2 Engineering for ageing and longevity

§2.1 *Ageing and Health*

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The 'discovery' of ageing

- Over the past 50 years, environmental and social improvements and medical advances have increased the life expectancy of the world's population. The *population's **life expectancy** corresponds to the average number of years that a person at a specific age can expect to live, assuming that age-specific mortality remains constant.*
- Today, for the first time in human history, most people have a life expectancy of over 60 years. The increase in life expectancy over the past 100 years has been about 80 times faster than in the past 10,000. Furthermore, since the increase in life expectancy has been linear over past centuries and that life expectancy trajectories do not appear to be near a plateau, one study predicts that more than 50% of children born in 2000, in most Western countries and Japan, will become centenarians (Christensen et al., 2009).
- One of the consequences of this change is the **aging of the population**, due both to the reduction of infant mortality and infectious diseases in developing countries and to the previously described increase in life expectancy in high-income countries.

Longevity

- ***Longevity*** *is the ability to survive beyond the species-specific average age*.
- The oldest person ever lived, according to verifiable documents, was a French woman who died in 1997 at the age of 122. Such exceptionally long lives make us ask: what is the secret? The genes? What makes the difference? Is it the place where people live or how they live? Is it something they do or something they do not do?
- Several studies indicate that longevity reflects various underlying factors, including *genetics*, *environment*, and *health*. It also contains a *stochastic component* that results from the interaction between the individual probabilities of survival and the unexpected events that occur in life.
- It is commonly accepted that the genetic heritage explains about 20-30% of the variability in longevity, the stochastic component about 20%, and the other factors, in particular environmental ones, the remaining 50-60%.

Blue zones

https://www.bluezones.com/

Ikaria, Greece

Travel to this tiny Aegean island to discover the secrets of residents who live eight years longer than Americans, have half the rate of heart disease and almost no dementia.

Learn More

Loma Linda, California

Pull off the San Bernardino freeway east of Los Angeles and you'll encounter a community of Adventists teaching us new lessons about the power of faith, friendship and fruit.

Learn More

Sardinia, Italy

Visit this Mediterranean island—home to the greatest concentration of male centenarians in the world—and you'll discover healthy lifestyles that have not changed much since the time of Christ.

Learn More

Okinawa, Japan

Touch down on these South Pacific islands and you'll meet residents – including the world's longest-lived women – eating three foods that could help every American live longer.

Learn More

Nicoya, Costa Rica

Grab a bike and pedal along a path on this Pacific coast peninsula and you'll find colorful houses, exotic fruits and residents twice as likely as Americans to reach a healthy age 90. Is it something in the water?

Learn More

What is ageing

Ageing and the lifespan

- Ageing is a process we all undergo from the moment of our birth.
- At the beginning, ageing means **growing**, **getting stronger**, and **differentiating** ourselves while we build our *identities*, *gain experience* and *knowledge*.
- Around the age of 20, our physical, sensory, and cognitive capabilities peak and stabilize until we reach our 50s/60s.
- While our life experiences and our knowledge (and perhaps our wisdom) will continue to grow, our capabilities start to decline depending on factors like our genetics, lifestyle, and social environment.
- The exact reason of this decline is not yet entirely understood. Some theories speak of a natural and programmed process that takes place in our bodies, while others explain decline as the result of damage accumulated over time (Goldsmith, 2012).
- Independently of the reasons that determine decline, ageing unavoidably affects functioning as a complex interaction of genetics, chemistry, physiology, and behavior/lifestyle (Stibich, 2009).

Theories of ageing

- In recent years, several models have been proposed to explain the aging process.
- The *biological clock theory* implies that a specific biological clock would give each organism a share of time to perform its fundamental function, reproduction, causing systemic changes which, when it can no longer reproduce, cause its deterioration.
- The *genetic theories*, on the other hand, indicate in specific functional modifications of the genome the primum movens of the processes that lead to cellular senescence, with progressive accumulation of unrepaired damage at the gene level due to the constant exposure of the organism to extrinsic and intrinsic damaging factors.
- Finally, the *stochastic theories* argue that damage occurs randomly in the molecules and accumulates over time, leading to loss of cellular functionality. The most famous of the stochastic theories is that of *oxidative stress*, also called free radical theory. A free radical is any chemical species that, by containing one or more unpaired electrons, has a high energy instability that leads it to interact with nearby molecules, damaging them. According to this theory, *aging can be considered as a continuous process related to the accumulation of oxidative damage from free radicals to proteins, lipids, and nucleic acids.*

Theories of ageing

- As cells accumulate damage, the body expresses *symptoms*, *frailty*, *motor slowdown*, *disease*, and *functional disability*.
- The speed and severity of the accumulation of such damage depend on numerous conditions such as stress, nutrition, lifestyles, the environment.
- Biological changes at the old age are neither linear nor consistent, and they are only loosely associated with age in years. Thus, while some 70-year-olds may enjoy good physical and mental functioning, others may be frail or require significant support to meet their basic needs. In part, this is because many of the mechanisms of ageing are random. But it is also because these changes are strongly influenced by the environment and behaviours of the individual.

➔ Health in the geriatric age would result from numerous environmental influences, such as protective and risk factors, which act on a biological and genetic background specific to each individual throughout their life, starting from the intrauterine phase up to the geriatric age.

