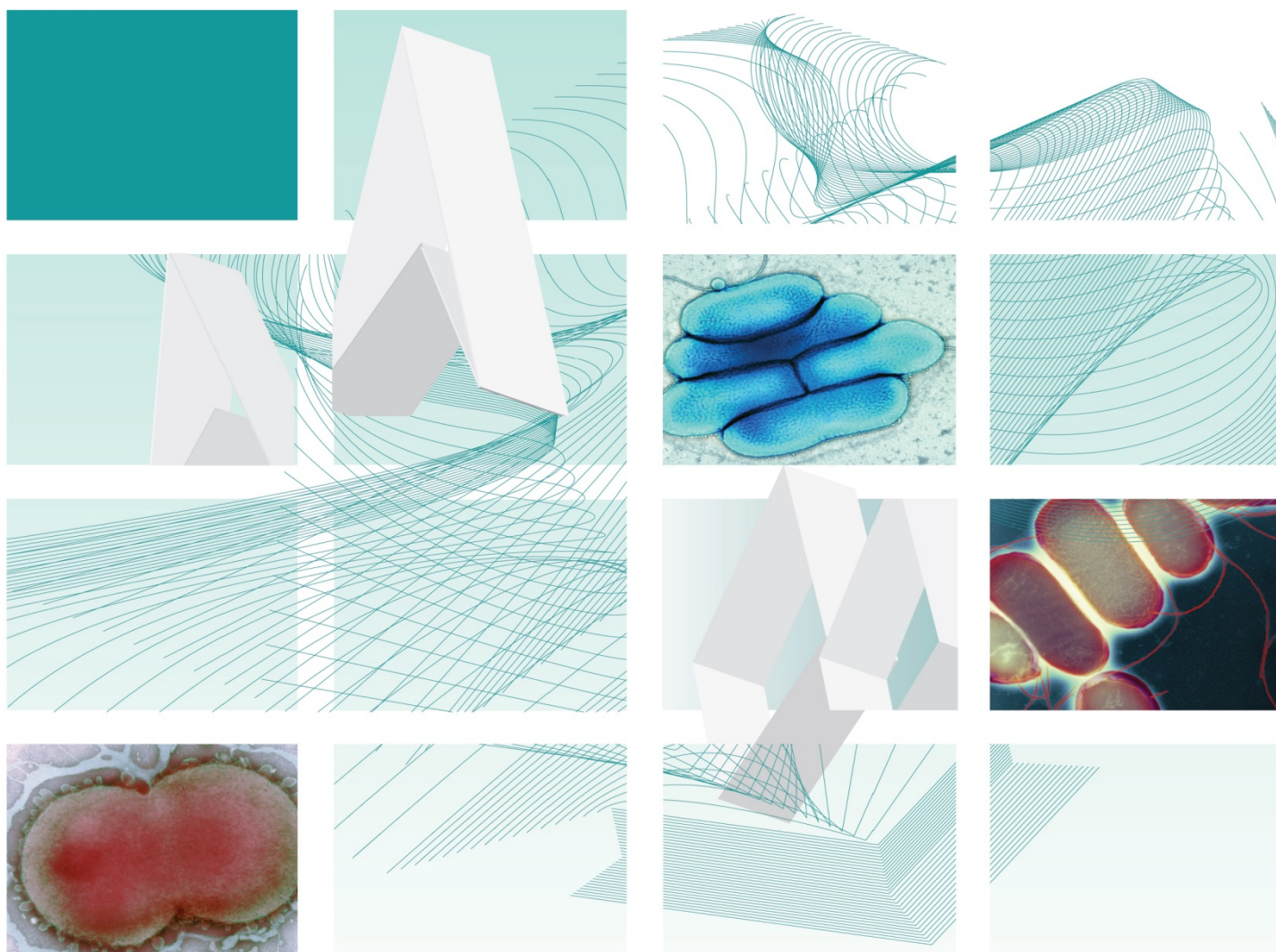




UK Standards for Microbiology Investigations

Investigation of pus and exudates



NICE has accredited the process used by Public Health England to produce Standards for Microbiology Investigations. Accreditation is valid for 5 years from July 2011. More information on accreditation can be viewed at www.nice.org.uk/accreditation.

For full details on our accreditation visit: www.nice.org.uk/accreditation.

Acknowledgments

UK Standards for Microbiology Investigations (SMIs) are developed under the auspices of Public Health England (PHE) working in partnership with the National Health Service (NHS), Public Health Wales and with the professional organisations whose logos are displayed below and listed on the website <https://www.gov.uk/uk-standards-for-microbiology-investigations-smi-quality-and-consistency-in-clinical-laboratories>. SMIs are developed, reviewed and revised by various working groups which are overseen by a steering committee (see <https://www.gov.uk/government/groups/standards-for-microbiology-investigations-steering-committee>).

The contributions of many individuals in clinical, specialist and reference laboratories who have provided information and comments during the development of this document are acknowledged. We are grateful to the medical editors for editing the medical content.

For further information please contact us at:

Standards Unit
Microbiology Services
Public Health England
61 Colindale Avenue
London NW9 5EQ

E-mail: standards@phe.gov.uk

Website: <https://www.gov.uk/uk-standards-for-microbiology-investigations-smi-quality-and-consistency-in-clinical-laboratories>

PHE publications gateway number: 2016127

UK Standards for Microbiology Investigations are produced in association with:



Logos correct at time of publishing.

Contents

Acknowledgments	2
Amendment table.....	4
UK SMI: scope and purpose.....	6
Scope of document.....	9
Key recommendations.....	9
Introduction.....	9
Technical information/limitations	17
1 Safety considerations	19
2 Specimen collection	19
3 Specimen transport and storage.....	20
4 Specimen processing/procedure	20
5 Reporting procedure	25
6 Notification to PHE, or equivalent in the devolved administrations	27
Appendix: Investigation of pus and exudates	28
References	29



NICE has accredited the process used by Public Health England to produce Standards for Microbiology Investigations. Accreditation is valid for 5 years from July 2011. More information on accreditation can be viewed at www.nice.org.uk/accreditation.

For full details on our accreditation visit: www.nice.org.uk/accreditation.

Amendment table

Each SMI method has an individual record of amendments. The current amendments are listed on this page. The amendment history is available from standards@phe.gov.uk.

New or revised documents should be controlled within the laboratory in accordance with the local quality management system.

Amendment no/date.	10/22.08.16
Issue no. discarded.	6.1
Insert issue no.	6.2
Section(s) involved	Amendment
4.5.1.	Incubation temperature and atmosphere on clinical conditions " <i>Nocardiosis</i> " has been updated.
Appendix.	Updated to reflect section 4.5.1 culture media, conditions and organisms table.

Amendment no/date.	9/08.08.16
Issue no. discarded.	6
Insert issue no.	6.1
Section(s) involved	Amendment
4.3.2.	Section regarding swabs has been clarified.

Amendment no/date.	8/20.06.16
Issue no. discarded.	5.2
Insert issue no.	6
Section(s) involved	Amendment
Title.	Changed to 'investigation of pus and exudates'.
Whole document.	References reviewed and updated.
Type of specimen.	Pus or exudate.
Key recommendations.	Key recommendation section included.
Introduction.	Document streamlined and re-structured.

	<p>Information regarding skin related abscesses and post-operative wound infections removed and transferred to B 11 - Investigation of swabs from skin and superficial soft tissue infections.</p> <p>Inclusion of throat and neck abscesses.</p>
Technical information /limitations.	Inclusion of information on selective media and rapid methods.
Safety considerations.	Recommendations included regarding the use of Class I or Class II microbiological safety cabinets where Gram negative coccobacilli are identified.
Specimen collection.	Samples of pus are preferred to swabs.
Culture and investigation.	<p>Section 4.5.1 - Table updated to include specimen type.</p> <p>Neomycin fastidious anaerobic agar replaced by selective anaerobic agar for all specimens.</p> <p>Cooked meat broth or equivalent added as alternative to fastidious anaerobic broth.</p> <p>GN Medium (NAV) replaced with selective Gram negative anaerobe medium.</p> <p>Minor changes to incubation and culture reads throughout for consistency.</p> <p>Section 4.6 - Minimum level of identity updated for the following organisms: anaerobes, β-haemolytic streptococci, enterobacteriaceae and yeast.</p> <p>Consider sending staphylococci isolates from post mortem samples for toxin testing.</p> <p>Section 4.7 - Antimicrobial susceptibility testing section updated. Recommendations for selective reporting are not included.</p> <p>Section 4.9 - Consider sending <i>S. aureus</i> isolates for toxin testing where appropriate clinical details are provided.</p>
Reporting procedure.	<p>Updated in line with bacteriology template.</p> <p>Report antimicrobial susceptibilities as clinically indicated.</p>
Appendix.	Updated to reflect section 4.5.1 culture media, conditions and organisms table.

