Histiocytic diseases

Histiocytes are white cells that occur in the tissues and include macrophages and dendritic cells. There are several well-defined conditions, but the terminology of these diseases is somewhat confused.

- **Reactive histiocytoses** are considered non-neoplastic, but occur due to a degree of immune dysregulation. *Cutaneous histiocytosis* is confined to the skin and draining lymph nodes; *systemic histiocytosis* may involve other body sites.
- **Histiocytic sarcoma complex** is a malignant disease. *Histiocytic sarcomas* are localised lesions which may occur in many tissues including spleen, lymph nodes, skin, and brain tissue. Histiocytic sarcomas have also been termed 'localised histiocytosis'. *Disseminated histiocytoma* occurs when histiocytic sarcomas occur in multiple organs. This is also sometimes known as 'malignant histiocytosis' and is rapidly progressive and fatal.
- **Canine cutaneous histiocytoma** is a solitary lesion in a young dog which often regresses spontaneously: see under separate heading.

Histoplasmosis

The causal organism, *Histoplasma capsulatum*, is a saprophytic soil fungus. Histoplasmosis is uncommon and occurs mainly in the central USA, India and southeastern Asia. Clinical signs include fever, anorexia, weight loss, cough, dyspnoea and ocular and skin lesions; however, many infections are subclinical.

Horner's syndrome

Neurological disease characterized by miosis (constricted pupil), ptosis (drooping eyelid), enophthalmos (shrunken eye), and prolapsed nictitans. Causes in dogs include trauma and ocular disease, but 50% of cases are idiopathic (cause unknown).

Hydrocephalus

Hydrocephalus occurs where there is dilatation of all or part of the ventricular system of the brain, and may be congenital or acquired (usually secondary to neoplasia or inflammatory disease). Signs include a domed cranium, seizures and altered mental status.

Hyperadrenocorticism (Cushing's syndrome)

One of the most commonly diagnosed endocrinopathies in the dog, but rare in the cat. Hyperadrenocorticism occurs where there is a sustained and inappropriately elevated secretion of cortisol from the adrenal cortex. Hyperadrenocorticism may be pituitary-dependent, where there is excessive adrenocorticotrophic hormone (ACTH) secretion leading to adrenal cortical hyperplasia and increased cortisol secretion, or it may be adrenal-dependent, where there is a functional adrenocortical tumour.

Hypercholesterolaemia

High levels of serum cholesterol. Associated with atherosclerosis and coronary heart disease in humans. May be primary or secondary, e.g. to endocrine diseases, nephrotic syndrome or cholestasis.

Hyperhomocysteinaemia

This multifactorial condition has been reported in Greyhounds with suspected gastrointestinal disease.

Hypertrophic cardiomyopathy (HCM)

In this condition a hypertrophied ventricle causes congestive heart failure and dysrhythmias. The incidence is reported as being 1.6–5.2% in cats, but it is rare in dogs. It is likely that the condition is inherited, although modifying factors may cause variable expression of the condition.

Hypertrophic neuropathy
An inherited neuropathy reported in the Tibetan Mastiff which results in generalized weakness, hyporeflexia and dysphonia from 7–10 weeks of age. There is no treatment, and the prognosis is guarded.

Hyperuricosuria
Excessive excretion of uric acid in the urine. Predisposes to urate urolithiasis. See also *Urolithiasis*.

Hypoadrenocorticism (Addison's disease)
A condition in which there is inadequate adrenocortical hormone production, leading to a deficiency in mineralocorticoids and/or glucocorticoids. Primary hypoadrenocorticism (Addison's disease) results most commonly from immune-mediated destruction of the adrenal cortices leading to deficiencies of all adrenocortical hormones. A hereditary factor has been suggested in some breeds. It is very rare in the cat.

Hypocobalaminaemia
Low blood cobalamin (vitamin B_{12}) levels.

Hypodontia
Missing teeth due to a failure of the teeth to develop.

Hypokalaemic polymyopathy
Clinical signs of this condition include ventroflexion of the neck and transient weakness. There may also be a tremor. Serum potassium levels of less than 3 mmol/l are seen.

Hypomagnesaemia
Low levels of magnesium can occur for a wide number of reasons such as reduced intake, reduced gastrointestinal absorption (with gastrointestinal disease) and increased renal loss (e.g. renal disease, diabetes mellitus, hyperadrenocorticism). It can lead to a variety of signs including weakness, arrhythmia and seizures.

Hypomyelination syndrome
In this condition there is a reduction or absence of myelin in the axons of the central nervous system. The myelin is biochemically normal but present in reduced amounts, leading to nervous signs such as tremors, ataxia and hypermetria. The myelin deficiency may be permanent or simply delayed, and in some cases the clinical signs disappear with age.

Hypospadias
Hypospadias results from incomplete fusion of the urethral folds during the formation of the male urethra such that the urethra opens abnormally on the underside of the penis, proximal to the normal urethral opening. It may be seen with other congenital defects such as cryptorchidism and intersexuality. It has also been described in the female dog, where it is mostly seen in intersex states.

Hypothyroidism
A common endocrine disease in the dog. There is a deficiency in the secretion of thyroid hormone either as a result of thyroid gland destruction (primary hypothyroidism), inadequate pituitary production of thyroid-stimulating hormone (TSH) (secondary hypothyroidism) or inadequate hypothalamic secretion of thyrotropin-releasing hormone (TRH) (tertiary hypothyroidism). Many breeds seem predisposed to primary hypothyroidism, most notably Dobermann Pinschers and Golden Retrievers.

Ichthyosis (fish scale disease)
Extreme hyperkeratosis is seen, and affected dogs are abnormal at birth. Scaling, erythema and severe seborrhoea are seen.

Idiopathic epilepsy
See *Epilepsy*.

Idiopathic facial dermatitis in Persians and Himalayans
This is an uncommon disease demonstrating crusting, erythema and self-trauma to the head and neck. Secondary bacteria and yeasts are common.

Idiopathic head tremor syndrome
The head tremors seen in this condition are of unknown aetiology, but may be seizures or dyskinesia. Dogs remain fully conscious during the event, which last for a variable amount of time.

Idiopathic nasodigital hyperkeratosis
This rare keratinization disorder causes hyperkeratosis of the dorsal nasal planum.

Idiopathic polyneuropathy in Alaskan Malamutes
A progressive polyneuropathy of young adults causing neurological signs such as paraparesis and muscle atrophy.

Idiopathic sterile granuloma and pyogranuloma
Thought to be an immune-mediated disease, causing non-painful lesions, typically around the face and feet.

Idiopathic ulcerative dermatosis in Shetland Sheepdogs and Collies
This condition may be related to dermatomyositis. Vesicles and bullae progress to ulcers, especially in the inguinal and axillar regions and mucocutaneous junctions.

Immune-mediated haemolytic anaemia (IMHA)
Mild to severe anaemia, chronic or acute, can be seen with this condition. Haematology shows anaemia (with a regenerative response if the anaemia is not too acute) and spherocytosis. Although many cases respond well to treatment, the potential for serious complications means that the prognosis for this condition is guarded.

Immune-mediated inflammatory myopathy with severe tongue muscular atrophy
Thought to be a generalized myopathy which particularly targets the muscles of the head and tongue to cause atrophy.

Immune-mediated polyarthritis
Inflammation affecting multiple joints. This may be primary or secondary to other conditions.

Immune-mediated rheumatic disease (IMRD)
Chronic stiffness and joint pain characterize this disorder, which may be related to systemic lupus erythematosus.

Immune-mediated thrombocytopenia (IMTP)
This disorder is characterized by immune-mediated destruction of platelets. Epistaxis, haematochezia and mucosal haemorrhage are often seen.

Immunodeficiency syndrome
Several different breeds have primary immunodeficiencies, predisposing to a variety of infections. Respiratory conditions in related Irish Wolfhounds have been attributed to an underlying immunodeficiency, possibly in cell-mediated immunity or in IgA.

Immunoglobulin deficiency
See *Pneumocystis carinii infection*.

Immunoproliferative enteropathy (of Basenjis)
A specific disease of Basenjis of unknown cause. Several forms of pathology may be identified in the gastrointestinal tract including hypertrophic gastritis, lymphocytic plasmacytic enteritis and villous clubbing and fusion resulting in chronic diarrhoea, anorexia and weight loss.

Incomplete ossification of the humeral condyle (IOHC)
This condition may present with a history of mild intermittent lameness which is unresponsive to anti-inflammatory drugs. Acute severe lameness may follow exercise or mild trauma, corresponding with a humeral condylar fracture.

Increased C-reactive protein (CRP)
CRP is an acute-phase protein that is a marker for inflammation.

Increased osmotic fragility of erythrocytes (resulting in haemolytic anaemia)
Extreme fragility of the erythrocytes (red blood cells) can lead to recurrent and severe anaemia, with splenomegaly and weight loss. Prednisolone and blood transfusions may be helpful.

Inflammatory bowel disease
Immune-mediated intestinal disease. This may be a reaction to food allergens, but other mechanisms are possible. Causes signs of malabsorption such as diarrhoea, vomiting and weight loss.

Inflammatory myopathy
Generalized inflammation of the muscles may be due to immune-mediated polymyositis, infectious causes and preneoplastic syndromes. Focal inflammation may be due to diseases such as masticatory myositis and dermatomyositis.

Inherited focal retinal degeneration
This condition is distinct from generalized progressive retinal degeneration. Lesions can progress to blindness and cataract formation.

Inguinal/scrotal herniation
A weakness in the body wall in the inguinal region.

Inherited myopathy of Great Danes
Previously known as central core myopathy, this very rare condition leads to signs of muscle weakness, which becomes progressively more severe. The reported cases were euthanized before 2 years of age.

Inherited polyneuropathy
An idiopathic polyneuropathy of Leonbergers which is thought to have a sex-linked inheritance. Similar to Charcot–Marie–Tooth disease in humans.

Innocent systolic heart murmur
Abnormal heart noises may indicate cardiac disease, or may be incidental.

Insulinoma
Insulinomas are functional insulin-secreting tumours of the pancreatic beta cells. Insulin secretion is independent of the normal negative feedback control, resulting in hypoglycaemia. These tumours are generally slow growing but malignant with a high metastatic potential.

Intervertebral disc disease (IVDD)
Degeneration of the intervertebral discs, resulting in extrusion or protrusion of the nucleus pulposus, may result in spinal cord compression and pain/paresis. Nuclear extrusion occurs early in chondrodystrophoid breeds, e.g., Pekingese, Dachshunds, Beagles, Welsh Corgis, French Bulldogs, some Spaniels and Basset Hounds, giving rise to signs in younger dogs.

Intestinal adenocarcinoma
A malignant tumour found most frequently in the colon of dogs and the jejunum and ileum of cats. Most are locally invasive and metastasize early to the lymph nodes and liver.

Intestinal adenoma
A benign intestinal tumour.