Macro-areas of manifestation of ageing

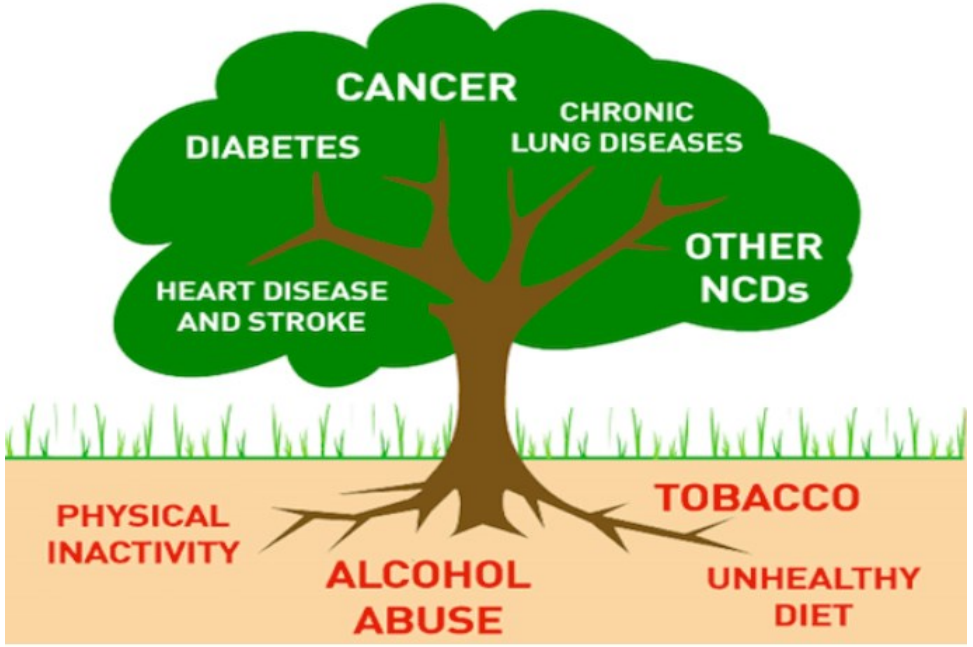
- Independently of health, there are three macro-areas of manifestations of age that group different phenomena that affect quality of life:
  1. **physical capacity**, i.e., the capacity to perform physical activities;
  2. **sensory capacity**, i.e., the capacity to capture and interpret information; and
  3. **cognitive capacity**, i.e., the capacity to process, reason on, and produce information.
- Common cardiovascular, neuromuscular, physiological, sensorimotor, and cognitive changes associated with ageing are summarized in the literature (e.g., see Morrison and Baxter, 2012).
- It is worth noting in this context that social, mental and physical lifestyle components may also beneficially effect on cognition and dementia (Fratiglioni et al., 2004).

Health and ageing

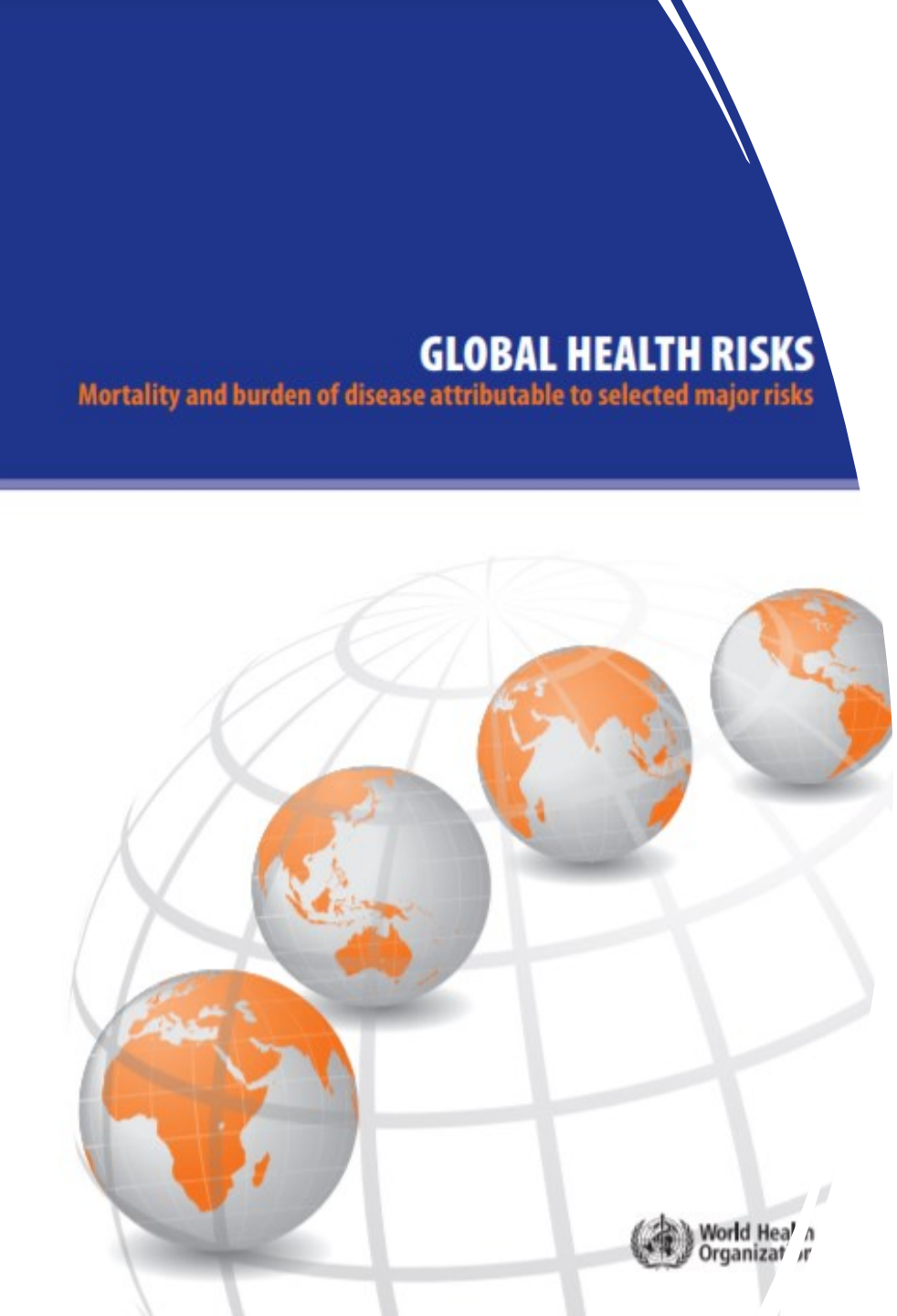
- Ageing often comes with **augmented risk of adverse health conditions** that may affect *physical, sensory* and *cognitive functioning*.
- Some of the most common age-related health problems are mobility and/or cognitive related.
- Sometimes the changes in physical capabilities come as a result of diseases.
- **Most of the health problems in old age are sensory losses and chronic non-communicable diseases** (WHO, 2015), which require constant monitoring and care.
- **Non-communicable chronic diseases** (NCDs) increase in most societies and negatively effect on physical and cognitive functioning. Examples of non-communicable diseases:
  - *diabetes*
  - *cancer*
  - *hypertension*
  - *dementia*
  - *Alzheimer's*
  - *Parkinson's*