UK SMI[#]: scope and purpose

Users of SMIs

Primarily, SMIs are intended as a general resource for practising professionals operating in the field of laboratory medicine and infection specialties in the UK. SMIs also provide clinicians with information about the available test repertoire and the standard of laboratory services they should expect for the investigation of infection in their patients, as well as providing information that aids the electronic ordering of appropriate tests. The documents also provide commissioners of healthcare services with the appropriateness and standard of microbiology investigations they should be seeking as part of the clinical and public health care package for their population.

Background to SMIs

SMIs comprise a collection of recommended algorithms and procedures covering all stages of the investigative process in microbiology from the pre-analytical (clinical syndrome) stage to the analytical (laboratory testing) and post analytical (result interpretation and reporting) stages. Syndromic algorithms are supported by more detailed documents containing advice on the investigation of specific diseases and infections. Guidance notes cover the clinical background, differential diagnosis, and appropriate investigation of particular clinical conditions. Quality guidance notes describe laboratory processes which underpin quality, for example assay validation.

Standardisation of the diagnostic process through the application of SMIs helps to assure the equivalence of investigation strategies in different laboratories across the UK and is essential for public health surveillance, research and development activities.

Equal partnership working

SMIs are developed in equal partnership with PHE, NHS, Royal College of Pathologists and professional societies. The list of participating societies may be found at <https://www.gov.uk/uk-standards-for-microbiology-investigations-smi-quality-and-consistency-in-clinical-laboratories>. Inclusion of a logo in an SMI indicates participation of the society in equal partnership and support for the objectives and process of preparing SMIs. Nominees of professional societies are members of the Steering Committee and working groups which develop SMIs. The views of nominees cannot be rigorously representative of the members of their nominating organisations nor the corporate views of their organisations. Nominees act as a conduit for two way reporting and dialogue. Representative views are sought through the consultation process. SMIs are developed, reviewed and updated through a wide consultation process.

Quality assurance

NICE has accredited the process used by the SMI working groups to produce SMIs. The accreditation is applicable to all guidance produced since October 2009. The process for the development of SMIs is certified to ISO 9001:2008. SMIs represent a good standard of practice to which all clinical and public health microbiology

[#] Microbiology is used as a generic term to include the two GMC-recognised specialties of Medical Microbiology (which includes Bacteriology, Mycology and Parasitology) and Medical Virology.

laboratories in the UK are expected to work. SMIs are NICE accredited and represent neither minimum standards of practice nor the highest level of complex laboratory investigation possible. In using SMIs, laboratories should take account of local requirements and undertake additional investigations where appropriate. SMIs help laboratories to meet accreditation requirements by promoting high quality practices which are auditable. SMIs also provide a reference point for method development. The performance of SMIs depends on competent staff and appropriate quality reagents and equipment. Laboratories should ensure that all commercial and in-house tests have been validated and shown to be fit for purpose. Laboratories should participate in external quality assessment schemes and undertake relevant internal quality control procedures.

Patient and public involvement

The SMI working groups are committed to patient and public involvement in the development of SMIs. By involving the public, health professionals, scientists and voluntary organisations the resulting SMI will be robust and meet the needs of the user. An opportunity is given to members of the public to contribute to consultations through our open access website.

Information governance and equality

PHE is a Caldicott compliant organisation. It seeks to take every possible precaution to prevent unauthorised disclosure of patient details and to ensure that patient-related records are kept under secure conditions. The development of SMIs is subject to PHE Equality objectives <https://www.gov.uk/government/organisations/public-health-england/about/equality-and-diversity>.

The SMI working groups are committed to achieving the equality objectives by effective consultation with members of the public, partners, stakeholders and specialist interest groups.

Legal statement

While every care has been taken in the preparation of SMIs, PHE and the partner organisations, shall, to the greatest extent possible under any applicable law, exclude liability for all losses, costs, claims, damages or expenses arising out of or connected with the use of an SMI or any information contained therein. If alterations are made by an end user to an SMI for local use, it must be made clear where in the document the alterations have been made and by whom such alterations have been made and also acknowledged that PHE and the partner organisations shall bear no liability for such alterations. For the further avoidance of doubt, as SMIs have been developed for application within the UK, any application outside the UK shall be at the user's risk.

The evidence base and microbial taxonomy for the SMI is as complete as possible at the date of issue. Any omissions and new material will be considered at the next review. These standards can only be superseded by revisions of the standard, legislative action, or by NICE accredited guidance.

SMIs are Crown copyright which should be acknowledged where appropriate.

Suggested citation for this document

Public Health England. (2016). Investigation of pus and exudates. UK Standards for Microbiology Investigations. B 14 Issue 6.2. <https://www.gov.uk/uk-standards-for-microbiology-investigations-smi-quality-and-consistency-in-clinical-laboratories>

Scope of document

Type of specimen

Pus, exudate

This SMI describes the processing and microbiological investigation of pus and exudate specimens from abscesses and infections which are deep seated or associated with specific organs (including the skin).

Investigations of these specimens for parasitic infections are in [B 31 - Investigations of specimens other than blood for parasites](#), whereas investigations for mycobacterial cultures are in [B 40 – Investigations of specimens for *Mycobacterium* species](#).

For information regarding genital tract abscesses and infections refer to [B 28 – Investigation of genital tract and associated specimens](#).

For information on skin and soft tissue infections and regarding testing of swabs of pus refer to [B 11 - Investigation of swabs from skin and superficial soft tissue infections](#).

This SMI should be used in conjunction with other SMIs.

Key recommendations

Samples should be transported to the laboratory and processed rapidly.

Gram stain should be undertaken on all samples.

Gram stain results should be taken into consideration when choosing which investigations to carry out.

Significant microscopy, culture and sensitivity results should be issued as soon as they become available.

A mechanism for urgent reporting should be in place to communicate key, significant results.

Introduction

Abscesses are accumulations of pus in tissue and any organism isolated from them may be of significance. They occur in many parts of the body as superficial infections or as deep-seated infections associated with any internal organ. Many abscesses are caused by *Staphylococcus aureus* alone, but others are mixed infections. Anaerobes are predominant isolates in intra-abdominal abscesses and abscesses in the oral and anal areas. Members of the "*Streptococcus anginosus*" group and Enterobacteriaceae are also frequently present in lesions at these sites.

Bartholin gland abscesses and tubo-ovarian abscesses are considered in [B 28 – Investigation of genital tract and associated specimens](#). Processing of specimens for *Mycobacterium* species, for example from subcutaneous cold abscesses, is described in [B 40 – Investigation of specimens for *Mycobacterium* species](#).

Brain abscess¹⁻⁴

Brain abscesses are serious and life-threatening.

Sources of abscess formation include⁵:

- direct contiguous spread from chronic otitic or paranasal sinus infection
- metastatic haematogenous spread either from general sepsis or secondary to chronic suppurative lung disease
- penetrating wounds
- surgery
- cryptogenic (ie source unknown)

Brain abscesses of dental origin are rare⁶. The mortality rate of these abscesses is high even when appropriately treated⁷.

Treatment of brain abscesses involves the drainage of pus and appropriate antimicrobial therapy⁵. Brain stem abscesses have a poor prognosis due to their critical anatomical location⁸.

Bacteria isolated from brain abscesses are usually mixtures of aerobes and obligate anaerobes, and the prevalent organism may vary depending upon geographical location, age and underlying medical conditions. The most commonly isolated organisms include⁹⁻¹¹:

- anaerobic streptococci
- anaerobic Gram negative bacilli
- "*Streptococcus anginosus*" group
- Enterobacteriaceae
- *Streptococcus pneumoniae*
- β -haemolytic streptococci
- *S. aureus*

Organisms commonly isolated vary according to the part of the brain involved. Many other less common organisms, for example *Haemophilus* species, may be isolated^{9,10,12}. *Nocardia* species often exhibit metastatic spread to the brain from the lung. Any organism isolated from a brain abscess must be regarded as clinically significant.

Organisms causing brain abscesses following trauma may often be environmental in origin, such as *Clostridium* species or skin derived, such as staphylococci and *Propionibacterium* species¹³.

Brain abscesses due to fungi are rare. Aspergillus brain abscess can occur in patients who are neutropenic. Zygomycosis (mucormycosis) is an uncommon opportunistic infection caused by *mucoraceous* moulds, for example *Lichtheimia* (formerly *Mucor*), *Absidia* and related fungi. *Scedosporium apiospermum* (*Pseudallescheria boydii*) enters the body and spreads haematogenously¹⁴.

The use of culture based methods for organism identification is time consuming; molecular tests are becoming popular resulting in improved management of brain abscesses³.