Intracutaneous cornifying epithelioma (keratoacanthoma)
Benign cutaneous neoplasms which can be solitary or multiple (generalized).

Intussusception
A condition where one part of the intestines telescopes inside another, which can cause a partial or complete obstruction.

Iridociliary cysts
These cysts of the eye occur spontaneously in older dogs. They are often incidental findings.

Iris hypoplasia
Failure of the iris to develop properly.

Irish Setter hypochondroplasia
The limbs are slightly shortened in this condition. The ulna and radius may be bowed and carpal valgus is seen.

Ischaemic stroke
Blockage of a blood vessel, usually by a thrombus, causing damage to part of the brain.

Ivermectin and milbemycin
Toxicosis from the use of these parasiticides causes signs including drooling, vomiting and seizures.

Joint flexibility
Unique flexibility of the joints (especially the shoulder and neck) seen in the Norwegian Lundehund.

Junctional epidermolysis bullosa (JEB)
Separation of the dermis from the epidermis, leading to bullae and ulcers over prominences and claw dystrophy. See also *Epidermolysis bullosa acquisita*.

Juvenile-onset distal myopathy
This condition has been reported in several pups and has been described as a muscular dystrophy. Clinical signs include decreased activity and various postural abnormalities.

Juvenile renal disease
Chronic kidney disease can occur at a young age, causing a number of signs including polyuria, polydipsia, vomiting and weight loss.

Keratoconjunctivitis sicca (KCS, dry eye)
A common disease characterized by reduced aqueous tear production resulting in drying and inflammation of the conjunctiva and cornea. The condition may be congenital (rarely), or result from infectious, drug-induced, neurological or immune-mediated causes. A genetic influence is suggested by the high incidence in a number of breeds.

Kidney disease
A number of diseases can affect the kidneys, including inherited disorders such as dysplasia, neoplastic disorders, and idiopathic conditions. Signs include vomiting, weight loss and polyuria/polydipsia. See also *Chronic kidney disease* and *Familial renal disease*.

Kitten birth weight
The average weight of newborn kittens can vary by breed. Kitten birth weight tends to be lower with larger litters and shorter gestation, but breed seems to exert an independent effect

L-2-Hydroxyglutaric aciduria (organic aciduria)
This metabolic disorder causes neurological signs with onset from 6 months of age to 7 years. Typical changes are observed on MRI scans.

Lafora's disease
Progressive myoclonic epilepsy is seen in this condition. Diagnosis is by histopathological examination of affected tissue.

Laryngeal paralysis–polyneuropathy syndrome
Usually idiopathic but may be related to generalized myopathies or neuropathies. Stridor, aggravated by excitement and exercise, is the main clinical sign, although severe cases may progress to cyanosis and collapse.

Lateral luxation of the superficial digital flexor tendon
A tear in the retinaculum of the superficial digital flexor tendon can cause mild to moderate lameness with luxation of the tendon.

Left atrial rupture
This is a rare cause of pericardial effusion, and is usually secondary to mitral valve disease.

Left systolic apical murmur
Heart murmurs in this region are often related to mitral valve disease.

Leishmaniasis
A disease caused by the protozoa *Leishmania* spp. The visceral form causes systemic signs including lymphadenopathy, weight loss, epistaxis and melaenia. The cutaneous form causes ulcerative nodules. The sandfly is the vector of transmission.

Lens luxation
Displacement of the lens from its normal position. Lens luxation may be primary (not associated with other ocular conditions) and considered inherited, or secondary to trauma, cataract formation, glaucoma, neoplasia or uveitis. Lens luxation is a potentially serious condition and may result in raised intraocular pressure, glaucoma and loss of vision. Where both lens luxation and glaucoma occur, it is not always clear which condition is primary. Primary lens luxation (PLL) is an inherited disease in which the lens comes free from its attachments and moves anteriorly or posteriorly in the eye. It is usually bilateral, though both lenses do not usually luxate simultaneously. Terrier breeds are predisposed, and it is usually first diagnosed when dogs are 2–6 years old. The lens in the eye can also luxate secondary to conditions such as glaucoma, cataract and trauma.

Leptospirosis
A bacterial infection caused by *Leptospira* spp., of which there are many subtypes (serovars). Causes signs of renal and liver failure.

Lethal astrocytosis
A neurological disorder of Gordon Setters manifesting as early onset of gait and postural abnormalities. The condition is progressive, and affected puppies are recumbent at 5–6 weeks of age.

Leucopenia
Low white blood cell count.

Leucodystrophy
Several leucodystrophies have been reported in different breeds, generally presenting with signs of ataxia and paresis leading to paralysis.

Leucoencephalomyelopathy
This is believed to be an inherited condition. Degeneration of the myelin of the spinal cord, brainstem, cerebellum and sometimes optic tracts results in ataxia, tetraparesis and loss of conscious proprioception, with increased spinal reflexes and muscle tone. Vision is usually unaffected. The condition progresses over 6–12 months.

Limber tail
A sudden development of a flaccid tail. Thought to be caused by a strain of the tail muscles.

Lingual haemangiosarcoma
A malignant tumour of the tongue.

Lingual plasma cell tumour
A tumour of the tongue.

Lipaemia of the aqueous humour
A transient milky appearance in the eyes of young Burmese cats which may be related to abnormal lipid metabolism.

Lipoidystrophy (amaurotic idiocy)
Amaurotic idiocy is one of several lipoidystrophies involving the central nervous system.

Lipoma
A benign tumour of fat cells, generally found in the subcutaneous tissues. Lipomas are common, affecting up to 16% of dogs. Infiltrative lipomas are locally invasive, making surgical excision more difficult, but they do not metastasize.

Lissencephaly
A developmental anomaly where the cerebral cortex has reduced or absent gyri or sulci, resulting in a smooth appearance. Clinical signs are usually seen from a few months of age and may include behavioural abnormalities, lack of training, aggressive behaviour, visual deficits and seizures.

Localized parakeratotic hyperkeratosis
A scaling disorder which may be responsive to zinc supplementation.

Low fertility
Various medical and environmental conditions can contribute to poor fertility.

Low immunological response to vaccination
The immune response is a complex continuous trait with multiple genetic, environmental and lifestyle factors. Various factors including breed can affect the strength and duration of response to vaccination, emphasizing the need for widespread vaccination to provide protection by herd immunity. Larger breeds and dogs aged < 1 year are predisposed to lower titre responses.

Low Schirmer tear test (STT)
The Schirmer tear test measures tear production.

Low serum cobalamin and cTLI concentrations
Low levels of vitamin B_{12} and trypsin-like immunoreactivity, a marker for exocrine pancreatic function.

Low thiopurine methyltransferase (TPMT) activity in red blood cells
This enzyme is important in the metabolism of certain drugs such as azathioprine, and its activity is lower in some breeds than others.

Low thrombocyte count (physiological thrombocytopenia)
Low platelet levels.

Lower urinary tract neoplasia
Neoplasia of the lower urinary tract can cause signs of haematuria, pollakiuria, dysuria and urinary obstruction. Transitional cell carcinoma is one of the most common types of lower urinary tract neoplasia.

Lumbosacral disease
Stenosis (narrowing) of the lumbosacral vertebral canal and/or intervertebral foramina causes compression of the lumbosacral nerve roots. Clinical signs may include pain on palpation of the area, pelvic limb paresis or lameness, tail paralysis, hypotonia of the anal sphincter and bladder atonicity ('lumbosacral syndrome').

Lumbosacral transitional vertebrae
Abnormally formed vertebra occur congenitally between the last normal lumbar vertebra and the first normal sacral vertebra. This vertebral anomaly may predispose to cauda equina syndrome.

Lung lobe torsion
Rotation of a lung lobe along its long axis. This rare and life-threatening condition is more common in large, deep-chested breeds. Presenting signs include dyspnoea and pleural effusion. There may be an accompanying chylothorax.

Lyme nephritis
This condition is seen in 1–2% of cases that have recovered from borreliosis, and involves a protein-losing nephropathy.

Lymphangiectasia
Distension of the lymphatic vessels in the intestinal mucosa. It may be a primary congenital disease, or it may be secondary to other disorders including inflammatory bowel disorders, neoplasia, thoracic duct occlusion or right-sided heart failure. The condition results in *protein-losing enteropathy* leading to weight loss, diarrhoea and in some cases oedema and ascites.

Lymphoma
Lymphoma is a malignant lymphoproliferative disease also known as malignant lymphoma or lymphosarcoma. Lymphoma is the most common haematopoietic tumour in the dog and cat. Lymphoma may be classified anatomically by the location of the disease (multicentric, mediastinal, alimentary, cutaneous or extranodal), histologically, or immunophenotypically as B-cell or T-cell.

Lymphoproliferative disease
Excessive production of lymphocytes, usually due to neoplastic disease.

Lysosomal storage disease
Lysosomal storage diseases include ceroid lipofuscinosis, fucosidosis, glycogen storage disease type II (Pompe disease), glycogen storage disease type IV, GM_1 gangliosidosis, GM_2 gangliosidosis and α-mannosidosis.

These rare diseases result from a failure of normal metabolic processes due to a deficiency of an enzyme within the lysosomes of neuronal tissues. As a result, substrate accumulates, causing cellular dysfunction and eventually death. One of a variety of lysosomal enzymes may be affected. Signs usually occur before 1 year of age and may include ataxia, tremors, seizures, dementia and blindness. Most lysosomal storage diseases are believed to be inherited as an autosomal recessive trait.

Macroblepharon (diamond eye)
An abnormally large palpebral fissure. In some cases (e.g. brachycephalic breeds), this occurs as a result of exophthalmos (protrusion of the globe) leading to exposure keratopathy. In others it results from overlong eyelid margins and laxity of the canthal structures leading to both upper lid entropion and lower lid ectropion, resulting in 'diamond eye' in severe cases. The precorneal tear film is often disturbed, and corneal and conjunctival disease may occur secondarily.

Malassezia dermatitis
This yeast infection by *Malassezia pachydermatis* commonly causes pruritus and a greasy, scaly skin disease.

Malassezia skin colonization
Some breeds are prone to increased carriage of *Malassezia pachydermatis* despite being clinically healthy.

Male pseudohermaphroditism (persistent Müllerian duct syndrome)
A pseudohermaphrodite is an individual in whom the chromosomal and gonadal sex agree, but the phenotypic sex is reversed. Therefore, a male pseudohermaphrodite has both an X and a Y chromosome, testes (usually undescended) and female genitalia. Persistent Müllerian duct syndrome is an inherited form seen in Miniature Schnauzers.

Mammary neoplasia
This is common in both the dog and the cat. Mammary tumours are derived from the epithelial and sometimes myoepithelial tissues of the mammary glands. In dogs approximately 50% are benign, in cats over 80% are malignant. Entire animals or those spayed after several seasons are predisposed. Behaviour varies depending on the histological grade, but malignant mammary tumours may be very aggressive, metastasizing to the local lymph nodes, the lungs, and occasionally the abdominal organs and bone.