Behavioral determinants of health

- Although research has shown that many of these conditions have their origins in early childhood, it is well known that **behavioral factors**; e.g., tobacco or alcohol consumption, a sedentary lifestyle, etc. **considerably increase the risk of developing or aggravating non-communicable diseases**.
- The likelihood of suffering cognitive decline or developing dementia increases with age, and is, furthermore, related to non-communicable diseases.
- The extent of usual age-associated cognitive decline - a.k.a. normal cognitive ageing - differs in extent between individuals. Some of the aspects of age-related cognitive decline already begin in healthy educated adults when they are in their 20s and 30s. There is growing appreciation, however, that factors affecting general bodily ageing also influence cognitive functions in old age.



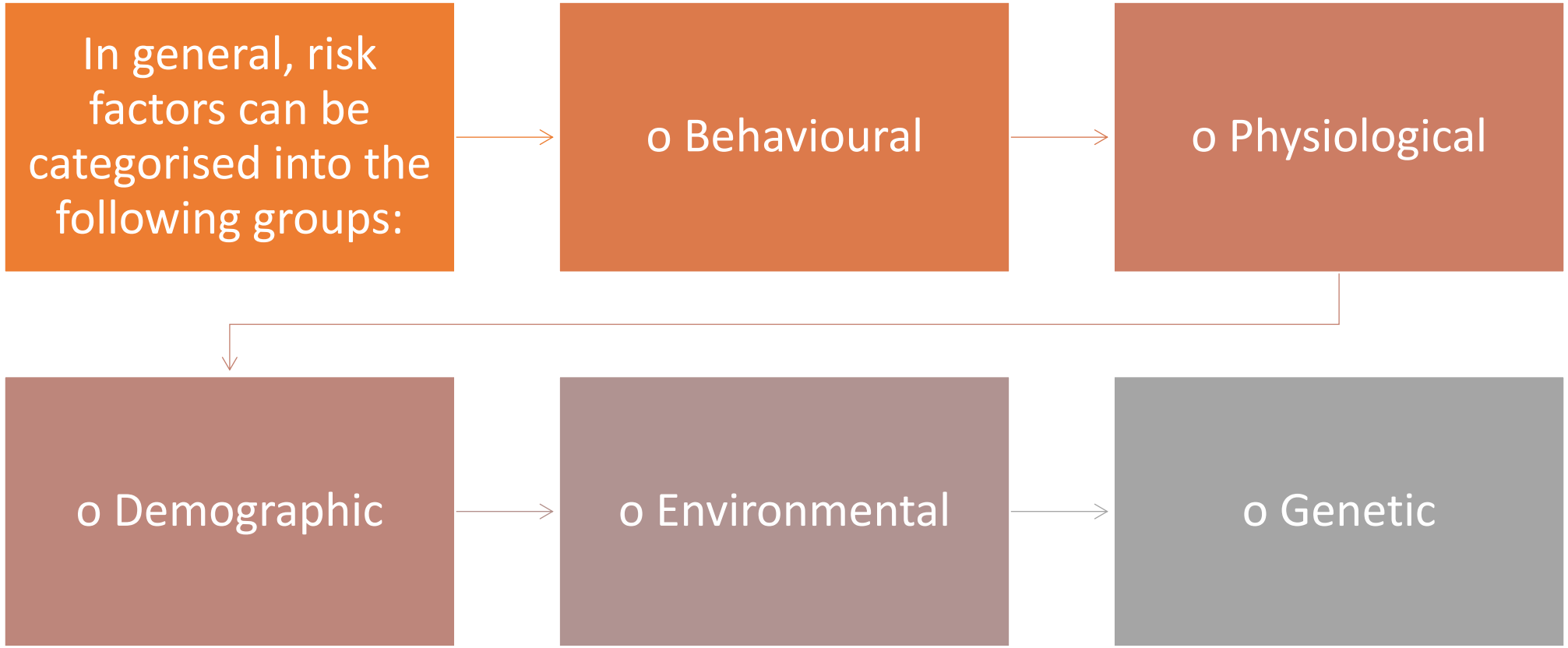
Non-communicable diseases and some of their causes (bmrat.org)



Risk factors in health and disease

- Health and wellbeing are affected by many factors – those linked to poor health, disability, disease or death, are known as *risk factors*.
- **A risk factor is a characteristic, condition, or behaviour that increases the likelihood of getting a disease or injury.**
- Risk factors are often presented individually, however in practice they do not occur alone. **They often coexist and interact with one another.**
- For example, physical inactivity will, over time, cause weight gain, high blood pressure and high cholesterol levels. Together, these significantly increase the chance of developing chronic heart diseases and other health related problems.
- Ageing populations and longer life expectancy have led to an increase in long-term (chronic), expensive-to-treat diseases and disabilities.