Breast abscess

Breast abscesses occur in both lactating and non-lactating women. In the former, infections are commonly caused by *S. aureus*, but may be polymicrobial, involving anaerobes and streptococci^{7,15}. Signs include discharge from the nipple, swelling, oedema, firmness and erythema.

In non-lactating women a subareolar abscess forms often with an inverted or retracted nipple. Mixed growths of anaerobes are usually isolated¹⁶. Some patients require surgery involving complete duct excision¹⁶. Abscesses may also be caused by *Pseudomonas aeruginosa* and *Proteus* species¹⁷.

Dental abscess¹⁸⁻²⁰

Dental abscesses involve microorganisms colonising the teeth that may become responsible for oral and dental infections, leading to dentoalveolar abscesses and associated diseases. They may also occur as a direct result of trauma or surgery.

Periodontal disease involves the gingiva and underlying connective tissue, and infection may result in gingivitis or periodontitis²¹.

Organisms most commonly isolated in acute dentoalveolar abscesses are facultative or strict anaerobes. The most frequently isolated organisms are anaerobic Gram negative rods; however other organisms have also been isolated. Examples include^{18,19}:

- α -haemolytic streptococci
- anaerobic Gram negative bacilli
- anaerobic streptococci
- "*S. anginosus*" group
- *Aggregatibacter actinomycetemcomitans*
- *Actinomyces* species
- spirochaetes

Aspiration of dental abscesses may be taken, where possible, to assist in the identification of the causative organism(s). Swabs may be contaminated with superficial commensal flora. In cases of intraosseal abscess, swabs can be useful, but only if taken from a disinfected site.

Liver abscess²²

Liver abscesses can be amoebic or bacterial (so-called pyogenic) in origin or, more rarely, a combination of the two.

Pyogenic liver abscesses usually present as multiple abscesses and are potentially life-threatening. They require prompt diagnosis and therapy by draining and/or aspirating purulent material, although it is possible to treat liver abscesses with antibiotics alone. They occur in older patients than those with amoebic liver abscesses, and are often secondary to a source of sepsis in the portal venous distribution.

Examples of the sources of pyogenic liver abscess include:

- biliary tract disease

- extrahepatic foci of metastatic infection
- surgery
- trauma

Many different bacteria may be isolated from pyogenic liver abscesses. The most common include²³⁻²⁵:

- Enterobacteriaceae
- *Bacteroides* species
- *Clostridium* species
- anaerobic streptococci
- "*S. anginosus*" group
- enterococci
- *P. aeruginosa*
- *B. pseudomallei* (in endemic areas)

Other causes include *Candida* species.

Amoebic liver abscesses arise as a result of the spread of *Entamoeba histolytica* via the portal vein from the large bowel which is the primary site of infection (investigation of amoebae is described in [B 31 – Investigation of specimens other than blood for parasites](#)).

Hydatid cysts may also occur as fluid-filled lesions in the liver. However, the clinical presentation is usually different from that of liver abscesses (refer to [B 31 – Investigation of specimens other than blood for parasites](#)). Cysts may become super-infected with gut flora and progress to abscess formation.

Lung abscess

Lung abscesses involve the destruction of lung parenchyma and present on chest radiographs as large cavities often exhibiting air-fluid levels. This may be secondary to aspiration pneumonia, in which case the right middle zone is most frequently affected. Other organisms may give rise to multifocal abscess formation and the presence of widespread consolidation containing multiple small abscesses (<2 cm diameter) is sometimes referred to as necrotising pneumonia. Pneumonia caused by *S. aureus* and *Klebsiella pneumoniae* may show this picture (refer to [B 57 – Investigation of bronchoalveolar lavage, sputum and associated specimens](#)).

Lung abscesses most often follow aspiration of gastric or nasopharyngeal contents as a consequence of loss of consciousness, resulting for example from alcohol excess, cerebrovascular accident, drug overdose, general anaesthesia, seizure, diabetic coma, or sepsis. Other predisposing factors include oesophageal or neurological disease, tonsillectomy and tooth extraction.

Lung abscesses may arise from endogenous sources of infection. The bacteria involved in these cases are generally from the upper respiratory tract and anaerobes are often implicated, secondarily infecting consolidated lung after aspiration from the upper respiratory tract. Nosocomial infections involving *S. aureus*, *S. pneumoniae*, *Klebsiella* species and other organisms may also occur.

B. pseudomallei may cause lung abscesses or necrotising pneumonia in those who have visited endemic areas (mainly South East Asia and Northern Australia) especially in diabetics²⁶.

Nocardia infection is most often seen in the lung where it may produce an acute, often necrotising, pneumonia²⁷. This is commonly associated with cavitation. It may also produce a slowly enlarging pulmonary nodule with pneumonia, associated with empyema. Nocardiosis, almost always occurring in a setting of immunosuppression, may present as pulmonary abscesses.

Actinomyces species cause a thoracic infection that may involve the lungs, pleura, mediastinum or chest wall. Cases often go unrecognised until empyema or a chest wall fistula develops. Aspiration of oral contents is a risk factor for the development of thoracic actinomycosis, thus predisposing conditions include alcoholism, cerebral infarction, drug overdose, general anaesthesia, seizure, diabetic coma or sepsis.

Abscesses as a result of blood borne spread of infection from a distant focus may occur in conditions such as infective endocarditis.

Lemierre's syndrome (or necrobacillosis) originates as an acute oropharyngeal infection usually in a young adult. Infective thrombophlebitis of the internal jugular vein leads to septic embolisation and metastatic infection. The lung is most frequently involved but multifocal abscesses may develop. *Fusobacterium necrophorum* is the most common pathogen isolated from blood cultures in patients with this syndrome²⁸.

Aspergillus species have been isolated from lung abscesses in patients who are immunocompromised.

Pancreatic abscess

Pancreatic abscesses are potential complications of acute pancreatitis. Infections are often polymicrobial and common isolates include *Escherichia coli*, other Enterobacteriaceae, enterococci and anaerobes; longer-standing collections, especially after prolonged antibiotic therapy, are often infected with coagulase negative staphylococci and *Candida* species²⁹.

Perirectal abscess

Perirectal abscesses are encountered in patients with predisposing factors. These include³⁰:

- immunodeficiency
- malignancy
- rectal surgery
- ulcerative colitis

They are often caused by³¹:

- anaerobes
- Enterobacteriaceae
- streptococci
- *S. aureus*

Pilonidal abscess

Pilonidal abscesses result from infection of a pilonidal sinus. Anaerobes and Enterobacteriaceae are usually isolated, but they may be caused by *S. aureus* and β -haemolytic streptococci³².

Prostatic abscess³³

Abscesses within the prostate may be caused by, or associated with³⁴:

- diabetes mellitus
- acute and chronic prostatitis
- instrumentation of the urethra and bladder
- lower urinary tract obstruction
- haematogenous spread of infection

Organisms that may cause prostatic abscesses include³⁵:

- *E. coli* and other Enterobacteriaceae
- enterococci
- anaerobes
- *Neisseria gonorrhoea*
- *S. aureus*³³

Prostatic abscesses can act as reservoirs for *Cryptococcus neoformans* resulting in relapses of infection with this organism³⁶.

Psoas abscess

Psoas abscesses may be seen as secondary infections to:

- appendicitis
- diverticulitis
- osteomyelitis of the spine
- infection of a disc space
- bacteraemia
- perinephric abscess

Pus tracks under the sheath of the psoas muscle. Infection often occurs in drug abusers after injection into the ipsilateral femoral vein.

Psoas abscesses are predominantly caused by^{37,38}:

- Enterobacteriaceae
- *Bacteroides* species
- *S. aureus*
- streptococci
- *Mycobacterium tuberculosis*

Renal abscess

Renal abscesses are typically caused by Gram negative bacilli and result from ascending urinary tract infection, pyelonephritis, renal calculi or sepsis³⁹.

Renal abscesses are localised in the renal cortex and may occur as a result of, for example, *Staphylococcus aureus* bacteraemia. Pyuria may also be present, but urine culture is usually negative. Renal abscesses are increasingly being seen as complications of acute pyelonephritis caused by Gram negative bacilli. The rare condition of emphysematous pyelonephritis, which results in multifocal intrarenal abscesses and gas formation within the renal parenchyma, is usually seen in diabetic patients or as a complication of renal stones. The commonest cause is *Escherichia coli* and the condition carries a 70% mortality rate.

Perinephric abscess are an uncommon complication of UTI, which usually affects patients with one or more anatomical or physiological abnormalities⁴⁰. The abscess may be confined to the perinephric space or extend into adjacent structures. Pyuria, with or without positive culture, is normally, but not invariably seen on examination of urine. Causative organisms are usually Gram negative bacilli, but can also be staphylococci or *Candida* species. Mixed infections have also been reported.