Manx syndrome
The Manx breed has a mutation resulting in shortening or absence of the tail. This mutation may also result in spina bifida, a developmental abnormality of the spine which may result in loss of control of urination and defecation

(urinary and faecal incontinence), and rectal prolapse. Some cases also have reduction in the control of the hindlegs (paresis).

Mast cell tumour (MCT)

Mast cell tumours are relatively common in dogs, representing up to 20% of skin tumours. Up to 40% of cases have mutations in a proto-oncogene, *c-kit*. MCTs may present in a wide variety of forms, and therefore they need to be included in the differential of all skin masses. Clinical behaviour varies from benign to highly aggressive malignant tumours which have the potential to metastasize (usually to the liver, spleen or kidney).

Cutaneous mast cell tumours are less common in the cat. 'Mastocytic' mast cell tumours are similar to the canine mast cell tumours and occur mostly as solitary nodules in older cats. A variant classified histologically as a 'histiocytic' mast cell tumour has been seen in young Siamese cats. These tumours are multicentric and regress spontaneously over a number of months. Systemic and intestinal forms of mast cell tumour may also be seen in this species.

Medial displacement of the biceps brachii tendon

A gradual onset in lameness which is exacerbated by exercise is seen with this unusual condition. Palpation and manipulation of the shoulder can reveal pain, crepitus and sometimes a palpable popping of the tendon out of the intertubercular groove.

Mediastinal lymphoma

See *Lymphoma*.

Megacolon and constipation (part of Manx syndrome)

Dilatation of the colon which results in constipation.

Megaoesophagus and pyloric dysfunction

Oesophageal dilatation and reduced motility resulting in regurgitation. Megaoesophagus can be classified as congenital idiopathic megaoesophagus, which presents shortly after weaning, or acquired megaoesophagus, which occurs later in life and may be idiopathic or secondary to another condition such as myasthenia gravis.

Melanoma

Cutaneous melanomas represent 4–6% of canine skin tumours and 1–2% of feline skin tumours. They present as firm, pigmented dermal masses and are more common in dark-skinned animals. Those found on the digits and close to mucocutaneous junctions tend to be more malignant and may metastasize to local lymph nodes, lungs and other more distant sites.

Oral melanomas are the most common oropharyngeal malignancy in the dog. They are highly metastatic: up to 20% may have metastatic disease at the time of diagnosis.

Melanomas are the most common primary tumour of the globe. They are most commonly found in the anterior uvea (canine anterior uveal melanoma – CAUM) but may be found in other areas, for example the limbus. In the dog they have low metastatic potential but expansion may lead to destruction of the eye. In the cat they may be malignant.

Meningioma

See *Primary brain tumour*.

Meningoencephalitis

Also known as meningoencephalitis of unknown origin (MUO) or meningoencephalitis of unknown aetiology. This is a group of inflammatory diseases including necrotizing encephalitis and granulomatous encephalitis of unknown cause. The disease may be focal or diffuse and may affect any part of the central nervous system, leading to a wide range of clinical signs, including seizures, ataxia, nystagmus and visual deficits. The disease is often chronic and progressive. Small-breed dogs are most commonly affected.

Metaphyseal osteopathy (hypertrophic osteodystrophy)

This uncommon idiopathic condition affects the metaphyses of the long bones of young rapidly growing large-breed dogs, causing pain, swelling, lameness and pyrexia. It affects dogs aged 2–6 months, and males may be predisposed.

Methylmalonic aciduria

This organic aciduria is a metabolic disease, often associated with cobalamin deficiency, which can lead to neurological signs.

Microvascular portal dysplasia
Congenital malformation of the intrahepatic portal circulation resulting in vascular shunting and hepatic dysfunction. Cases are often subclinical; signs, where they occur, are similar to those of portosystemic shunts but occur later and are generally milder.

Middle ear polyps
Fleshy lumps originating from the tympanic epithelium. The cause is unknown but chronic inflammation may be a factor.

Mitochondrial encephalopathy
Inbuilt errors of mitochondrial metabolism can lead to neurological disorders.

Mitochondrial myopathy
A defect in mitochondrial function leads to decreased exercise tolerance with tachycardia and tachypnoea resulting from severe acidosis. This condition can occasionally cause sudden death.

Mitral stenosis
Narrowing of the mitral valve opening restricts blood flow from the atrium to the ventricle. This condition is usually congenital. Left atrial enlargement and congestive heart failure are common sequelae. There may be other concurrent congenital cardiac disorders present.

Mitral valve disease
Also known as chronic degenerative valvular disease, endocardiosis. This is the most common cause of heart disease in the dog, with up to 75% of dogs with congestive heart failure suffering from this condition. The heart valves become deformed by a myxomatous degeneration leading to regurgitation and congestive heart failure. This condition is likely to be inherited, although other proposed causes include stress, hypertension, hypoxia, infection and endocrine abnormalities. Males, older dogs and smaller breeds are predisposed.

Mitral valve dysplasia
This is the commonest congenital heart disease of cats but uncommon in dogs (in which it represents 8–10% of all congenital heart disease). It is thought to be inherited in some breeds of dog. The lesion consists of a malformation of the mitral valve, the normal function of which is to prevent blood flowing back from the left ventricle to the left atrium. Many animals with this condition do not show signs, and those that do usually demonstrate exercise intolerance and congestive heart failure.

Mucocutaneous pyoderma
A dermatological condition causing crusting of the mucocutaneous junctions.

Mucopolysaccharidosis (including types IIIA, IIIB, IV and VI)
This group of conditions results from inherited chromosomal abnormalities and leads to a metabolic bone disease. There are a number of subcategories. Type I disease causes a large broad head which may be associated with ocular and cardiac abnormalities. Pectus excavatum, fusion of the cervical vertebrae and hip subluxations also occur. Type III, divided into subtypes A and B, causes neurological signs. Type IV disease causes gross physical abnormalities of the skeleton, including a severe general laxity and luxation of the joints. Type VI disease causes dwarfism and skeletal, neurological and retinal abnormalities. There is no treatment, although some affected animals may have an acceptable quality of life.

Multifocal chorioretinitis (Borzoi chorioretinopathy)
A clinically inapparent, non-progressive chorioretinitis described in the Borzoi. Lesions may be uni- or bilateral and consist of focal retinal oedema which becomes pigmented and hyperreflective later.

Multifocal retinopathy
Multifocal grey lesions develop initially in the outer retina, followed by the development of areas of serous retinal detachment more centrally. No significant progression with time and no loss of vision.

Multiple autoimmune diseases syndrome
A disorder similar to autoimmune polyendocrine syndrome has been reported in Italian Greyhounds.

Multiple collagenous naevi (nodular dermatofibrosis)
Cutaneous hamartomas, non-neoplastic lumps formed by normal parts of an organ that are arranged erroneously.

Multiple drug sensitivity
A mutation of the gene *MDR1* (*ABCB1*) affects the P-glycoprotein drug transport pump. Dogs with this mutation can be prone to drug toxicity including antiparasitic and chemotherapy drugs.

Multiple ocular defects
Several congenital defects present in the same eye.

Multisystem neuronal degeneration
A slowly progressive degenerative disease. Diffuse neuronal loss throughout the subcortical, brainstem and cerebellar nuclei results in signs, including loss of recognition of the owner, apathy, hyperactivity, hypersexuality and aggression.

Mural folliculitis and parakeratosis
Seen in Labrador Retrievers, this is a skin condition in which cracks and fissures develop in the nasal planum.

Muscle cramping ('Scottie cramp')
An inherited disorder of Scottish Terriers. Affected dogs are normal at rest, but exercise may provoke muscle spasms which in the mildest form of the disease appear as pelvic limb stiffness. Severe attacks cause rigidity of all muscles, including facial muscles, causing the dog to fall over into a tightly curled ball. Consciousness is maintained and the animal makes a spontaneous recovery. The cause is unknown but it is believed to be a disorder of central nervous system neurotransmitters. A similar condition has been reported in Dalmatians and Norwich Terriers.

Muscular dystrophy – X-linked
A sex-linked muscular dystrophy of Golden Retriever found in the USA has been found to be similar to Duchenne muscular dystrophy of humans. Clinical signs include exercise intolerance, gait abnormalities, trismus and occasionally cardiac involvement. Creatinine kinase (CK) is massively elevated on biochemistry.

Muscular dystrophy of pharyngeal and oesophageal muscles causing dysphagia
Atrophy of oesophageal and pharyngeal muscles resulting in difficulty swallowing.

Muscular stiffness of Labrador Retrievers
A movement disorder of young Labradors causing extreme muscle stiffness. An X-linked hereditary disease was suspected.

Mycobacterial infections
Mycobacteria, including *M. tuberculus* and *M. avium*, are aerobic, acid-fast bacteria, with each species having a variation in host affinity and disease potential. The bacterium causes progressive systemic signs, with granulomatous masses affecting organs such as lymph nodes, lungs and liver.

Mycobacterium avium complex infection
Mycobacterium avium complex has a worldwide distribution in soil and water, but disease is rare. The organisms cause extensive granuloma formation, and the site of formation determines the signs. The bowel, spleen, liver and mesenteric lymph nodes are usually involved in dogs, while regional lymph nodes, skin and gastrointestinal tract are commonly involved in cats.

Myocardial infarction (MI)
A clot affecting the blood supply to the heart causing cardiac damage.

Myokymia and neuromyotonia
Myokymia involves a worm-like writhing of muscles, while neuromyotonia involves spontaneous muscle activity from hyperexcitable peripheral nerves.

Myopathy
Muscle disease characterized by muscle weakness and atrophy (wasting). Usually progressive in nature.

Myopia (short-sightedness)
Loss of ability to focus eyesight on long distance. Vision is blurred because images are focused in front of the retina.

Myositis
Inflammatory muscle disease can be generalized, such as immune-mediated polymyositis, or localized, such as with masticatory myositis. Affected muscles may swell in the early stages and atrophy in later stages, and signs include pain and joint stiffness.

Myotonia
Clinical signs of this condition include excess muscle mass, stiff gait after rest and collapse. Dyspnoea may be seen if the respiratory muscles are involved.

Narcolepsy–cataplexy
Narcolepsy is characterized by excessive sleepiness at inappropriate times, while cataplexy is acute flaccid paralysis from which the animal makes a complete recovery after a few seconds to several minutes. In dogs, cataplexy seems to be the more common, often associated with excitement, e.g., eating or playing.

Nasal cavity tumours
The most common nasal cavity tumours diagnosed in the dog are carcinomas (in particular adenocarcinomas). Other types include sarcomas (fibrosarcoma, chondrosarcoma or osteosarcoma), lymphoma and melanoma. Most are malignant, causing local invasion and progressive destruction, but are slow to metastasize. Doliocephalic dogs, particularly of large and medium size, are reported to be at increased risk; disease in these breeds may be associated with pollutants, e.g., passive smoking or living in urban environments. In the cat, lymphoma is the most common nasal cavity tumour, followed by adenocarcinoma and squamous cell carcinoma.