Risk factors in health and disease



Types of risk factors

Behavioural risk factors

Behavioural risk factors usually relate to 'actions' that the individual has chosen to take. They can therefore be eliminated or reduced through lifestyle or behavioural choices. Examples include:

- o smoking tobacco
- o drinking too much alcohol
- o nutritional choices
- o physical inactivity
- o not having certain vaccinations

Physiological risk factors

Physiological risk factors are those relating to an individual's body or biology. They may be influenced by a combination of genetic, lifestyle and other broad factors. Examples include:

- o being overweight or obese
- o high blood pressure
- o high blood cholesterol
- o high blood sugar (glucose)

Types of risk factors

Demographic risk factors

Demographic risk factors are those that relate to the overall population. Examples include:

- o age
- o gender
- o population subgroups, such as occupation, religion, or income

Environmental risk factors

Environmental risk factors cover a wide range of topics such as social, economic, cultural and political factors as well as physical, chemical and biological factors. Examples include:

- o access to clean water and sanitation
- o risks in the workplace
- o air pollution
- o social settings

Types of risk factors

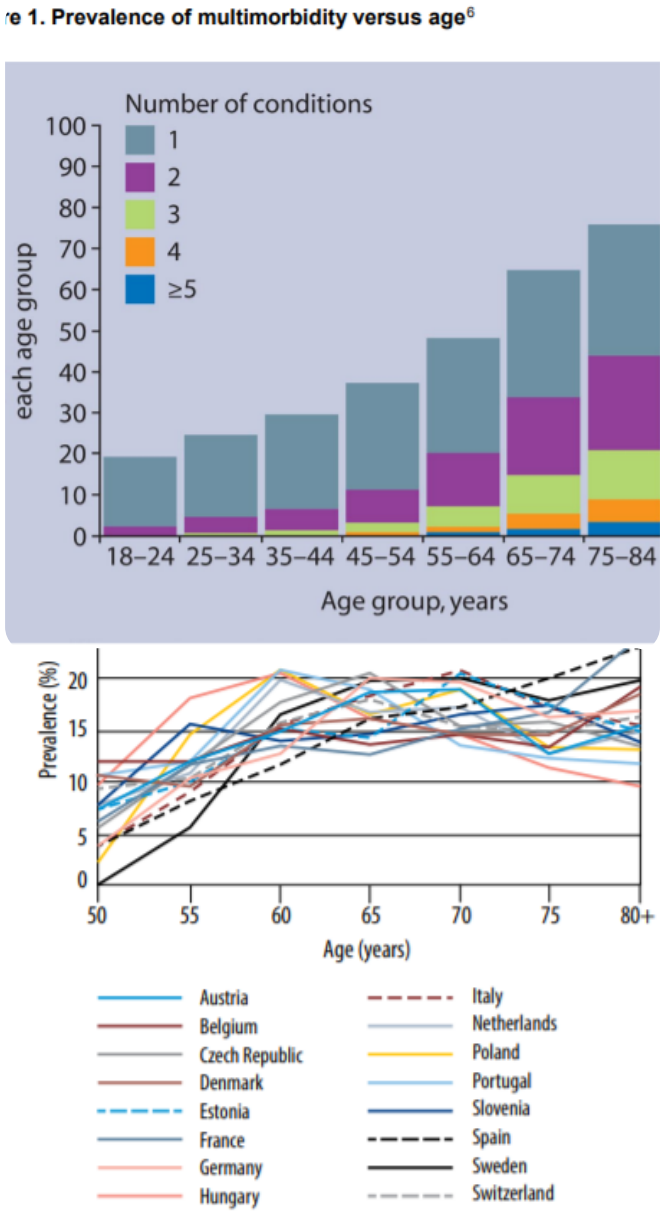
Genetic risk factors

Genetic risk factors are based on an individual's genes. Some diseases, such as cystic fibrosis and muscular dystrophy, come entirely from an individual's 'genetic make-up'. Many other diseases, such as asthma or diabetes, reflect the interaction between the genes of the individual and environmental factors. Other diseases, like sickle cell anaemia, are more prevalent in certain population subgroups.

Factors can be referred to different outcomes. Examples:

- Mortality
- Hospitalization
- Developing a disease/syndrome

Multimorbidity

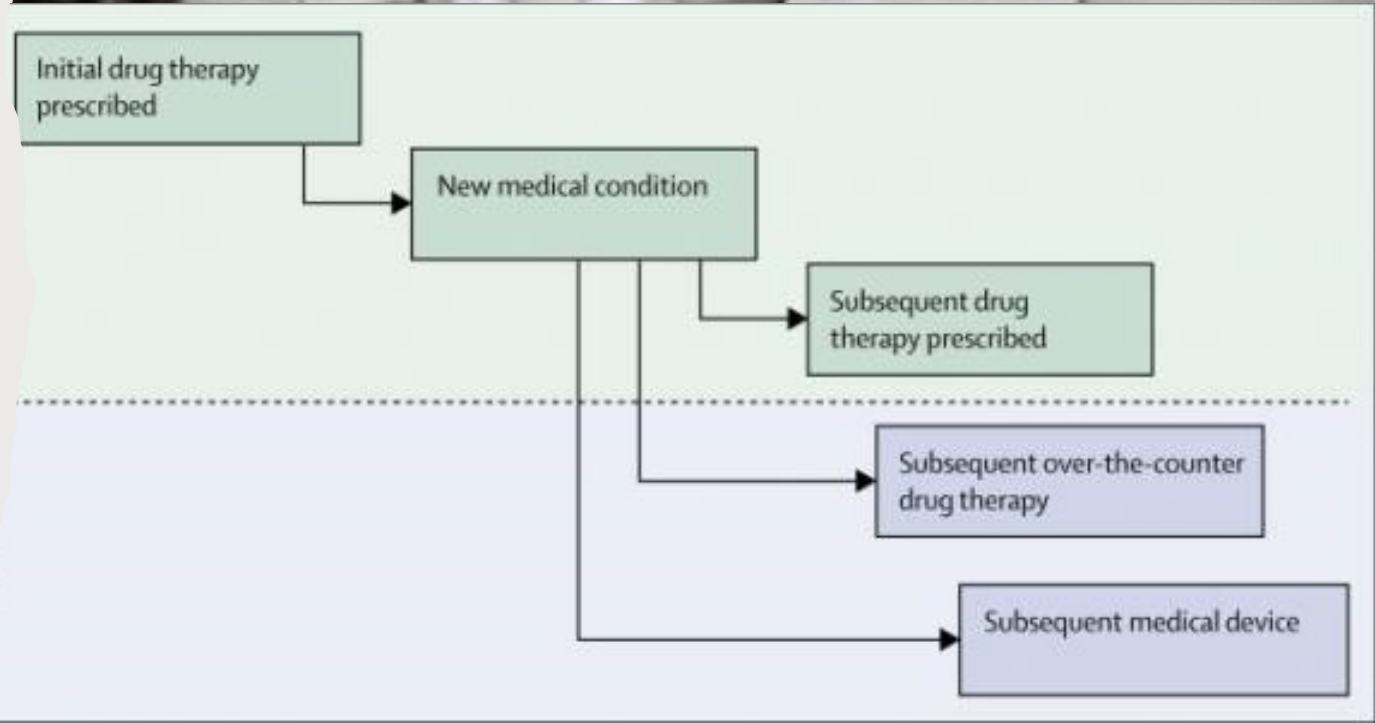


Note: Multimorbidity is generally defined as having two or more chronic morbidities (*72*). The following health conditions were included in the study: ischaemic heart disease, high blood pressure, stroke, diabetes, chronic obstructive pulmonary disease, asthma, arthritis, osteoporosis, cancer, Parkin-

- **Ageing is also associated with an increased risk of experiencing more than one chronic condition at the same time** (known as *multimorbidity*).
- Hence, it is simplistic to consider the burden from each of these conditions independently.
- **Multimorbidity can lead to interactions among conditions**; between one condition and the treatment recommendations for another condition; and among the medications prescribed for different conditions. As a result, *the impact of multimorbidity on functioning, quality of life and risk of mortality may be significantly greater than the sum of the individual effects that might be expected from these conditions.*
- Predictably, multimorbidity is also associated with higher rates of health-care utilization and higher costs.
- One large systematic review of studies in seven high-income countries concluded that **more than half of all older people are affected by multimorbidity**, with the prevalence increasing sharply in very old age (Marengoni et al., 2011). Additional studies in China and Spain yielded similar results.
- In high-income countries, the greatest increases in the prevalence of multimorbidity commonly occur in two periods: between the ages of 50 years and 60 years, and in advanced old age (see figure).
- Multimorbidity is more prevalent in people with low socioeconomic status.