Salivary gland abscess

There are three pairs of major salivary glands; the parotid, submandibular and sublingual. Parotid abscesses are more commonly seen in the elderly. Common organisms include:

- *S. aureus*
- anaerobes

Spinal epidural abscess⁴¹

Spinal epidural abscesses may occur in patients with:

- predisposing disease (such as diabetes)
- prior infection elsewhere in the body which may serve as a source for haematogenous spread
- abnormality of, or trauma to, the spinal column (often involving invasive medical procedures such as epidural catheterisation)

The most common isolate is *S. aureus*⁴². *Staphylococcus epidermidis* may be isolated in patients following invasive spinal manipulation. Streptococci (α -haemolytic, β -haemolytic and *S. pneumoniae*), Enterobacteriaceae and pseudomonads may also be isolated^{42,43}.

Subphrenic abscess

Subphrenic abscesses occur immediately below the diaphragm, often as a result of⁴⁴:

- gastric, duodenal or colonic perforation
- acute cholecystitis
- procedures on the liver and upper part of the gastrointestinal tract
- ruptured appendix

- trauma

Subphrenic abscesses are caused by mixed infections from the normal gastrointestinal flora⁴⁴.

Throat/neck abscess

Throat and neck abscess are relatively common⁴⁵⁻⁴⁷.

Causative organisms include^{45,48}:

- β -haemolytic streptococci
- anaerobes

Surgical incision and drainage may be undertaken through intraoral or extra oral procedures.

Unusual cases of abscess formation

Unusual cases of abscess formation can occur in patients with many underlying conditions and may be caused by a vast range of organisms⁴⁹⁻⁵⁶. Any organism isolated from abscess pus is potentially significant.

Actinomycosis is a chronic suppurative infection characterised by chronic abscess formation with surrounding fibrosis. It is rare and usually follows perforation of a viscous, trauma or surgery. It is caused by *Actinomyces israelii*, usually in mixed culture with other bacteria⁵⁷.

Abscess formation is most often associated with the gastrointestinal tract, the jaw and the pelvis. Other areas of the body may be involved and the formation of abdominal abscesses may occur. Thoracic involvement occurs in 15% of cases of actinomycosis. Pulmonary actinomycosis can be difficult to diagnose prior to cutaneous involvement, which results in direct extension through the chest wall. The disease progresses to form a chronic indurated mass with draining fistulae. Material should be drained from abscesses and biopsies taken. Skin biopsies may reveal the presence of organisms (refer to [B 17 – Investigation of tissues and biopsies from deep-seated sites and organs](#)).

"Sulphur granules" are sought in the pus specimen⁵⁸. These are discharged from actinomycosis abscesses. Sulphur granules are colonies of organisms forming a filamentous inner mass which is surrounded by host reaction. They are formed only *in vivo*. They are hard, buff to yellow in colour, and have a clubbed surface.

Intra-abdominal sepsis

Intra-abdominal sepsis is infection occurring in the normally sterile peritoneal cavity⁵⁹. The term covers primary and secondary peritonitis, as well as intra-abdominal abscesses.

Primary peritonitis is infection of the peritoneal fluid in which no perforation of a viscous has occurred. Infection usually arises via haematogenous spread from an extra-abdominal source and is often caused by a single pathogen⁵⁹. It is common in patients with ascites following hepatic failure. In females it may also result from organisms ascending the genital tract (refer to [B 28 - Investigation of genital tract associated specimens](#)).

Secondary peritonitis is acute, suppurative inflammation of the peritoneal cavity usually resulting from bowel perforation or postoperative gastrointestinal leakage. Secondary peritonitis is most often treated with a combination of drainage and antibiotics.

The most frequent isolates encountered in intra-abdominal sepsis with secondary peritonitis are derived from the normal gastrointestinal flora. Anaerobic bacteria are isolated from the majority of cases with *Bacteroides* species being isolated. However, infections are usually polymicrobial and organisms that have been isolated include:

- *Enterococcus* species
- *Bacteroides* species
- pseudomonads
- *Peptostreptococcus* species
- yeasts (mostly *Candida* species)
- β -haemolytic streptococci
- *Clostridium* species
- Enterobacteriaceae

Tuberculous peritonitis is a rare disease in the UK. It is more common on the Indian sub-continent, so it is important to consider this in immigrants from that area. In most cases a primary pulmonary focus is present with secondary spread of *Mycobacterium tuberculosis* (refer to [B 40 – Investigation of specimens for *Mycobacterium* species](#)).

Technical information/limitations

Limitations of UK SMIs

The recommendations made in UK SMIs are based on evidence (eg sensitivity and specificity) where available, expert opinion and pragmatism, with consideration also being given to available resources. Laboratories should take account of local requirements and undertake additional investigations where appropriate. Prior to use, laboratories should ensure that all commercial and in-house tests have been validated and are fit for purpose.

Selective media in screening procedures

Selective media which does not support the growth of all circulating strains of organisms may be recommended based on the evidence available. A balance therefore must be sought between available evidence, and available resources required if more than one media plate is used.

Specimen containers^{60,61}

SMIs use the term “CE marked leak proof container” to describe containers bearing the CE marking used for the collection and transport of clinical specimens. The requirements for specimen containers are given in the EU in vitro Diagnostic Medical Devices Directive (98/79/EC Annex 1 B 2.1) which states: “The design must allow easy handling and, where necessary, reduce as far as possible contamination of, and leakage from, the device during use and, in the case of specimen receptacles, the risk

of contamination of the specimen. The manufacturing processes must be appropriate for these purposes”.

Rapid methods

To reduce turnaround times, rapid identification and sensitivity tests may be performed in conjunction with routine methods where appropriate. A variety of rapid identification and sensitivity methods have been evaluated; these include molecular techniques and the Matrix Assisted Laser Desorption Ionisation Time-of-Flight (MALDI-TOF)^{62,63}. It is important to ensure that fresh cultures of pure single isolates are tested to avoid reporting misleading results.

Laboratories should follow manufacturers’ instructions and all rapid tests must be validated and be shown to be fit for purpose prior to use.

1 Safety considerations^{60,61,64-78}

1.1 Specimen collection, transport and storage^{60,61,64-67}

Use aseptic technique.

Collect specimens in appropriate CE marked leak proof containers and transport in sealed plastic bags.

Avoid accidental injury when pus is aspirated.

Compliance with postal, transport and storage regulations is essential.

1.2 Specimen processing^{60,61,64-78}

ContGram positiveainment Level 2.

If infection with a Hazard Group 3 organism eg *Mycobacterium* species, *Paracoccidioides brasiliensis* or *Brucella* species is suspected, all specimens must be processed in a microbiological safety cabinet under full Containment Level 3 conditions. Thus initial examination and all follow up work on specimens from patients with suspected *Mycobacterium* species, or suggesting a diagnosis of blastomycosis, coccidioidomycosis, histoplasmosis, paracoccidioidomycosis or penicilliosis must be performed inside a microbiological safety cabinet under full Containment Level 3 conditions.

It is recommended that all Gram negative coccobacilli from sterile sites should be processed in a Class I or Class II microbiological safety cabinet until Hazard Group 3 pathogens (ie *Brucella*) have been definitively excluded⁷⁹.

Laboratory procedures that give rise to infectious aerosols must be conducted in a microbiological safety cabinet⁷⁰.

Any grinding of sulphur granules should be performed in a microbiological safety cabinet.

Prior to staining, fix smeared material by placing the slide on an electric hotplate (65-75°C), under the hood, until dry. Then place in a rack or other suitable holder.

Note: Heat-fixing may not kill all *Mycobacterium* species⁸⁰. Slides should be handled carefully.

Specimen containers must also be placed in a suitable holder.

Refer to current guidance on the safe handling of all organisms documented in this SMI.

The above guidance should be supplemented with local COSHH and risk assessments.

2 Specimen collection

2.1 Type of specimens

Pus, exudate

2.2 Optimal time and method of collection⁸¹

For safety considerations refer to Section 1.1.

Collect specimens before antimicrobial therapy where possible⁸¹.

Samples of pus are preferred to swabs. However, pus swabs are often received. When using a swab disinfect the superficial areas first. The deepest part of the wound should be sampled, avoiding the superficial microflora.

The specimen will usually be collected by a medical practitioner. Cleaning the site with sterile saline or 70% alcohol is recommended by some sources⁸².

Collect specimens other than swabs into appropriate CE marked leak proof containers and place in sealed plastic bags.

Unless otherwise stated, swabs for bacterial and fungal culture should then be placed in appropriate transport medium⁸³⁻⁸⁷.

2.3 Adequate quantity and appropriate number of specimens⁸¹

Ideally, a minimum volume of 1mL of pus should be submitted.

Swabs are not the optimal sample type. However, if received, swabs should be well soaked in pus. Refer to [B 11 - Investigation of swabs from skin and superficial soft tissue infections](#).