Nasopharyngeal turbinates
The presence of nasal turbinates protruding caudally from the choanae into the nasopharynx of dogs and cats. May be a component contributor to brachycephalic obstructive airway syndrome.

Necrotizing meningoencephalitis
Usually fatal, mean survival of 3 months. See also *Meningoencephalitis*.

Neonatal cerebellar ataxia
Causes neurological signs such as ataxia and tremor from the age of 2 weeks.

Neonatal encephalopathy with seizures (NEWS)
Puppies affected with this condition are small and weak and often die in the first week of life. Those surviving longer show tremors, ataxia and seizures. None have been reported to survive past 7 weeks of age.

Neuroaxonal dystrophy
A degenerative central nervous system disorder of unknown cause, seen primarily in Rottweilers. Pathological findings include swellings of the distal axons within the central nervous system and cerebellar atrophy. Signs include ataxia, hypermetria and intention tremors which may be slowly progressive over several years.

Neuronal ceroid lipofuscinosis
This lysosomal storage disease causes signs including reduction in vision, ataxia, tremors, seizures and death. Clinical signs may not appear until adulthood.

Nodular granulomatous episclerokeratitis (proliferative keratoconjunctivitis)
Single or multiple, raised fleshy masses originating at the limbus and invading the cornea. Involvement of the nictitating membrane may occur. Usually a bilateral condition. The lesions are inflammatory and respond to prednisolone and azathioprine.

Noise sensitivity
Some breeds are more prone to hypersensitivity to loud noises.

Non-accidental injury (NAI, battered pet)
This refers to deliberate injury and/or abuse, which may be inflicted by a caregiver, someone else in the household, or someone outside the household.

Non-spherocytic haemolytic anaemia
This condition is due to a defect in the calcium pump system. Chronic haemolysis may lead to myelofibrosis.

Norwegian Elkhound chondrodysplasia
Dwarfism occurring as a result of a disturbance of endochondral ossification.

NT-ProBNP measurement
This peptide is increased with ventricular stretch and is a marker for heart disease.

Ocular melanosis (abnormal pigment deposition)
Large numbers of melanocytes infiltrate the iridocorneal angle, episclera, choroid and iris, predisposing to glaucoma (melanocytic glaucoma).

Oculocutaneous albinism
Albinism of the eyes and skin. May be associated with other ocular abnormalities.

Oculoskeletal dysplasia
This condition is inherited as an autosomal recessive, and causes clinical signs of shortened

limbs and deviated joints, associated with ocular signs such as cataracts and retinal detachment.

Oesophageal and gastric foreign bodies
Some breeds are predisposed to obstruction of the oesophagus or stomach caused by ingestion of foreign bodies, such as toys, household items or bones, leading to signs of vomiting and regurgitation, and possibly resulting in rupture and mediastinitis or peritonitis. See also *Gastrointestinal foreign bodies*.

Olecranon fracture
A fracture of the proximal part of the ulna.

Optic nerve hypoplasia
A congenitally small optic disc with reduced numbers of optic nerve axons and visual impairment.

Oral epulis
A swelling on the gingival (gum) margin, which may be neoplastic. Classified into four types: fibromatous, ossifying, acanthomatous and giant cell.

Oral fibrosarcoma
A malignant tumour of the mouth.

Oral neoplasia
A number of cancers can affect the mouth, including squamous cell carcinoma, melanoma and lymphoma.

Oropharyngeal neoplasia
The most common canine oropharyngeal tumours are squamous cell carcinomas, malignant melanomas, epulides and fibrosarcomas. The most common feline oropharyngeal tumours are squamous cell carcinomas and fibrosarcomas. See also *Melanoma*.

Oropharyngeal penetrating injury
Penetrations of the oropharynx can occur because of foreign body ingestion or 'stick injuries' involving penetration caused by a thrown or retrieved stick. These can lead to severe and difficult-to-treat infections.

Osteochondrodysplasia
A disorder of development of the bone and cartilage.

Osteochondrosis
Including osteochondrosis of the elbow, hock, sacrum, shoulder and stifle. Osteochondrosis is characterized by abnormal development of the cartilage in the physeal and epiphyseal sites. Common regions for osteochondrosis are the caudal humeral head, the medial condyle of the humerus, the medial coronoid process of the ulna, the anconeal process of the elbow, the lateral and medial condyles of the stifle and the medial ridge of the talus. Lumbosacral osteochondrosis causes signs of cauda equina syndrome.

Osteogenesis imperfecta
This group of inherited diseases causes osteopenia and increased bone fragility. The underlying defect is probably in collagen formation. The condition is rare, and the exact mode of inheritance is unknown. Cases may present with a history of multiple fractures following little or no trauma.

Osteosarcoma
Osteosarcoma is the most common of the malignant primary bone tumours in the dog, representing 80–90% of bone tumours in large dogs. It is rapid in growth and highly invasive and destructive. Osteosarcoma of the appendicular skeleton of dogs is highly malignant and metastasizes early (commonly to the lungs). In common with other primary bone tumours, appendicular osteosarcoma is more common in large- and giant-breed dogs. They generally occur in older dogs, but those affecting giant breeds may be seen at an earlier age. Osteosarcoma of the axial skeleton (including the skull) is generally considered less malignant. Osteosarcoma in the cat is also less aggressive.

Otitis externa
Inflammation/infection of the external ear canal, causing signs of pain, discharge and irritation. Causes include underlying skin disease and foreign bodies.

Otitis media
Inflammation/infection of the middle ear, which can lead to vestibular signs and pain. May occur due to haematogenous spread of bacteria or local extension from otitis externa.

Overweight/obesity
Some breeds are prone to developing an increased body condition, often related to an abnormally large appetite. Overall, 20–50% of dogs are obese, but classifying obesity is subjective. A genetic basis for obesity has been described.

Pain perception and fear memory resilience
An ability to overcome pain to maintain sufficient focus and continue to work is a strong asset for a working dog. Dogs that are resilient have an enhanced chance of working success especially in challenging environments such the Australian outback.

Palate agenesis, anotia and polydactyly
A familial condition in which the external ear and palate fail to form, associated with extra toes.

Palpebral neoplasia
Cancer of the eyelids.

Pancreatitis
Inflammation of the pancreas which may be acute or chronic and results in lethargy, abdominal pain and vomiting. The inciting causes are often unknown, but it can be associated with hyperlipoproteinaemia, certain drugs, trauma or pancreatic ischaemia, and it may follow a high-fat meal.

Panosteitis (enostosis, eosinophilic panosteitis)
This condition is fairly common, affecting young dogs aged 6–18 months. Acute intermittent lameness affecting one or more limbs is seen, often associated with pyrexia. A viral aetiology is suspected. The condition is usually self-limiting.

Paroxysmal dyskinesia
Intermittent movement disorders characterized by disturbed movement, with the animal being normal between episodes.

Parvovirus enteritis
An infectious viral disease which most commonly causes a severe gastroenteritis; however, it may also manifest as acute myocarditis or neonatal mortality.

Patellar luxation
Usually presents as an intermittent lameness, although in bilateral cases it may present as a hindlimb gait abnormality. It is usually seen from 6 months of age, although in some cases it may not cause clinical signs until the animal is older.

Patent ductus arteriosus
The ductus arteriosus carries blood from the pulmonary artery to the aorta in the fetus to bypass the lung, which is not in use in utero. The ductus arteriosus normally closes within the first week after birth. Failure of the vessel to close leads to a patent ductus arteriosus. Females are at a higher risk of developing the condition than males. Signs range from none, to congestive heart failure and poor body condition, to weakness, collapse and seizures. Congenital heart disease is uncommon in dogs, but patent ductus arteriosus is one of the more common types (third most common in one study, representing 20.9% of diagnosed cases). Previous studies have suggested that patent ductus arteriosus is the most common form of congenital heart disease.

Pattern baldness (follicular dysplasia, bald thigh syndrome)
A disease causing baldness of the lateral and caudal thighs. An endocrinopathy may underlie this condition.

Pectinate ligament dysplasia (PLD)
Abnormal development of the iridocorneal filtration angle which may predispose to closed-angle glaucoma later in life.

Pectus excavatum (funnel chest)
Ventral thoracic wall deformity.

Pelger–Huet anomaly
This anomaly involves a decreased segmentation of granulocyte nuclei. There does not seem to be an increased predisposition to infection in these cases.

Pemphigus foliaceus
This is probably the most common autoimmune skin condition of dogs and cats. Clinical signs of crusting and pustules usually start on the face and ears and progress to become multifocal or generalized. Secondary bacterial infection is common.

Perianal (hepatoid) gland adenomas
These are benign tumours that arise from the modified sebaceous glands of the perianal area. They appear as well-circumscribed raised lesions which may ulcerate.

Perianal adenocarcinomas
These are malignant and difficult to distinguish from their benign counterparts in gross appearance. They are less common than perianal gland adenomas.

Pericardial effusion
This condition involves a build-up of fluid between the heart wall and the pericardium. It can be caused by tumours of the heart, but often has no known single cause ('benign' or 'idiopathic' pericardial effusion). The idiopathic form is poorly understood, and it is not known whether it is inherited. However, it does tend to affect large- and giant-breed dogs. Signs are precipitated by the inability of the heart to fill properly because of restriction caused by the fluid-filled pericardial sac. Chronic cases exhibit weight loss, ascites and dyspnoea resulting from pleural effusion. Acute cases may show rapidly progressing weakness, collapse and death.

Perineal herniation
This relatively common condition presents as a swelling in the perineal region or as a defect palpable per rectum. Urinary bladder retroflexion with associated metabolic complications is seen in 20% of affected dogs.

Perinuclear antineutrophilic cytoplasmic autoantibodies (pANCA)
These autoantibodies are primarily associated with intestinal inflammation. Levels are often high in healthy Soft-Coated Wheaten Terriers, especially if they are related to individuals with protein-losing nephropathy or enteropathy.

Periodontal disease
Disease of the gingiva and periodontal tissue which can lead to infection and tooth loss.

Peritoneopericardial diaphragmatic hernia (PPDH)
This uncommon congenital disease is seen in only about 0.5% of cases of congenital heart disease. It involves a continuation of the pericardium with the peritoneum, and often abdominal viscera are found within the pericardial sac. It may be asymptomatic, or may cause signs of respiratory distress, vomiting and colic.

Persistent hyaloid remnants
Remains of the hyaloid artery may persist into adulthood. This may not cause clinical problems, but can lead to cataract formation.

Persistent hyperplastic primary vitreous (PHPV)
A congenital condition in which there is abnormal development and regression of the hyaloid system and primary vitreous. It is often associated with persistent hyperplastic tunica vasculosa lentis (PHTVL), in which there is persistence of an embryonic vascular system attached to the posterior lens capsule. The condition is rare, but is seen more frequently in Dobermanns and Staffordshire Bull Terriers. The condition varies in severity. In its most severe form, it is associated with microphthalmia and other ocular defects.