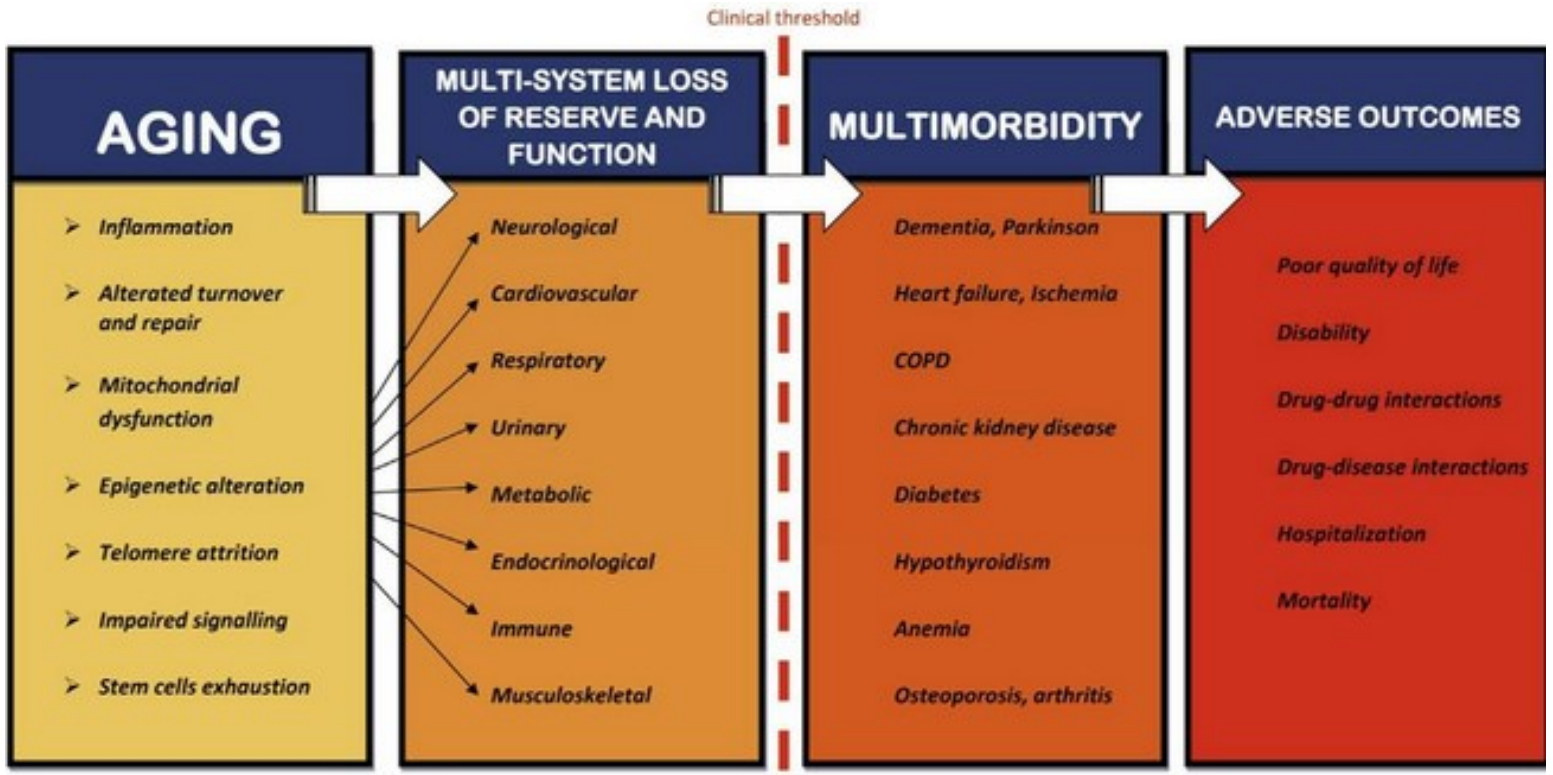
Multimorbidity

- One common consequence is **polypharmacy**, which may be appropriate in terms of the individual conditions being treated but places the patient at *risk of adverse drug interactions and side-effects*. However, the risk of drug interactions in comorbid and frail older people can limit the use of potentially beneficial pharmacological therapies.
- Most clinical trials fail to consider the impact of comorbidity, and generally exclude older people entirely, despite their altered physiology. This severely limits their usefulness in guiding care and optimizing treatment outcomes in patients at older ages. Innovative approaches are therefore needed to identify the best treatments for older people with comorbidities.