Numbers and frequency of specimen collection are dependent on clinical condition of patient.

3 Specimen transport and storage^{60,61}

3.1 Optimal transport and storage conditions

For safety considerations refer to Section 1.1.

Specimens should be transported and processed as soon as possible⁸¹.

The volume of specimen influences the transport time that is acceptable. Large volumes of purulent material maintain the viability of anaerobes for longer^{88,89}.

The recovery of anaerobes in particular is compromised if the transport time is delayed.

If processing is delayed, refrigeration is preferable to storage at ambient temperature.

4 Specimen processing/procedure^{60,61}

4.1 Test selection

Divide specimen on receipt for appropriate procedures such as examination for parasites ([B 31 – Investigation of specimens other than blood for parasites](#)) and culture for *Mycobacterium* species ([B 40 – Investigation of specimens for *Mycobacterium* species](#)), depending on clinical details.

4.2 Appearance

Describe presence or absence of sulphur granules (if sought).

4.3 Sample preparation

4.3.1 Pre-treatment

Exudates

Centrifuge in a sterile, capped, conical-bottomed container at 1200 x g for 5-10 min.

Transfer the supernatant with a sterile pipette, leaving approximately 0.5mL, to another CE marked leak proof container in a sealed plastic bag for additional testing if required.

Resuspend the deposit in the remaining fluid.

Supplementary

Wash any sulphur granules that are present in saline.

Suspend an aliquot of pus containing sulphur granules in sterile water or saline in a CE marked leak proof container in a sealed plastic bag. Agitate gently to wash pus from the granules.

Grind the washed granules in a small amount of sterile water or saline, with a sterile tissue grinder (Griffiths tube or unbreakable alternative) or a pestle and mortar.

Use this homogenised sample to make a smear for Gram staining and to inoculate agar plates.

Note 1: All grinding of sulphur granules should be performed in a microbiological safety cabinet.

Note 2: If a fungal infection is suspected then grinding of the whole specimen should be avoided. This is to prevent damaging hyphae that would result in a reduced yield, particularly with zygomycetes.

4.3.2 Specimen processing

Pus

Inoculate agar plates and enrichment broth with the pus or centrifuged deposit with a sterile pipette (refer to [Q 5 – Inoculation of culture media for bacteriology](#)).

If sulphur granules are present, these should be ground and included in the culture.

For the isolation of individual colonies, spread inoculum with a sterile loop.

All additional pus/fluid from the specimen should be stored at 4°C for at least 7 days after the issue of the final report.

Swabs

If a swab of pus is received, follow the recommendations in [B 11 – Investigation of swabs from skin and superficial soft tissue infections](#).

4.4 Microscopy

4.4.1 Standard

Swab

Prepare a thin smear on a clean microscope slide for Gram staining after performing culture (refer to [Q 5 – Inoculation of culture media for bacteriology](#)).

Pus

Using a sterile pipette place one drop of neat specimen or centrifuged deposit (see 4.5.1), as applicable, on to a clean microscope slide. Spread this using a sterile loop to make a thin smear for Gram staining (refer to [TP 39 – Staining procedures](#)). The Gram film result should be used as a guide for supplementary cultures (eg fungal, Actinomyces) when appropriate.

4.4.2 Supplementary

Gram stain of sulphur granules

With care, either squash the sulphur granules that have been washed in saline between two slides using gentle pressure, or use the homogenised granules (see section 4.5.1) and make a thin smear for Gram staining.

Note: Any grinding of sulphur granules should be performed in a microbiological safety cabinet.

For microscopy, *Mycobacterium* species ([B 40 – Investigation of specimens for *Mycobacterium* species](#)) and parasites ([B 31 – Investigation of specimens other than blood for parasites](#)). For fungi and other staining procedures refer to [TP 39 – Staining procedures](#).

4.5 Culture and investigation

Inoculate each agar plate using a sterile pipette ([Q 5 - Inoculation of culture media for bacteriology](#)).

For the isolation of individual colonies, spread inoculum with a sterile loop.

4.5.1 Culture media, conditions and organisms

Clinical details/ conditions	Specimen	Standard media	Incubation			Cultures read	Target organism(s)
			Temp °C	Atmos	Time		
All clinical conditions	All pus and exudates	Blood agar	35-37	5–10% CO ₂	40-48hr	daily	Any organism
		CLED/ MacConkey agar	35-37	Air	18-24hr	≥18hr	
		Selective anaerobe agar with a metronidazole 5µg disc	35-37	Anaerobic	5 d	≥40hr and at 5 d	Anaerobes
		Fastidious anaerobic cooked meat broth or equivalent. Subculture if evidence of growth (≥40hr), or at day 5 to above media (excluding	35-37	Air	5 d	N/A	Any organism
			35-37	As above	40-48hr	≥40hr	

		MacConkey)					
For these situations, add the following:							
Clinical details/ conditions	Specimen	Supplementary media	Incubation			Cultures read	Target organism(s)
			Temp °C	Atmos	Time		
Submandibular abscess Brain abscess Liver abscess Lung empyema/ abscess Psoas abscess Spinal abscess	Pus	Chocolate agar	35–37	5–10% CO ₂	40 – 48hr	≥40hr	Fastidious organisms
Actinomycosis (or where microscopy suggestive of actinomycetes)	Pus	Blood agar supplemented with metronidazole and nalidixic acid	35-37	Anaerobic	10 d	≥40hr, at 7 d and 10 d	<i>Actinomyces</i> species
Nocardiosis	Pus	Blood agar	35-37	5-10% CO ₂	16-48hr	daily	<i>Nocardia</i> species*
Immunocompromised or fungi suspected (Gram film or clinical details)	Pus	Sabouraud agar	28-30	Air	14 d	daily	Yeast Mould
Prostatic abscess Primary peritonitis in females	Pus	GC selective/ Chocolate agar	35-37	5-10% CO ₂	40-48hr	≥40hr	<i>N. gonorrhoeae</i>
Clinical details/ conditions	Specimen	Optional media	Incubation			Cultures read	Target organism(s)
			Temp °C	Atmos	Time		
When clinical details or microscopy suggestive of mixed infection	Pus	Staph/strep selective agar	35-37	Air	40-48hr	daily	<i>S. aureus</i> Streptococci
		Selective Gram negative anaerobe medium	35-37	Anaerobic	Up to 5 d	≥40hr and 5 d	Gram negative anaerobes
Other organisms for consideration - Fungi (B 39 – Investigation of dermatological specimens for superficial mycoses)							

and *Mycobacterium* species ([B 40 – Investigation of specimens for *Mycobacterium* species](#))

*Refer to [B 17 – Investigation of tissues and biopsies from deep-seated sites and organs](#) for isolation of *Nocardia* species using specimen type, biopsy (this includes bronchoalveolar lavage (BAL)).

4.6 Identification

Refer to individual SMIs for organism identification.

4.6.1 Minimum level of identification in the laboratory

Actinomycetes	species level ID 10 – Identification of aerobic Actinomycetes ID 15 – Identification of anaerobic <i>Actinomyces</i> species
Anaerobes	genus level (in brain samples to species level)
β-haemolytic streptococci	species level
Coagulase negative staphylococci	"coagulase negative" level
Enterobacteriaceae	genus level
Yeast	species level
Mould	species level
Neisseria	species level
Pseudomonads	species level
S. aureus	species level (consider Panton-Valentine leukocidin (PVL) and toxin testing if appropriate clinical details) (consider toxin testing on samples from post mortem samples)
"S. anginosus" group	"S. anginosus" group level
Mycobacterium	B 40 - Investigation of specimens for <i>Mycobacterium</i> species
Parasites	B 31 - Investigation of specimens other than blood for parasites

Organisms may be further identified if this is clinically or epidemiologically indicated.

4.7 Antimicrobial susceptibility testing

Refer to [British Society for Antimicrobial Chemotherapy \(BSAC\)](#), [EUCAST](#) and/or [CSLI](#) guidelines or manufacturer's validation for preparatory methods.

This SMI does not contain recommendations for the selective and restrictive reporting of susceptibilities to antimicrobials due to the diversity of organisms associated with pus and exudate samples. Local decisions on antimicrobial susceptibility testing should be subject to consultation that should include local antimicrobial stewardship groups.

4.7.1 Antimicrobial susceptibility testing and reporting table

N/A

4.8 Referral for outbreak investigations

N/A

4.9 Referral to reference laboratories

For information on the tests offered, turn around times, transport procedure and the other requirements of the reference laboratory [click here for user manuals and request forms](#).

Organisms with unusual or unexpected resistance and whenever there is a laboratory or clinical problem, or anomaly that requires elucidation should be sent to the appropriate reference laboratory.