Persistent hyperplastic tunica vasculosa lentis
A congenital ocular disease.

Persistent pupillary membranes (PPM, membrana pupillaris persistens)
Persistent pupillary membranes are uveal remnants which fail to regress normally in the first 6 weeks of life and persist in the anterior chamber (either unilaterally or bilaterally). Strands which bridge from iris to iris are generally of no clinical significance; however, iris-to-cornea or iris-to-lens strands may cause focal corneal and lenticular opacities, respectively. PPMs are a common finding, but severe visual impairment is rare.

Pes varus
This limb deformity is seen at 5–6 months of age, and may be related to an underlying tibial dysplasia.

Phosphofructokinase deficiency
Haemolytic crises and exertional myopathy are seen with this relatively common enzyme deficiency. Exercise intolerance is often seen.

Photoreceptor dysplasia
One of the diseases that make up progressive retinal atrophy.

Pigmentary uveitis
Inflammation of the iris and ciliary body associated with abnormal pigment deposition. Seen most commonly in the Golden Retriever and often seen in conjunction with iris cysts. Cataract and glaucoma are common sequelae.

Pilomatrixoma
An uncommon benign tumour of the hair follicle. Pilomatrixoma presents as a solitary, firm mass in the dermis or subcutis, with ulceration of the overlying epidermis. They usually occur over the neck, back and tail of dogs. They are rare in cats.

Pituitary dwarfism (hyposomatotropism)
Pituitary dwarfism results from a failure of growth hormone secretion in an immature animal. The most striking abnormality is a failure to grow, animals remaining of small stature. There may be a wide range of other clinical signs such as hair and coat changes and changes in dentition, or concurrent failure of other pituitary hormones (panhypopituitarism). The condition is most commonly seen in the German Shepherd Dog but has been identified in several other breeds.

Plasma cell infiltration of the nictitating membrane (plasmoma)
Bilateral plasma cell infiltration of the nictitating membrane resulting in follicle formation and depigmentation. Often associated with chronic superficial keratitis (pannus).

Platelet disorder
Abnormality of platelet function which is associated with blood clotting.

Pneumocystis carinii infection
A predisposition to respiratory disease caused by *Pneumocystis carinii* is suspected to be promoted by an underlying immunodeficiency, but the exact nature of this, and inheritance of the condition, is not known. However, IgG levels are lower in affected dogs than in control animals.

Polyarthritis
Canine idiopathic polyarthritis is the most common form of immune-mediated arthropathy. Approximately 25% of cases are associated with chronic infection remote from the joint, 15% are associated with gastrointestinal disease, and another subset is associated with neoplasia remote from the joints. In the other cases, which account for about 50%, there is no other pathology or underlying aetiology detected.

Polycystic kidney disease (PKD)
In this disorder, large portions of the renal parenchyma are replaced by multiple cysts. Both kidneys are generally involved and in some cases cysts are also found in the liver. Kidneys may be palpably enlarged and irregular, and the diagnosis can be confirmed by ultrasound. The condition progresses to renal failure at a variable rate. Renal cysts may also be seen in cases of renal dysplasia or neoplasia.

Polycystic liver disease
Fluid-filled cysts in the liver parenchyma. Liver function may or may not be affected. Often seen in conjunction with polycystic kidney disease.

Polydactyly
Several breeds show a tendency to have more than the typical number of digits (polydactyly) or fused digits (syndactyly). These abnormalities do not generally cause severe clinical problems. In some breeds, an extra digit or claw is considered 'normal'.

Polymyopathy
Generalized muscle disease.

Polyneuropathy
Polyneuropathies can cause signs of weakness, ataxia and sensory deficits.

Polyneuropathy with ocular abnormalities and neuronal vacuolation (POANV)
A juvenile-onset polyneuropathy which is also associated with microphthalmia and cataracts.

Polyodontia
Additional teeth, which may be seen in temporary or permanent dentition. Incisors and premolars are most commonly affected.

Portal vein hypoplasia
Previously known as hepatic microvascular dysplasia. Describes a microscopic histopathological vascular anomaly of dogs and cats that is often present in conjunction with a macroscopic portosystemic shunt (PSS). Clinical signs that may be seen with portal vein hypoplasia are

suggestive of a PSS, although some dogs may be asymptomatic. Signs include hepatoencephalopathy, vomiting, diarrhoea, urinary tract signs associated with ammonium biurate urolithiasis, stunted growth, and prolonged recovery from anaesthesia.

Postoperative bleeding

It has been noted that retired Greyhounds bleed postoperatively more frequently than expected, and a clotting disorder is suspected. However, a disorder of primary or secondary haemostasis has not been identified.

Primary brain tumour

Primary brain tumours are derived from tissues of the nervous system, including nerve cells, glial cells, meninges and neuroepithelial cells. They are generally solitary, and most cases will present with signs of a space-occupying lesion in the brain, the specific signs varying with the location. Meningiomas and gliomas are the most common primary brain tumours in dogs. Meningiomas are the most common primary brain tumours in the cat and may be single or multiple in this species. Meningiomas are generally histologically benign, but can be locally invasive, especially in dogs. Choroid plexus neoplasms are tumours derived from the choroid plexus (the plexus of cells producing cerebrospinal fluid in the brain).

Primary ciliary dyskinesia

In this condition, the mechanism for removing mucus from the airways is defective, leading to respiratory infections. Other conditions associated with defective ciliary function include loss of hearing and loss of sperm motility, with consequent infertility.

Primary hepatitis

Primary hepatitis covers the most frequently occurring group of liver diseases in dogs. It comprises all inflammatory hepatic diseases that are not characterized by the non-specific changes that are described as non-specific reactive hepatitis. The diagnosis of hepatitis in dogs is mainly based on histologic morphology. Primary hepatitis spans a wide range of aetiologies including disease caused by microorganisms, toxins and drugs, immune-mediated reactions and breed-associated metabolic errors.

Primary hyperlipidaemia (primary hypertriglyceridaemia, idiopathic hypertriglyceridaemia)

This familial condition can cause multisystemic signs such as abdominal pain, seizures and pancreatitis.

Primary hyperoxaluria

An autosomal recessive disorder of glyoxylate metabolism which predisposes to oxalate urolithiasis.

Primary hyperparathyroidism

Primary hyperparathyroidism is usually the result of a functional parathyroid adenoma. The excess of parathyroid hormone results in hypercalcaemia. The Keeshond seems particularly susceptible to the condition.

Primary hypoparathyroidism

This is an uncommon condition in which lymphocytic plasmacytic destruction of the parathyroid glands results in a deficiency of parathyroid hormone and hypocalcaemia.

Primary lens luxation (PLL)

See *Lens luxation*.

Primary orthostatic tremor

This disease is characterized by a severe tremor present when standing, i.e. abolished by walking or sitting.

Primary seborrhoea

This is an inherited disorder of keratinization and cornification which has an early age of onset. Clinical signs include flaking, scaling, crusting and greasy, smelly skin. The claws may also be affected. Secondary bacterial and fungal infections are common.

Primary secretory otitis media

Cavalier King Charles Spaniels are prone to getting a build-up of secretions in the middle ear, which can lead to signs of middle ear disease.

Primary splenic torsion

Twisting of the spleen. Can be acute, with signs including collapse and shock, or may be vague and intermittent in the chronic form.

Progressive axonopathy

An inherited neuropathy causing progressive pelvic limb ataxia from 2–3 months of age.

Progressive degenerative polyneuropathy
A progressive degenerative polyneuropathy with a distal axonal distribution.

Progressive retinal atrophy (PRA)
Degeneration of the retinal cells. An autosomal recessive inheritance is suspected in most breeds. Different breeds are affected at different ages by different types of PRA. However, all cases are bilateral and progress to blindness. In most cases, the earliest clinical sign is night blindness, with day vision being lost at a variable time later. Ophthalmoscopically there is attenuation of retinal vessels and tapetal hyper-reflectivity. In the later stages, the condition is often accompanied by cataracts.

Progressive rod–cone degeneration (PRCD)
Progressive rod–cone degeneration is an autosomal recessive photoreceptor degeneration of late onset in dogs. It results in complete blindness in almost every case, and is one of several inherited diseases designated as progressive retinal atrophy (PRA). The disease is homologous to human retinitis pigmentosa (RP).

Prolapse of the gland of the nictitating membrane ('cherry eye')
Prolapse of the tear gland normally located behind the nictitating membrane results in exposure and irritation of the gland. It is usually first seen in young dogs, less than 2 years of age.

Prolonged activated partial thromboplastin time (aPTT)
aPTT is a test to assess the clotting ability of the blood, and prolonged test results are associated with reduced ability to clot.

Pronounced eosinophilic response
Immune-mediated, allergic, parasitic and neoplastic diseases can cause an increase in eosinophils.

Proptosis
Expulsion of the globe from the orbit with entrapment of the eyelids behind the eyeball.

Prostate disease
Common diseases of the prostate include benign prostatic hyperplasia, prostatitis and neoplasia.

Prostate neoplasia – including prostatic carcinoma
Prostatic carcinoma is very invasive locally and metastasizes early to the sublumbar lymph nodes, pelvic bones, lumbar vertebrae, and further afield to the lungs. In contrast to the disease in humans, canine prostatic carcinoma is not androgen-dependent, and several studies have suggested an increased risk in castrated dogs.

Protothecosis
The causal organisms of this condition, *Prototheca* spp., are ubiquitous algae. Infection is rare. Gastrointestinal, ocular and nervous signs are more common than dermatological signs.

Pseudohyperkalaemia
False readings of potassium levels, especially in certain breeds with intra-erythrocyte potassium.

Pulmonary artery dissection
Dissection of major elastic arteries such as the aorta or pulmonary artery involves a tear in the tunica intima and subsequent infiltration of blood into the vessel wall. Dissection in animals may be associated with systemic hypertension, elastin dysplasia, aortic aneurysm, with uncorrected patent ductus arteriosis or secondary to tumour infiltration.

Pulmonary carcinoma
A malignant lung tumour.

Pulmonic stenosis
This is a congenital condition, affecting 20% of dogs diagnosed with congenital heart disease. The condition may be asymptomatic, or may cause signs of syncope and right-sided congestive heart failure.

Pyometra (cystic endometrial hyperplasia–pyometra complex)
Accumulation of purulent fluid in the uterus, usually in dioestrus. Clinical signs include inappetance, polyuria/polydipsia, vomiting and a vulval discharge if the cervix is open.

Pyothorax
Purulent infection in the thoracic cavity. This can be caused by haematogenous spread of bacteria or penetrating foreign bodies, though in many cases a cause is not identified. Can cause fever, dyspnoea and sepsis.