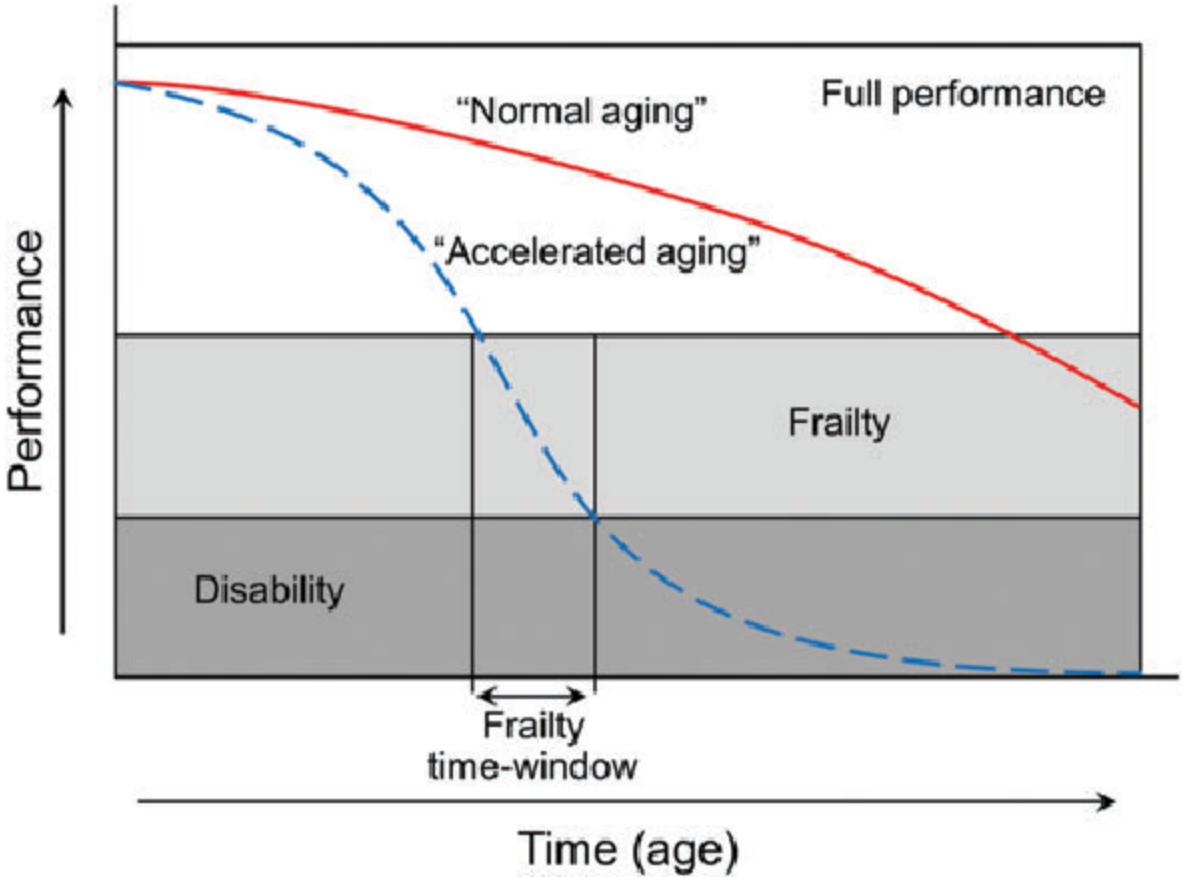
Multimorbidity

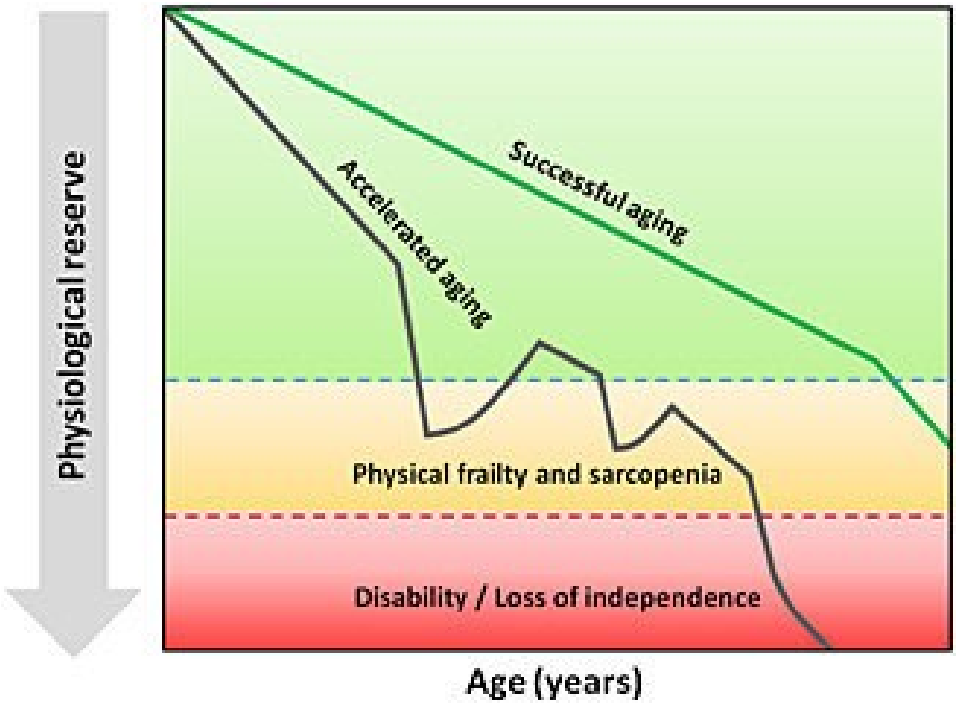
The age-related multisystem loss of reserve and function, rooted in the biological determinants of the aging process, is associated with increased susceptibility for chronic diseases, which becomes clinically evident as multimorbidity when a certain threshold of impairment has been a reached (Fabbri et al., 2015).



Different ageing trajectories

Trajectories of health and functioning with ageing





Ageing trajectories

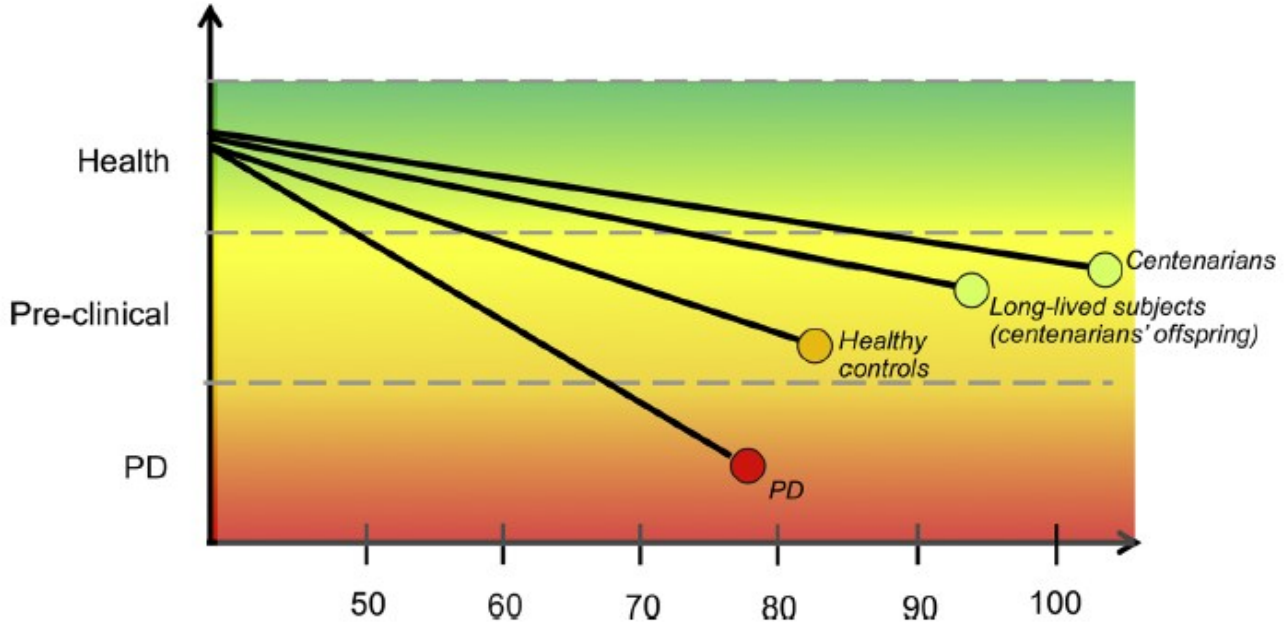
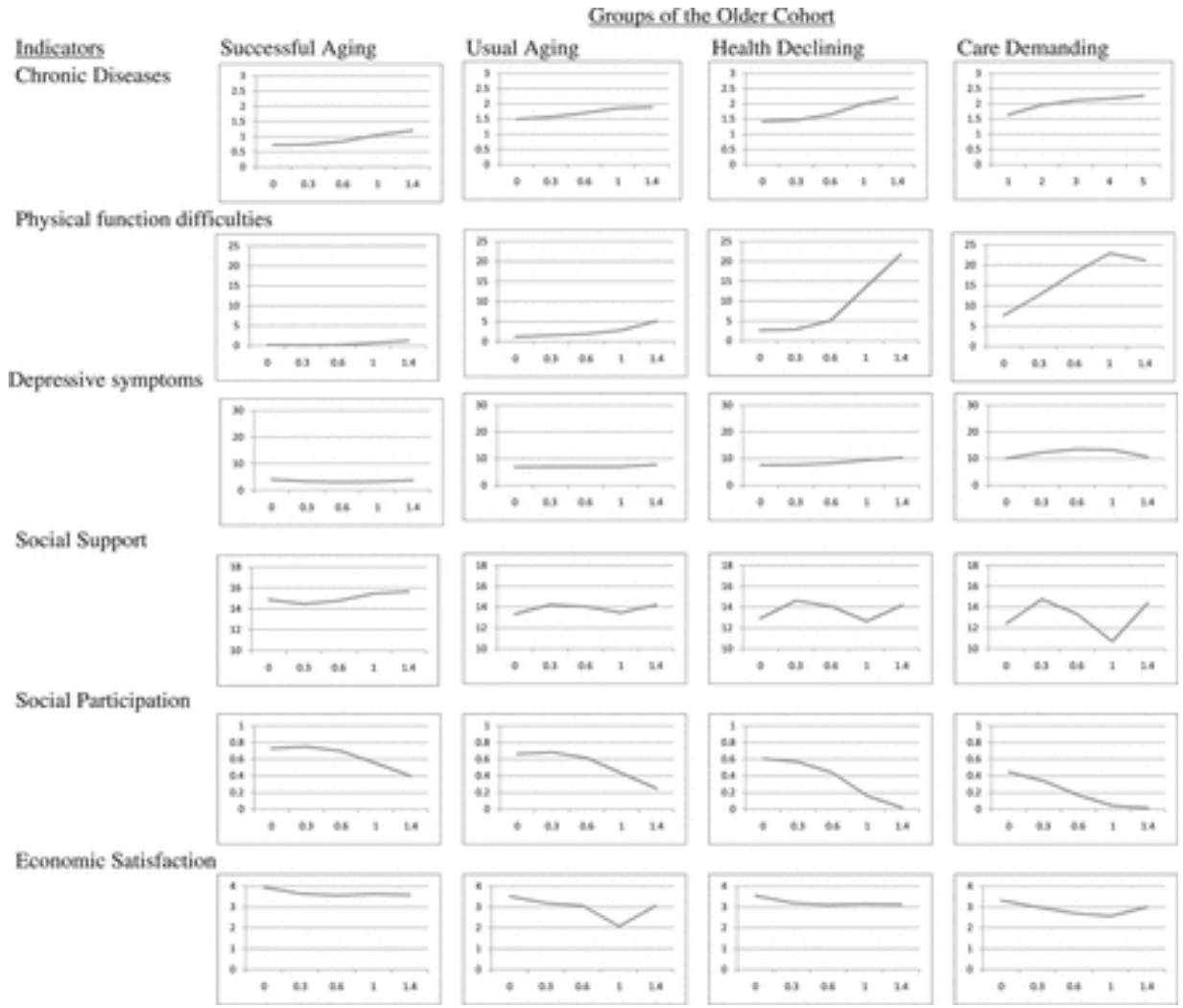