Consider sending *S. aureus* isolates for toxin testing where appropriate clinical details are provided. For example, isolates from post mortems where the specimen is suspected to be the cause of death should be sent for toxin testing.

Contact appropriate devolved national reference laboratory for information on the tests available, turnaround times, transport procedure and any other requirements for sample submission:

England and Wales

<https://www.gov.uk/specialist-and-reference-microbiology-laboratory-tests-and-services>

Scotland

<http://www.hps.scot.nhs.uk/reflab/index.aspx>

Northern Ireland

<http://www.publichealth.hscni.net/directorate-public-health/health-protection>

5 Reporting procedure

5.1 Microscopy

Gram stain

Report on WBCs and organisms detected.

5.1.1 Microscopy reporting time

All results should be issued to the requesting clinician as soon as they become available, unless specific alternative arrangements have been made with the requestors.

Urgent results should be telephoned or transmitted electronically in accordance with local policies.

For the reporting of microscopy for fungi, *Mycobacterium* species and parasites ([B 40 – Investigation of specimens for *Mycobacterium* species](#)) and parasites ([B 31 – Investigation of specimens other than blood for parasites](#)).

5.2 Culture

The following results should be reported:

- clinically significant organisms isolated
- other growth

- absence of growth

Report on the presence of sulphur granules.

Also, report results of supplementary investigations: fungi, *Mycobacterium* species and parasites. ([B 31 – Investigation of specimens other than blood for parasites](#)).

5.2.1 Culture reporting time

Interim or preliminary results should be issued on detection of potentially clinically significant isolates as soon as growth is detected, unless specific alternative arrangements have been made with the requestors.

Urgent results should be telephoned or transmitted electronically in accordance with local policies.

Final written or computer generated reports should follow preliminary and verbal reports as soon as possible.

5.3 Antimicrobial susceptibility testing

Report susceptibilities as clinically indicated; guidance on selective reporting is not included in this SMI. Prudent use of antimicrobials according to local and national protocols is recommended.

Generally, all resistant results should be reported as this is good practice and informs the user.

6 Notification to PHE^{90,91}, or equivalent in the devolved administrations⁹²⁻⁹⁵

The Health Protection (Notification) regulations 2010 require diagnostic laboratories to notify Public Health England (PHE) when they identify the causative agents that are listed in Schedule 2 of the Regulations. Notifications must be provided in writing, on paper or electronically, within seven days. Urgent cases should be notified orally and as soon as possible, recommended within 24 hours. These should be followed up by written notification within seven days.

For the purposes of the Notification Regulations, the recipient of laboratory notifications is the local PHE Health Protection Team. If a case has already been notified by a registered medical practitioner, the diagnostic laboratory is still required to notify the case if they identify any evidence of an infection caused by a notifiable causative agent.

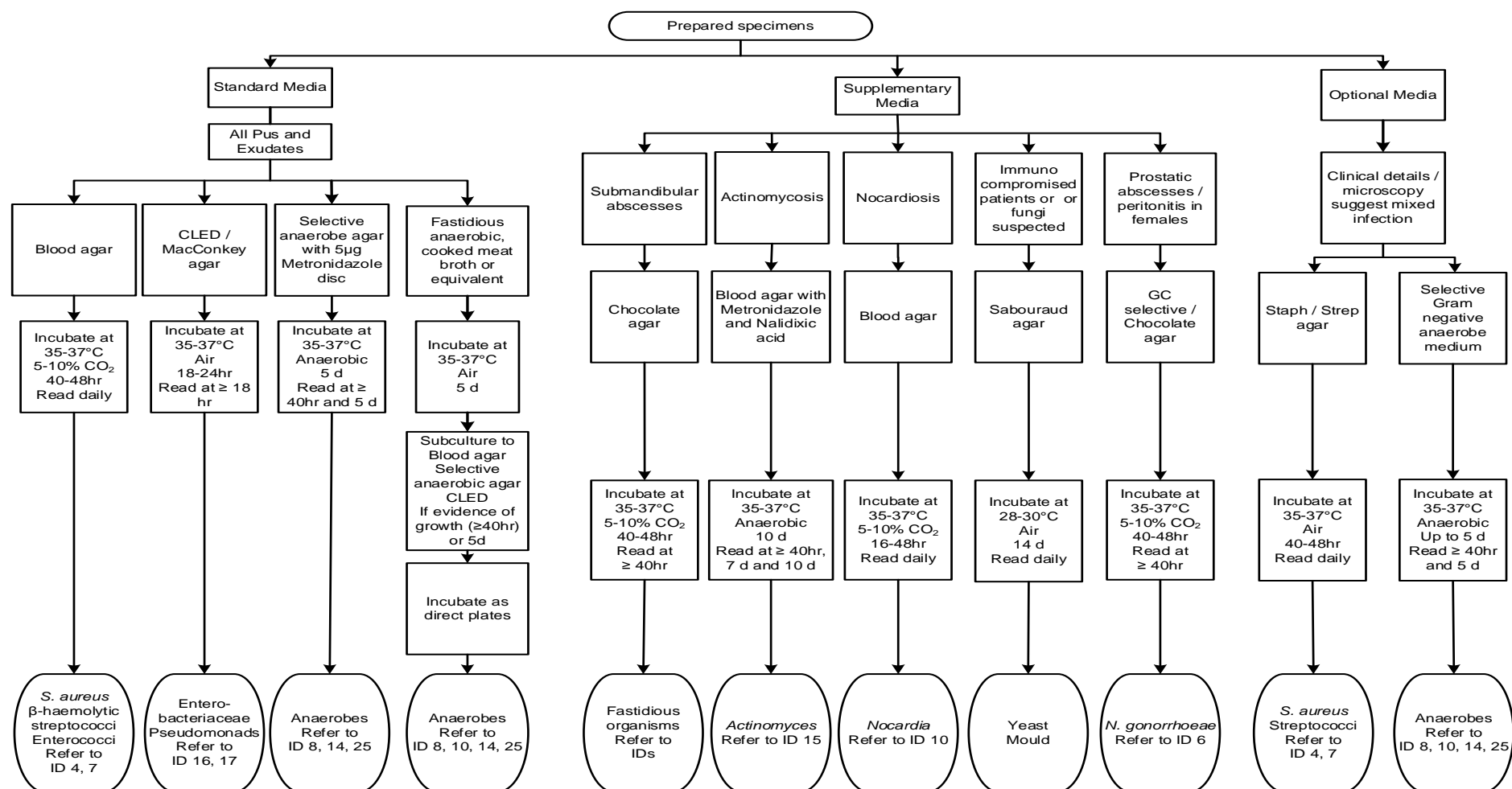
Notification under the Health Protection (Notification) Regulations 2010 does not replace voluntary reporting to PHE. The vast majority of NHS laboratories voluntarily report a wide range of laboratory diagnoses of causative agents to PHE and many PHE Health protection Teams have agreements with local laboratories for urgent reporting of some infections. This should continue.

Note: The Health Protection Legislation Guidance (2010) includes reporting of Human Immunodeficiency Virus (HIV) & Sexually Transmitted Infections (STIs), Healthcare Associated Infections (HCIs) and Creutzfeldt–Jakob disease (CJD) under ‘Notification Duties of Registered Medical Practitioners’: it is not noted under ‘Notification Duties of Diagnostic Laboratories’.

<https://www.gov.uk/government/organisations/public-health-england/about/our-governance#health-protection-regulations-2010>

Other arrangements exist in [Scotland](#)^{92,93}, [Wales](#)⁹⁴ and [Northern Ireland](#)⁹⁵.