Pyotraumatic folliculitis (acute moist dermatitis, hot spot, wet eczema, summer sores)
Acute inflammation of the skin, which may be triggered by a stimulus such as a flea bite, but is perpetuated by self-trauma. This can be acutely painful.

Pyruvate dehydrogenase phosphatase 1 deficiency
This rare inherited condition causes exercise intolerance, and may shorten life expectancy owing to heart and lung problems.

Pyruvate kinase deficiency
In this condition of red blood cells, the affected cells lose the ability to retain their normal shape and have a reduced affinity for oxygen and a shortened lifespan. Genetic carriers are asymptomatic. Onset and severity of symptoms are variable.

Radial carpal bone fracture
Fracture of one of the bones of the carpus.

Raised serum alkaline phosphatase
Alkaline phosphatase (ALP) is an enzyme found in many tissues, including bone and liver, as well as in corticosteroid-induced isoenzymes. ALP is a marker for liver disease, but can also be elevated in young animals, bone disease and neoplasia.

Rectal prolapse (part of Manx syndrome)
See *Manx syndrome*.

Red cell microcytosis
Small red blood cells may be normal in some breeds.

Renal amyloidosis
Amyloidosis results from the deposition of an insoluble fibrillar protein (amyloid) in a variety of organs, resulting in their dysfunction. Reactive systemic amyloidosis is a systemic syndrome in which amyloid deposition can be found in many organs. Chronic inflammatory or neoplastic disease may predispose to systemic amyloidosis in other breeds. Amyloid deposits in the kidney lead to progressive renal dysfunction. In most cases there is glomerular involvement, resulting in moderate to severe proteinuria and sometimes nephrotic syndrome. In most breeds, renal amyloidosis is seen in older dogs; however, in the Shar Pei dog and Abyssinian cat it is seen at an earlier age.

Renal arteriosclerosis
Endothelial lesions are found in the renal arteries of young greyhounds.

Renal calculi
Kidney stones – see *Urolithiasis*.

Renal cystadenocarcinomas
This is a condition of bilateral and multifocal renal neoplasia which is seen primarily in the German Shepherd Dog. Cases present at 5–11 years of age with anorexia, weight loss and polydipsia. The renal condition is associated with generalized cutaneous nodules and, in females, with multiple uterine leiomyomas.

Renal dysplasia
The term renal dysplasia refers to conditions where there is disorganized development of the renal parenchyma resulting in the persistence of structures inappropriate to the stage of development, e.g., immature glomeruli.

Respiratory distress syndrome (acute respiratory distress syndrome, ARDS)
This condition has been reported in related Dalmatians. Progressive pulmonary failure occurred, leading to death in 3 weeks. No known risk factors for ARDS could be identified.

Restrictive cardiomyopathy (RCM)
A form of heart muscle disease seen most commonly in cats. There is a loss of ability of the myocardium to relax, leading to diastolic dysfunction. Sequelae include heart failure and thromboembolism.

Retinal degeneration
Hereditary retinal degenerations are blinding disorders characterized by dysfunction and death of rod and cone photoreceptor cells of the retina. They are genetically and phenotypically heterogeneous, with differing causative mutations and clinical presentations.

Retinal detachment
Separation of the retina from the underlying tissues resulting in loss of function of the detached portion. May be partial or complete. Usually secondary to other ocular or systemic disease.

Retinal dysplasia
Retinal dysplasia is characterized by disorganized retinal development. There are three categories: multifocal, geographic and complete. More severe forms are associated with significant vision loss. Has various causes but is commonly genetic in origin.

Retinal pigment epithelial dystrophy (RPED, central progressive retinal atrophy)
Abnormal accumulation of pigment within the retina resulting in a progressive retinal degeneration and visual deficiencies. The condition was previously reported most commonly in England, but is now infrequently seen. Similar retinal lesions have been seen in dogs fed vitamin-E-deficient diets, and in some breeds RPED lesions have been associated with a deficiency of vitamin E due to a metabolic abnormality.

Retinopathy (rod–cone dystrophy)
Causes day blindness.

Rhinitis/bronchopneumonia syndrome
Leads to transient or chronic cough, dyspnoea and nasal discharge. Some affected dogs have decreased IgA levels.

Rhipicephalus sanguineus
The brown dog tick, which can be a vector for diseases such as ehrlichiosis.

Ruptured chordae tendineae
The chordae tendineae are major components of the atrioventricular valve apparatus. They anchor the mitral valve, and rupture can lead to severe and acute congestive heart failure.

Sacrocaudal fusion
May result from breeding for speed, and is often an incidental finding.

Sacroiliac joint biomechanics
The sacroiliac joint (SIJ) is formed between the surfaces of the sacrum and ilium bones. Its function is weight-bearing and transmission of the propulsion from the pelvic limbs to the spine during locomotion. In a four-legged stance, about 30–40% of body weight is distributed to the pelvic limbs when standing but the hip joint is subjected to forces approximately three times body weight during locomotion.

Salivary gland neoplasia
Tumours of the salivary gland include adenocarcinoma, squamous cell carcinoma and sarcoma.

Salmonellosis
Salmonella spp. are zoonotic bacteria that lead to gastrointestinal signs such as vomiting and diarrhoea as well as weight loss, fever and abdominal pain.

Sarcoma – soft tissue
A malignant tumour arising in non-epithelial tissue.

Sarcoptic mange (scabies, fox mange)
A contagious skin disease caused by the *Sarcoptes* spp. mite, which can lead to severe itching and hair loss.

Seasonal flank alopecia
See *Canine follicular dysplasia*.

Sebaceous adenitis
An autoimmune skin condition that is uncommon in dogs and rare in cats. Different breeds show different manifestations, including scaling, alopecia, hyperkeratosis and occasional systemic signs. Generally the disease is non-pruritic unless there is secondary bacterial infection.

Sebaceous gland tumours
One of the most common skin tumours of the dog, but less common in the cat. They may be single or multiple. There are various histologic types: *sebaceous hyperplasia* (which is not a neoplastic condition but may be the precursor of sebaceous adenomas or epitheliomas), *sebaceous epitheliomas*, *sebaceous adenomas* and *sebaceous adenocarcinomas*. All types appear as wart-like lesions which may be ulcerated or melanocytic, regardless of histopathological type. With the exception of adenocarcinomas, which may (rarely) metastasize, sebaceous gland tumours are generally benign in behaviour.

Secondary lens luxation
See *Lens luxation*.

Selective IgA deficiency
This condition causes different clinical signs in different breeds, including dermatological disease, respiratory disease such as rhinitis, and gastrointestinal disease such as antibiotic-responsive diarrhoea and anal furunculosis.

Selective malabsorption of cobalamin (vitamin B_{12})
Malabsorption of vitamin B_{12} (cobalamin) may occur as a result of an absence of the appropriate receptors in the ileum. Signs include inappetance, failure to grow, non-regenerative anaemia and neutropenia. The condition resembles Imerslund–Gräsbeck syndrome in humans.

Sensory ataxic neuropathy
A slowly progressive neurological disorder of Golden Retrievers which leads to ataxia and dysmetria from the age of 2–8 months.

Sensory neuropathy (acral mutilation syndrome)
Sensory neuropathies have been seen in a number of breeds. In Pointers, signs of self-mutilation associated with loss of pain sensation predominate, whereas in Dachshunds loss of proprioception and ataxia may be seen. In Boxers, the condition is termed *progressive axonopathy* and is characterized by pelvic limb hyporeflexia, hypotonia and proprioceptive loss. In some cases acral mutilation will result. See also *Acral mutilation and analgesia*.

Sesamoid disease
Diseases of these small bones of the metacarpo/metatarso-phalangeal joints include degeneration and fracture leading to pain and crepitus.

Severe combined immunodeficiency
Severe combined immunodeficiency leads to a marked susceptibility to infection and frequently results in early mortality.

Severe subacute necrotizing encephalopathy (Leigh-like syndrome)
This condition causes rapidly progressive vestibular signs at 6–8 weeks of age.

Sex reversal
See *XX sex reversal*.

Shaker dog disease
This condition has been most commonly observed in dogs with white hair coats, particularly Maltese and West Highland White Terriers. Dogs develop a fine whole-body tremor which may worsen with excitement and stress. Other signs may include nystagmus, menace deficits, proprioceptive deficits and seizures. There may be an underlying mild lymphocytic encephalitis, and affected animals are usually responsive to immunosuppressive doses of corticosteroids with benzodiazepines.

Sialocoele
A swelling of the salivary glands or their ducts causing a subcutaneous or submucosal cavity containing mucinous saliva. It may be idiopathic or secondary to salivary calculi, infections and foreign bodies.

Short tail (bobtail)
Tail length is often a breed-specific trait. It depends on the number of the caudal vertebrae, which can vary significantly between individual dogs and breeds. A C189G mutation in exon 1 of the T-box transcription factor T gene has been identified as a genetic cause of short-tail phenotype. This mutation is thought to cause embryonic lethality in homozygotes and is associated with reduced litter size.

Sialorrhoea with spirocercosis
Infection with the nematode *Spirocerca* spp., which is mainly transmitted by dung beetles, can affect the salivary glands. See also *Spirocercosis*.

Sick sinus syndrome (bradycardia–tachycardia syndrome)
This dysrhythmia often involves periods of bradycardia and tachycardia, leading to syncope.

Sinonasal neoplasia
Cancer of the nose and associated nasal sinuses.

Slipped capital femoral epiphysis (SCFE)
A Salter–Harris fracture of the femur which can occur with minimal trauma.

Small intestinal volvulus
A rare condition where the small intestine rotates about its mesenteric axis, resulting in intestinal obstruction and ischaemia. The condition is rapidly fatal. Large-breed dogs are predisposed.

Solid intraocular xanthogranuloma
A solid intraocular mass comprised of macrophages. Hyperlipidaemia may be a predisposing factor.

Spiculosis
In this condition, multiple bone spicules are found, particularly over the lateral hock.

Spina bifida
This is a developmental defect resulting from the failure of the two halves of the dorsal spinous processes to fuse, most commonly in the lumbar spine. Protrusion of the spinal cord or meninges may result in signs including pelvic limb ataxia, paresis and urinary or faecal incontinence. If no protrusion occurs the condition is termed *spina bifida occulta*.

Spinal arachnoid pseudocysts
Developmental lesions of the spine leading to ataxia and hypermetria.

Spinal dysraphism
This is a congenital malformation of the spinal cord resulting in a wide-based stance and bunny-hopping gait of the hindlimbs. It may be associated with hemivertebrae or spina bifida. The condition is non-progressive.

Spinal muscular atrophy
A condition similar to motor neurone disease in humans, where premature degeneration of motor neurone cell bodies in the spinal cord and brainstem result in generalized weakness which may progress to muscular atrophy and tetraparesis/tetraplegia.