Appendix: Investigation of pus and exudates⁹⁶



References

1. Slazinski T. Brain abscess. *Crit Care NursClinNorth Am* 2013;25:381-8.
2. Muzumdar D, Jhawar S, Goel A. Brain abscess: an overview. *IntJSurg* 2011;9:136-44.
3. Mishra AK, Dufour H, Roche PH, Lonjon M, Raoult D, Fournier PE. Molecular revolution in the diagnosis of microbial brain abscesses. *EurJClinMicrobiolInfectDis* 2014;33:2083-93.
4. Rau CS, Chang WN, Lin YC, Lu CH, Liliang PC, Su TM et al. Brain abscess caused by aerobic Gram-negative bacilli: clinical features and therapeutic outcomes. *ClinNeurolNeurosurg* 2002;105:60-5.
5. Akuzawa N, Osawa T, Totsuka M, Hatori T, Imai K, Kitahara Y et al. Secondary brain abscess following simple renal cyst infection: a case report. *BMC Neurol* 2014;14:130.
6. Yang J, Liu SY, Hossaini-Zadeh M, Pogrel MA. Brain abscess potentially secondary to odontogenic infection: case report. *Oral Surg Oral Med Oral Pathol Oral Radiol* 2014;117:e108-11.
7. Dabbas N, Chand M, Pallett A, Royle GT, Sainsbury R. Have the organisms that cause breast abscess changed with time?--Implications for appropriate antibiotic usage in primary and secondary care. *Breast J* 2010;16:412-5.
8. Hakan T, Ceran N, Erdem I, Berkman MZ, Goktas P. Bacterial brain abscesses: an evaluation of 96 cases. *JInfect* 2006;52:359-66.
9. Prasad KN, Mishra AM, Gupta D, Husain N, Husain M, Gupta RK. Analysis of microbial etiology and mortality in patients with brain abscess. *JInfect* 2006;53:221-7.
10. Carpenter J, Stapleton S, Holliman R. Retrospective analysis of 49 cases of brain abscess and review of the literature. *EurJClinMicrobiolInfectDis* 2007;26:1-11.
11. Ko SJ, Park KJ, Park DH, Kang SH, Park JY, Chung YG. Risk factors associated with poor outcomes in patients with brain abscesses. *J Korean Neurosurg Soc* 2014;56:34-41.
12. Han XY, Weinberg JS, Prabhu SS, Hassenbusch SJ, Fuller GN, Tarrand JJ et al. Fusobacterial brain abscess: a review of five cases and an analysis of possible pathogenesis. *JNeurosurg* 2003;99:693-700.
13. Colen CB, Rayes M, Rengachary S, Guthikonda M. Outcome of brain abscess by *Clostridium perfringens*. *Neurosurgery* 2007;61:E1339.
14. Nesky MA, McDougal EC, Peacock Jr JE. *Pseudallescheria boydii* brain abscess successfully treated with voriconazole and surgical drainage: case report and literature review of central nervous system pseudallescheriasis. *Clin Infect Dis* 2000;31:673-7.
15. Eryilmaz R, Sahin M, Hakan TM, Daldal E. Management of lactational breast abscesses. *Breast* 2005;14:375-9.
16. Leach RD, Eykyn SJ, Phillips I, Corrin B. Anaerobic subareolar breast abscess. *Lancet* 1979;1:35-7.
17. Edmiston CE, Jr., Walker AP, Krepel CJ, Gohr C. The nonpuerperal breast infection: aerobic and anaerobic microbial recovery from acute and chronic disease. *J Infect Dis* 1990;162:695-9.
18. Sousa EL, Gomes BP, Jacinto RC, Zaia AA, Ferraz CC. Microbiological profile and antimicrobial susceptibility pattern of infected root canals associated with periapical abscesses. *Eur J Clin Microbiol Infect Dis* 2013;32:573-80.

19. Siqueira JF, Jr., Rocas IN. Microbiology and treatment of acute apical abscesses. *Clin Microbiol Rev* 2013;26:255-73.
20. Tek M, Metin M, Sener I, Bereket C, Tokac M, Kazancioglu HO et al. The predominant bacteria isolated from radicular cysts. *Head Face Med* 2013;9:25.
21. Loesche WJ. Bacterial mediators in periodontal disease. *Clin Infect Dis* 1993;16 Suppl 4:S203-S10.
22. Hsu YL, Lin HC, Yen TY, Hsieh TH, Wei HM, Hwang KP. Pyogenic liver abscess among children in a medical center in Central Taiwan. *Journal of microbiology, immunology, and infection = Wei mian yu gan ran za zhi* 2015;48:302-5.
23. Pineiro-Carrero VM, Andres JM. Morbidity and mortality in children with pyogenic liver abscess. *Am J Dis Child* 1989;143:1424-7.
24. Moore-Gillon JC, Eykyn SJ, Phillips I. Microbiology of pyogenic liver abscess. *Br Med J (Clin ResEd)* 1981;283:819-21.
25. Dorvilus P, Edoo-Sowah R. *Streptococcus milleri*: a cause of pyogenic liver abscess. *JNatIMedAssoc* 2001;93:276-7.
26. Cheng AC, Currie BJ. Melioidosis: epidemiology, pathophysiology, and management. *ClinMicrobiolRev* 2005;18:383-416.
27. Bach MC. *Nocardia*. In: Gorbach SL, Bartlett JG, Blacklow NR, editors. *Infectious Diseases*. 2nd ed. Philadelphia: WB Saunders Company; 1998. p. 1969-73.
28. Finegold SM. Lung abscess. In: Mandell GL, Bennett JE, Dolin R, editors. *Mandell Douglas and Bennett's Principles and Practice of Infectious Diseases*. 5th ed. Philadelphia: Churchill Livingstone; 2000. p. 751-5.
29. Kumar S, Bandyopadhyay MK, Bhattacharyya K, Ghosh T, Bandyopadhyay M, Ghosh RR. A Rare Case of Pancreatic Abscess due to *Candida Tropicalis*. *JGlobInfectDis* 2011;3:396-8.
30. Arditi M, Yogev R. Perirectal abscess in infants and children: report of 52 cases and review of literature. *PediatrInfectDis J* 1990;9:411-5.
31. Brook I, Frazier EH. The aerobic and anaerobic bacteriology of perirectal abscesses. *JClinMicrobiol* 1997;35:2974-6.
32. Brook I, Anderson KD, Controni G, Rodriguez WJ. Aerobic and anaerobic bacteriology of pilonidal cyst abscess in children. *AmJDisChild* 1980;134:679-80.
33. Dubos M, Barraud O, Fedou AL, Fredon F, Laurent F, Brakbi Y et al. Prostatic abscesses and severe sepsis due to methicillin-susceptible *Staphylococcus aureus* producing Pantone-Valentine leukocidin. *BMC Infect Dis* 2014;14:466.
34. Ludwig M, Schroeder-Printzen I, Schiefer HG, Weidner W. Diagnosis and therapeutic management of 18 patients with prostatic abscess. *Urology* 1999;53:340-5.
35. Liu KH, Lee HC, Chuang YC, Tu CA, Chang K, Lee NY et al. Prostatic abscess in southern Taiwan: another invasive infection caused predominantly by *Klebsiella pneumoniae*. *JMicrobiolImmunolInfect* 2003;36:31-6.
36. Larsen RA, Bozzette S, McCutchan JA, Chiu J, Leal MA, Richman DD. Persistent *Cryptococcus neoformans* infection of the prostate after successful treatment of meningitis. California Collaborative Treatment Group. *Ann Intern Med* 1989;111:125-8.

37. Bagul NB, Abeysekara AM, Jacob S. Primary psoas abscess due to *Streptococcus milleri*. *AnnClinMicrobiolAntimicrob* 2008;7:7.
38. van den BM, de Marie S, Kuipers T, Jansz AR, Bravenboer B. Psoas abscess: report of a series and review of the literature. *NethJMed* 2005;63:413-6.
39. Jaik NP, Sajutha K, Mathew M, Sekar U, Kuruvilla S, Abraham G et al. Renal abscess. *JAssocPhysicians India* 2006;54:241-3.
40. Gardiner RA, Gwynne RA, Roberts SA. Perinephric abscess. *BJUInt* 2011;107 Suppl 3:20-3.
41. Shweikeh F, Saeed K, Bukavina L, Zyck S, Drazin D, Steinmetz MP. An institutional series and contemporary review of bacterial spinal epidural abscess: current status and future directions. *Neurosurg Focus* 2014;37:E9.
42. Darouiche RO, Hamill RJ, Greenberg SB, Weathers SW, Musher DM. Bacterial spinal epidural abscess. Review of 43 cases and literature survey. *Medicine (Baltimore)* 1992;71:369-85.
43. Rubin G, Michowiz SD, Ashkenasi A, Tadmor R, Rappaport ZH. Spinal epidural abscess in the pediatric age group: case report and review of literature. *PediatrInfectDisJ* 1993;12:1007-11.
44. Brook I. Microbiology of subphrenic abscesses in children. *PediatrInfectDisJ* 1992;11:679-80.
45. Farmahan S, Tuopar D, Ameerally PJ. A study to investigate changes in the microbiology and antibiotic sensitivity of head and neck space infections. *Surgeon* 2014.
46. Sowerby LJ, Hussain Z, Husein M. The epidemiology, antibiotic resistance and post-discharge course of peritonsillar abscesses in London, Ontario. *J Otolaryngol Head Neck Surg* 2013;42:5.
47. Adamidou F, Anagnostis P, Karras S, Kita M. Neck abscess associated with a piriform fossa sinus tract in an adult. *BMJ Case Rep* 2013;2013.
48. Biron VL, Kurien G, Dziegielewski P, Barber B, Seikaly H. Surgical vs ultrasound-guided drainage of deep neck space abscesses: a randomized controlled trial: surgical vs ultrasound drainage. *J Otolaryngol Head Neck Surg* 2013;42:18.
49. Taguchi M, Nishikawa S, Matsuoka H, Narita R, Abe S, Fukuda K et al. Pancreatic abscess caused by *Corynebacterium coyleae* mimicking malignant neoplasm. *Pancreas* 2006;33:425-9.
50. Dobinsky S, Noesselt T, Rucker A, Maerker J, Mack D. Three cases of *Arcanobacterium haemolyticum* associated with abscess formation and cellulitis. *EurJClinMicrobiolInfectDis* 1999;18:804-6.
51. Aligeti VR, Brewer SC, Khouzam RN, Lewis JB, Jr. Primary gluteal abscess due to *Salmonella typhimurium*: a case report and review of the literature. *AmJMedSci* 2007;333:128-30.
52. Al Tawfiq JA, Ghandour J. *Cryptococcus neoformans* abscess and osteomyelitis in an immunocompetent patient with tuberculous lymphadenitis. *Infection* 2007;35:377-82.
53. Eiring P, Wagner D. *Peptostreptococcus ivorii*-associated skin abscess in a HIV-infected patient. *Anaerobe* 1999;5:1-3.
54. Hoefele J, Kroener C, Berweck S, Peraud A, Grabein B, Wintergerst U et al. *Haemophilus paraphrophilus*, a rare cause of intracerebral abscess in children. *EurJPediatr* 2008;167:629-32.
55. Tsai SH, Peng YJ, Wang NC. Pyomyositis with hepatic and perinephric abscesses caused by *Candida albicans* in a diabetic nephropathy patient. *AmJMedSci* 2006;331:292-4.
56. Arya M, Arya PK. Pancreatic abscess caused by *s. typhi*. *Indian JMedMicrobiol* 2001;19:18-9.

57. Garner JP, MacDonald M, Kumar PK. Abdominal actinomycosis. *Int JSurg* 2007;5:441-8.
58. Altaie SS, Kohout-Dutz E. Actinomycosis masquerading as incarcerated incisional hernia. *Clin Microbiol Newslett* 1993;15:100-4.
59. Sawyer MD, Dunn DL. Antimicrobial therapy of intra-abdominal sepsis. *InfectDisClinNorth Am* 1992;6:545-70.
60. European Parliament. UK Standards for Microbiology Investigations (SMIs) use the term "CE marked leak proof container" to describe containers bearing the CE marking used for the collection and transport of clinical specimens. The requirements for specimen containers are given in the EU *in vitro* Diagnostic Medical Devices Directive (98/79/EC Annex 1 B 2.1) which states: "The design must allow easy handling and, where necessary, reduce as far as possible contamination of, and leakage from, the device during use and, in the case of specimen receptacles, the risk of contamination of the specimen. The manufacturing processes must be appropriate for these purposes". 1998.
61. Official Journal of the European Communities. Directive 98/79/EC of the European Parliament and of the Council of 27 October 1998 on *in vitro* diagnostic medical devices 1998. 1-37.
62. Clark AE, Kaleta EJ, Arora A, Wolk DM. Matrix-assisted laser desorption ionization-time of flight mass spectrometry: a fundamental shift in the routine practice of clinical microbiology. *ClinMicrobiolRev* 2013;26:547-603.
63. Espy MJ, Uhl JR, Sloan LM, Buckwalter SP, Jones MF, Vetter EA et al. Real-time PCR in clinical microbiology: applications for routine laboratory testing. *ClinMicrobiolRev* 2006;19:165-256.
64. Health and Safety Executive. Safe use of pneumatic air tube transport systems for pathology specimens. 2009.
65. Department for transport. Transport of Infectious Substances, 2011 Revision 5. 2011.
66. World Health Organization. Guidance on regulations for the Transport of Infectious Substances 2013-2014. 2012.
67. Home Office. Anti-terrorism, Crime and Security Act. 2001.
68. Advisory Committee on Dangerous Pathogens. The Approved List of Biological Agents. Executive HaS 2013. 1-32.
69. Advisory Committee on Dangerous Pathogens. Infections at work: Controlling the risks. Her Majesty's Stationery Office 2003.
70. Advisory Committee on Dangerous Pathogens. Biological agents: Managing the risks in laboratories and healthcare premises. Health and Safety Executive 2005.
71. Advisory Committee on Dangerous Pathogens. Biological Agents: Managing the Risks in Laboratories and Healthcare Premises. Appendix 1.2 Transport of Infectious Substances - Revision. Health and Safety Executive 2008.
72. Centers for Disease Control and Prevention. Guidelines for Safe Work Practices in Human and Animal Medical Diagnostic Laboratories. *MMWR Surveill Summ* 2012;61:1-102.
73. Health and Safety Executive. Control of Substances Hazardous to Health Regulations. The Control of Substances Hazardous to Health Regulations 2002. 5th ed.: HSE Books; 2002.
74. Health and Safety Executive. Five Steps to Risk Assessment: A Step by Step Guide to a Safer and Healthier Workplace. HSE Books. 2002.

75. Health and Safety Executive. A Guide to Risk Assessment Requirements: Common Provisions in Health and Safety Law. HSE Books. 2002.
76. Health Services Advisory Committee. Safe Working and the Prevention of Infection in Clinical Laboratories and Similar Facilities. HSE Books 2003.
77. British Standards Institution (BSI). BS EN12469 - Biotechnology - performance criteria for microbiological safety cabinets 2000.
78. British Standards Institution (BSI). BS 5726:2005 - Microbiological safety cabinets. Information to be supplied by the purchaser and to the vendor and to the installer, and siting and use of cabinets. Recommendations and guidance. 2005. 1-14.
79. Reddy S, Manuel R, Sheridan E, Sadler G, Patel S, Riley P. Brucellosis in the UK: a risk to laboratory workers? Recommendations for prevention and management of laboratory exposure. J Clin Pathol 2010;63:90-2.
80. Allen BW. Survival of tubercle bacilli in heat-fixed sputum smears. J Clin Pathol 1981;34:719-22.
81. Baron EJ, Miller JM, Weinstein MP, Richter SS, Gilligan PH, Thomson RB, Jr. et al. A Guide to Utilization of the Microbiology Laboratory for Diagnosis of Infectious Diseases: 2013 Recommendations by the Infectious Diseases Society of America (IDSA) and the American Society for Microbiology (ASM). Clin Infect Dis 2013;57:e22-e121.
82. Murray Patrick R EJB, James Jorgensen, Michael Pfaller, Marie Louise Landry Manual of Clinical Microbiology 9th edition 2007:293.
83. Rishmawi N, Ghneim R, Kattan R, Ghneim R, Zoughbi M, Abu-Diab A et al. Survival of fastidious and nonfastidious aerobic bacteria in three bacterial transport swab systems. J Clin Microbiol 2007;45:1278-83.
84. Barber S, Lawson PJ, Grove DI. Evaluation of bacteriological transport swabs. Pathology 1998;30:179-82.
85. Van Horn KG, Audette CD, Sebeck D, Tucker KA. Comparison of the Copan ESwab system with two Amies agar swab transport systems for maintenance of microorganism viability. J Clin Microbiol 2008;46:1655-8.
86. Nys S, Vijgen S, Magerman K, Cartuyvels R. Comparison of Copan eSwab with the Copan Venturi Transystem for the quantitative survival of *Escherichia coli*, *Streptococcus agalactiae* and *Candida albicans*. Eur J Clin Microbiol Infect Dis 2010;29:453-6.
87. Tano E, Melhus A. Evaluation of three swab transport systems for the maintenance of clinically important bacteria in simulated mono- and polymicrobial samples. APMIS 2011;119:198-203.
88. Miller JM, Holmes HT. Specimen collection, transport, and storage. In: Murray PR, Baron EJ, Pfaller MA, Tenover FC, Tenover RH, editors. 7th ed.: American Society for Microbiology; 1999. p. 33-63.
89. Holden J. Collection and transport of clinical specimens for anaerobic culture. In: Isenberg HD, editor. Clinical Microbiology Procedures Handbook Vol 1. Washington D.C.: American Society for Microbiology; 1992. p. 2.1-7.
90. Public Health England. Laboratory Reporting to Public Health England: A Guide for Diagnostic Laboratories 2013. 1-37.
91. Department of Health. Health Protection Legislation (England) Guidance. 1-112. 2010.

92. Scottish Government. Public Health (Scotland) Act. 2008.
93. Scottish Government. Public Health etc. (Scotland) Act 2008. Implementation of Part 2: Notifiable Diseases, Organisms and Health Risk States. 2009.
94. The Welsh Assembly Government. Health Protection Legislation (Wales) Guidance. 2010.
95. Home Office. Public Health Act (Northern Ireland) 1967 Chapter 36. 1967.
96. Song Y, Liu C, Finegold SM. Development of a flow chart for identification of gram-positive anaerobic cocci in the clinical laboratory. JClinMicrobiol 2007;45:512-6.