Spinocerebellar ataxia (hereditary ataxia)
Early-onset degeneration of the area of the spinal cord which carries messages to the cerebellum results in the development of cerebellar ataxia as early as 2–6 months of age and progresses. Myokymia (involuntary twitching of muscles) develops and may progress to muscle spasms. Some cases develop epileptic seizures. Most dogs are euthanized young due to poor quality of life.

Spinocerebellar degeneration (late onset)
This is a late-onset degeneration of the spinocerebellar tracts, resulting in ataxia in older dogs.

Spirocercosis
Infection with *Spirocerca lupi*. *S. lupi* is carried by dung beetles and is most prevalent in warm climates. Infection causes nodules to develop in the oesophagus, stomach and aorta resulting in signs including regurgitation, vomiting and breathing difficulties. Neoplastic transformation of the nodules to osteosarcoma or fibrosarcoma may occur. See also *Sialorrhoea with spirocercosis*.

Splenic disease
Diseases of the spleen include masses, torsion and inflammation.

Splenic masses
Masses of the spleen include lymphosarcoma, fibrosarcoma and haemangiosarcoma.

Splenic torsion
Splenic torsion results from the twisting of the spleen on itself, preventing normal blood drainage and resulting in congestion and swelling. It is mostly seen in large- and giant-breed dogs.

Spondylocostal dysostosis
A rare inherited growth disorder characterized by severe abnormalities of the spine and ribs.

Spondylosis deformans
Also known as ankylosing spondylitis. Bony spurs (osteophytes) form around the margins of the vertebral endplates. They become more common with age, and are often apparent radiographically, but are rarely of clinical significance.

Spontaneous chronic corneal epithelial defects (refractory corneal ulceration, indolent ulcers)
Slow-healing, superficial corneal ulcers which may represent a form of corneal epithelial dystrophy. Originally described in the Boxer, but also occurs in other breeds. Usually seen in middle-aged dogs.

Spontaneous pneumothorax
A closed pneumothorax resulting from air leakage from the lungs within the chest cavity, with no apparent history of trauma. It may occur secondary to many diseases, including neoplasia, abscess, pneumonia, parasites, asthma or migrating foreign body (e.g. a grass awn).

Sporotrichosis
A fungal infection caused by *Sporothrix schenckii*. The organism is found worldwide in soils rich in decaying matter. Infection results in dermal and subcutaneous nodules, and may result in disseminated disease with multiple organ involvement, more commonly in cats than in dogs.

Squamous cell carcinoma
One of the more common malignant skin tumours in the dog, and the most common in the cat. Dogs are commonly affected on the head, trunk and perineum, whereas cats are commonly affected on the pinnae, nasal planum and eyelids. Squamous cell carcinoma is locally invasive but the incidence of metastasis is variable. Exposure to ultraviolet (UV) light may predispose to the development of actinic solar dermatitis, which may progress to squamous cell carcinoma.

Squamous cell carcinoma of the cornea is rare but may occur more commonly in brachycephalic breeds and those predisposed to keratoconjunctivitis sicca.

Squamous cell carcinoma is the most common cutaneous tumour of the digit in dogs. It is locally invasive, resulting in bone lysis, and metastasizes more frequently than squamous cell carcinomas found in other cutaneous sites. It occurs most commonly in large-breed dogs with black coats. Some dogs have multiple tumours.

Sterile nodular panniculitis
Inflammation of the subcutaneous fat presenting as deep nodules which may or may not have draining tracts.

Steroid-responsive meningitis–arteritis (SRMA)
An immune-mediated disorder seen in young dogs. Signs include neck pain and fever.

Stillborn kittens
Kittens may be born dead for many reasons including infectious or congenital disorders.

Stomatocytosis
Stomatocytes are bowl-shaped red blood cells. They have increased osmotic fragility and may predispose to haemolytic anaemia.

Stomatocytosis–hypertrophic gastritis
Abnormally shaped red blood cells which have increased osmotic fragility (stomatocytosis) seen with gastric mucosal hypertrophy.

Sudden acquired retinal degeneration (SARD, amaurosis)
This is an idiopathic irreversible loss of vision that occurs over days to months, without an apparent lesion affecting the eye.

Sulfonamide-associated hypersensitivity
Sulfonamides are associated with idiosyncratic drug reactions in some dogs. These reactions occur at normal dose rates and can include skin eruptions, uveitis, keratoconjunctivitis sicca, polyarthropathy, hepatotoxicity, thrombocytopenia, neutropenia and haemolytic anaemia. The widespread use of sulfonamides is therefore limited in dogs, as in humans.

Superficial necrolytic dermatitis
This is a drug reaction to certain shampoos. Cutaneous and systemic signs usually occur within 3 days. Cutaneous signs include papules, plaques and pustules; systemic signs include pyrexia and depression.

Sweat gland tumour
These may be adenomas (of glandular or ductal origin) or adenocarcinomas. They are uncommon in the dog and cat. They may present as small solitary nodules in the dermis and subcutis with or without ulceration. An inflammatory form of adenocarcinoma is poorly circumscribed and more infiltrative. Adenocarcinomas are highly invasive and may metastasize to local and regional lymph nodes, and occasionally to more distant sites, e.g. the lungs.

Swimmer puppy syndrome
Developmental abnormality of neonatal puppies. Affected puppies have splayed legs and are unable to walk. The condition may also be seen in kittens.

Symmetric lupoid onychodystrophy
All claws are shed. They may regrow but are usually brittle and deformed. An immune-mediated pathogenesis is suspected.

Synovial myxoma
Joint tumour in which the joint is filled with myxomatous nodules. Large-breed, middle-aged dogs are predisposed, and the stifle and digit are the most commonly affected joints.

Systemic amyloidosis
Deposition of amyloid (a type of protein) in multiple organs of the body, disrupting function.

Systemic histiocytosis
See *Histiocytic diseases*.

Systemic lupus erythematosus (SLE)
Diagnosis of this uncommon disease is made on the basis of the presence of at least two signs of autoimmune disease, together with high levels of antinuclear antibodies (ANA) (although 10% of cases are ANA-negative). Clinical manifestations include polyarthritis, mucocutaneous lesions, glomerular disease, autoimmune haemolytic anaemia, autoimmune thrombocytopenia and neurological signs.

Tail-chasing
Tail-chasing is a repetitive behaviour in which a dog spins slowly or rapidly in tight circles with or without biting its tail. The potential causes of this behaviour include an acute conflict behaviour only manifested in conflict situations, attention-seeking behaviour, neurological diseases (e.g. seizures), dermatological disease (e.g. flea allergy dermatitis), and compulsive/obsessive–compulsive disorder.

Tapetal degeneration
An inherited condition seen in Beagles, in which there is progressive degeneration of tapetal cells without any effect on vision.

Telangiectasia
Multiple vascular lesions across several organs including the kidneys, subcutaneous tissue, spleen and brain.

Temporomandibular joint dysplasia
Abnormal development of the articular surfaces leads to temporomandibular dysplasia with laxity of the joint. The condition can be seen from 6 months of age. Clinical signs include open mouth locking often associated with yawning, and luxation, which may be chronic. Degenerative joint disease and masticatory muscle wastage may be seen in chronic cases.

Testicular neoplasia
Testicular neoplasia is common in the dog. There are three main tumour types: Sertoli cell tumour, seminoma and interstitial (Leydig) cell tumour. They may be unilateral or bilateral, and two or more tumour types may occur in one or both testes. Neoplasia occurs more commonly in retained than descended testes: an increased risk of 13.6 times has been reported.

Tetralogy of Fallot
Pulmonic stenosis, ventricular septal defect, a dextrapositioned or over-riding aorta and a secondary right ventricular hypertrophy comprise the four parts of this congenital cardiac abnormality.

Thiobarbiturates
Anaesthetic drugs used less commonly nowadays.

Thoracic spinal stenosis
Narrowing of the thoracic spinal canal which results in neurological signs.

Thoracic vertebral malformations
Congenital vertebral malformations are common, especially in small brachycephalic dogs. Hemivertebrae are frequently reported in screw-tailed brachycephalic breeds such as the French bulldog and are assumed to be hereditary. These vertebral malformations are most frequently found in the thoracic vertebral column and can affect single or multiple vertebrae. Despite the potential to cause clinical signs of spinal cord dysfunction, vertebral malformations are frequently not associated with clinical disease.

Thoracic wall abnormalities
Congenital thoracic wall defects which may include pectus excavatum, unilateral thoracic wall concavity and scoliosis.

Thymoma
Thymoma is a tumour of the epithelial cells of the thymus gland, which is situated in the cranial mediastinum. It is uncommon in both dogs and cats. Thymomas are generally benign and slow-growing. Signs relate to the presence of a cranial mediastinal mass and may vary: cough, dyspnoea, regurgitation and occasionally obstruction of the cranial vena cava, leading to facial and forelimb oedema ('precaval syndrome'). Autoimmune conditions such as myasthenia gravis may be associated with thymoma.

Thyroid hormones
Levels of hormones produced by the thyroid gland below the normal reference range may be seen in healthy dogs of certain breeds (notably sight hounds).

Thyroid neoplasia
Most thyroid tumours in the dog are invasive and malignant carcinomas presenting as readily detectable masses in the neck. Adenomas do occur but are usually small and rarely detected during life. Thyroid tumours in the dog are generally non-functional, only 5–20% being functional, producing clinical signs of hyperthyroidism. Up to 30% of cases become hypothyroid as normal thyroid tissue is destroyed by the tumour. The remainder are euthyroid.

Tracheal and laryngeal tumours
Cartilaginous tumours of the larynx and trachea are uncommon in the dog. Arctic breeds seem to be the most commonly affected.

Tracheal collapse
This condition can occur in young dogs with a severe form of the condition, or later in life in those less severely affected. Clinical signs include coughing and inspiratory stridor. A characteristic 'goose-honk' cough may be heard.

Tracheal hypoplasia
Underdevelopment of the trachea can lead to marked respiratory complications.

Trance-like syndrome
During episodes, affected dogs may have a slow gait, aimless repetitive pacing and yet be aware of their surroundings and responsive. It is unclear whether this is a compulsive behaviour or a neurological condition. Dogs are normal between episodes.

Transmissible venereal tumour
Contagious venereal tumour which most commonly affects the external genitalia. Common in tropical and subtropical areas in sexually mature dogs. May also affect the oral and nasal mucosa, rectum and intra-abdominal organs.

Trapped neutrophil syndrome (cyclic haematopoiesis)
In this condition, neutrophil numbers decrease every 12 days. There may also be cyclic decreases in platelet, monocyte and reticulocyte numbers.

Traumatic proptosis
Anterior displacement of the eye from the orbit as a result of blunt trauma. Brachycephalic breeds most commonly affected.

Trichoepithelioma
An uncommon benign tumour of the hair follicle. Trichoepitheliomas present as solitary, firm masses in the dermis or subcutis, often with ulceration of the overlying epidermis. They usually occur over the back, trunk and limbs of dogs.

Tricuspid valve dysplasia
This is a relatively uncommon malformation of the tricuspid valve (3.1% of all congenital heart defects in one study), the consequence of which is to allow blood to flow back from the right ventricle into the right atrium. Affected dogs may have other congenital heart lesions. In some cases affected animals are asymptomatic for many years, while others show progressive heart failure leading to death.

Trigeminal neuropathy
Disease of the trigeminal nerve (cranial nerve V) which causes signs including masticatory muscle atrophy and loss of the palpebral reflex. Trigeminal neuritis is an idiopathic and self-limiting condition.

Triglyceridaemia
Increased levels of circulating triglycerides which, while considered normal after a fatty meal, would be considered abnormal if seen in the fasting state.

Tritrichomonas foetus infection
Tritrichomonas foetus is a parasite that infects the gastrointestinal system of cats, causing diarrhoea which may be accompanied by blood and mucus and persist for many months.

Ulcerative colitis (histiocytic ulcerative colitis)
Chronic inflammatory disease of the colon characterized histologically by an inflammatory infiltrate with large numbers of histiocytes. Ulceration of the mucosa may be a prominent feature, and the disease tends to be refractory to treatment.

Urethral prolapse
Prolapse of the urethral mucosa through the external urethral orifice may occur in young male dogs. Brachycephalic breeds may be predisposed.

Urethral sphincter mechanism incompetence

A weak urinary sphincter allows urine leakage, usually when the animal is relaxed and lying down. The condition is the most common cause of urinary incontinence in the adult dog and is most commonly diagnosed in neutered females of medium to large breeds (> 20 kg). In many cases, the condition is responsive to reproductive hormone and sympathomimetic administration.

Urinary incontinence (part of Manx syndrome)

See *Manx syndrome*.

Urinary tract infections (UTI)

Bacterial infection of the urinary tract.

Urolithiasis

The formation of stones (uroliths) anywhere within the urinary tract.

- **Apatite urolithiasis.** These are relatively uncommon uroliths composed of calcium phosphate. They are most commonly seen in patients with primary hyperparathyroidism, hyperadrenocorticism and hypercalciuria.
- **Calcium oxalate urolithiasis.** Calcium oxalate uroliths are commonly found in both dogs and cats. In dogs, hypercalciuria, hypercalcaemia and hyperadrenocorticism predispose to calcium oxalate urolith formation. Dietary risk factors include excessive calcium, excessive oxalic acid, high protein, high sodium, restricted phosphorus, restricted potassium and dry diet formulation. Calcium oxalate uroliths tend to be radiodense, often rough and round or oval in shape. The risk is higher in males and in older dogs. In cats the risk is higher in males and neutered cats.
- **Cystine urolithiasis.** Cystinuria occurs as a result of an (autosomal recessive) inherited defect in cystine transport in the renal tubules. Cystinuria predisposes to cystine urolithiasis. Most cystine uroliths are relatively radiolucent, smooth and oval, and they are more likely to form in acid urine. They represent 1–3% of canine uroliths in the USA. They are uncommon in cats. With the exception of the Newfoundland, almost all cases recorded have been in male dogs.
- **Silica urolithiasis.** Silica uroliths are uncommon. They have a characteristic jackstone appearance, are relatively radiodense and are less soluble in acid urine. There may be a link between dietary ingredients (notably corn gluten feed and soybean hulls) and silica urolith formation. Most affected dogs are male.
- **Struvite (magnesium ammonium phosphate) urolithiasis.** Struvite uroliths are relatively common in cats and dogs. Previously considered the most common type of urolith, several reports have suggested that calcium oxalate is now more common. They are generally radiodense, smooth, round or faceted stones. Most struvite uroliths are infection-induced in the dog, and since females are predisposed to urinary tract infections this may explain the strong female predisposition seen. Alkaline urine favours their formation.
- **Urate urolithiasis.** Urate uroliths are the third most common urolith in the dog after calcium oxalate and struvite, accounting for approximately 8% of canine uroliths. They are relatively radiolucent and are usually found as multiple, small, smooth, round or oval stones of brown-green colour. They tend to form more in acid urine. Dalmatians are predisposed to the development of urate uroliths because of a reduced capacity to convert uric acid to allantoin in the liver, leading to high levels of urinary uric acid excretion. Animals with hepatic portal vascular anomalies are predisposed to urate uroliths, owing to the reduced hepatic ability to convert ammonia to urea and uric acid to allantoin, leading to increased urinary excretion of these substances.

Urticaria

Sudden development of wheals (hives) as part of an anaphylactic allergic reaction.

Urticaria pigmentosa-like dermatosis

A condition seen in Devon Rex cats. Erythematous papules, some with crusting and pigmentation, develop in a linear pattern on the head, neck, chest and abdomen. May represent an atypical presentation of dermatophytosis or a reaction to allergic skin disease.

Uterine leiomyoma

A form of benign tumour affecting the smooth muscle of the uterus.

Uveal cysts
Cysts of the iris and ciliary body of the eye are usually benign and may be single or multiple, unilateral or bilateral. They may be congenital or acquired, most occurring spontaneously in adult dogs. They are generally benign and of no significance unless large or multiple.

Uveitis
Inflammation of the iris, ciliary body and/or choroid of the eye. Provoking causes include neoplasia, infection, excessive pigment and immune-mediated disease.

Uveodermatologic syndrome (Vogt–Koyanagi–Harada-like syndrome)
Believed to be an immune-mediated disorder similar to Vogt–Koyanagi–Harada syndrome in humans. Melanocytes are targeted by the immune system. Ocular signs include anterior uveitis, uveal depigmentation and retinal damage. Dermatological signs may include vitiligo (depigmentation) of the eyelids, nasal planum and lips.

Vaccine-associated adverse effect
Adverse reactions to vaccines are uncommon, but can range from mild to severe with signs including facial swelling, nausea, shock and anaphylaxis. In Weimaraners, routine vaccinations occasionally cause an acute systemic vasculitis, with gastrointestinal signs, metaphyseal osteopathy and lameness.

Vaccine-associated vasculitis with hypertrophic osteopathy
This vasculitis, which is associated with routine vaccinations, leads to initial gastrointestinal signs, which later develop into lameness and metaphyseal osteopathy.

Vaginal hyperplasia/vaginal prolapse
Vaginal hyperplasia is an exaggerated response of the vaginal mucosa to normal circulating oestrogen during pro-oestrus or oestrus. Vaginal oedema and thickening occurs and may result in a degree of vaginal prolapse. Young large-breed and brachycephalic bitches are most commonly affected.

Vascular ring anomaly – persistent right aortic arch (PRAA)
Vascular ring anomalies are uncommon congenital abnormalities of the major thoracic arteries leading to entrapment of the oesophagus and clinical signs of regurgitation at or after weaning. Persistent right aortic arch is the most common vascular ring anomaly.

Vascular tumours
Cancers of components of the wall of blood vessels.

Vasculitis
This uncommon condition causes various skin lesions such as wheals, papules, oedema, ulceration and scarring. Various cell types may be involved histologically, but the classification is usually of a type III hypersensitivity reaction. Various triggering factors may be involved, such as vaccinations, arthropod bites and mast cell tumours.

Ventral comedone syndrome
In this condition, comedones form because of pressure and friction on the sternum. Secondary bacterial infection, which may respond to topical antibiotic preparations, is common.

Ventricular arrhythmia and sudden death
Abnormal heart rhythm originating in the ventricles which can result in sudden death without prior signs of heart disease.

Ventricular septal defect
Congenital heart disease that is uncommon; patent ventricular septal defect was the fourth most common type in one study, representing 7.5% of diagnosed cases. This condition involves a hole in the interventricular septum. Defects vary in size but can be very large. Small defects may be asymptomatic, but larger defects can cause congestive heart failure, pulmonary vascular disease and pulmonary hypertension.

Vertebral anomalies
See *Thoracic vertebral malformations*.

Vertebral heart score (VHS)
VHS is a radiographic measurement used to assess heart size independently of the size of the dog. However, some breeds have a higher than normal range of VHS.

Vertebral tumours
Cancers of the vertebral column and its contents.

Vesicular cutaneous lupus erythematosus
A cutaneous ulcerative disease seen in Collie breeds. Aggressive immunosuppressive treatment is indicated.

Vincristine-associated myelosuppression
Vincristine is a vinca-alkaloid antineoplastic drug which may cause bone marrow suppression and reduction of blood cell counts. Border Collies seem to be unusually sensitive to this effect.

Vitamin-A-responsive dermatosis
This condition is characterized by a relatively refractory seborrhoea. There is often a waxy otitis externa. Vitamin A supplementation can lead to complete resolution, but therapy may need to be lifelong.

Vitamin-K-dependent coagulopathy
Clinical signs of this condition include prolonged bleeding after surgery or trauma. It is thought that an autosomal recessive defect in hepatic vitamin K metabolism leads to reduced levels of factors II, VII, IX and X. Affected animals can be detected by demonstrating a prolonged PT and aPTT.

Vitiligo
This is thought to be an autoimmune disease causing depigmentation of the face. The condition is usually seen in young adults.

Vitreal syneresis
Degeneration of the vitreous results in liquefaction. This is a common age-related finding and usually of no clinical significance; however, in some breeds it may occur at an earlier age. Extension of the abnormal vitreous into the anterior chamber may predispose to glaucoma. Rarely, it may predispose to retinal detachment.

Vitreoretinopathy
Liquefaction of the vitreous leads to retinal detachment and retinal tears, predisposing to glaucoma.

von Willebrand's disease (vWD)
This is the commonest inherited disorder of haemostasis in dogs, and is caused by a deficiency in von Willebrand factor (vWF), which is vital for platelet function. There are three recognized types. Type I involves a quantitative reduction in vWF, and the severity of the disease varies with breed; some individuals respond to desmopressin (DDAVP) treatment. Type II disease also involves a quantitative reduction in vWF, but the condition is more severe than type I, and there is no response to DDAVP. Type III disease is characterized by a complete absence of vWF leading to the most severe clinical disease, again with no response to DDAVP. Genetic tests are also available to identify carriers of the gene to allow appropriate selection of breeding stock.

Webbed feet
Webbed feet consist of toes that are connected by a membrane. These are characteristic of breeds that may spend time in aquatic environments.

Wool-sucking (compulsive)
This abnormal behaviour appears to be partly genetic, but environmental factors may also play a role, such as early weaning and small litter size. All cats affected in one study had abnormally intense appetites.

XX sex reversal
Sex reversal refers to the situation where the chromosomal and phenotypic sex do not agree. In XX sex reversal a phenotypic male is chromosomally a female.

Zinc-responsive dermatosis
Two syndromes of this condition are recognized. Syndrome I occurs in diets with sufficient zinc. Erythema, alopecia, crusting, scaling and suppuration are seen around the mouth, chin, eyes and ears. In syndrome II, zinc-deficient diets can lead to hyperkeratotic plaques on the footpads and nasal planum.

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