Fig. 1. The continuum between ageing and PD. The continuum is represented as a shade of color from green to red. Each line corresponds to the ageing trajectories of PD, general population (healthy controls) and long-lived subjects (centenarians and their offspring). The colour of circles corresponds to health status at death.

In 2016, 6.1 million people suffered from Parkinson's Disease (PD) worldwide (Dorsey et al., 2018). Among neurodegenerative diseases, PD is the second most common (after Alzheimer's Disease) and the one that displayed the largest increase in prevalence, which *more than doubled from 1990 to 2016*. ***This increase in the number of PD patients is largely, although not exclusively, sustained by the ageing of the population, as advanced age is acknowledged to be the major risk factor for developing PD*** (Reeve et al., 2014). Accordingly, PD is uncommon before 50 years and its prevalence steeply increases after 65 years, peaking between 85 and 89 years of age.

Pirazzini et al., Mechanisms of Ageing and Development, 2021

Figure 1. Multiple trajectories of successful aging.



Data from population-based studies

Zero-inflated Poisson probability distribution

$$\log\left(\text{chronic disease}_{it}^{j}\right) = \beta_0^j + \beta_1^j \text{Time}_{it} + \beta_2^j \text{Time}_{it}^2 + \beta_3^j \text{Time}_{it}^3 \text{and}$$

$$\log\left(\text{physical function difficulties}_{it}^{j}\right) = \beta_0^j + \beta_1^j \text{Time}_{it} + \beta_2^j \text{Time}_{it}^2 + \beta_3^j \text{Time}_{it}^3$$

Censored normal models

$$\text{Depressive symptoms}_{it}^{*j} = \beta_0^j + \beta_1^j \text{Time}_{it} + \beta_2^j \text{Time}_{it}^2 + \beta_3^j \text{Time}_{it}^3 + \epsilon_{it}$$

$$\text{Social support}_{it}^{*j} = \beta_0^j + \beta_1^j \text{Time}_{it} + \beta_2^j \text{Time}_{it}^2 + \beta_3^j \text{Time}_{it}^3 + \epsilon_{it}, \text{ and}$$

Logistic model

$$P^{jt}\left(\text{Social participation}\right) = \frac{e^{\beta_0^j + \beta_1^j \text{Time}_{it} + \beta_2^j \text{Time}_{it}^2 + \beta_3^j \text{Time}_{it}^3}}{1 + e^{\beta_0^j + \beta_1^j \text{Time}_{it} + \beta_2^j \text{Time}_{it}^2 + \beta_3^j \text{Time}_{it}^3}}$$

Censored normal model

$$\text{Economic satisfaction}_{it}^{*j} = \beta_0^j + \beta_1^j \text{Time}_{it} + \beta_2^j \text{Time}_{it}^2 + \beta_3^j \text{Time}_{it}^3 + \epsilon_{it}$$

Gerontologist, Volume 52, Issue 6, December 2012, Pages 843–856, https://doi.org/10.1093/geront/gns005

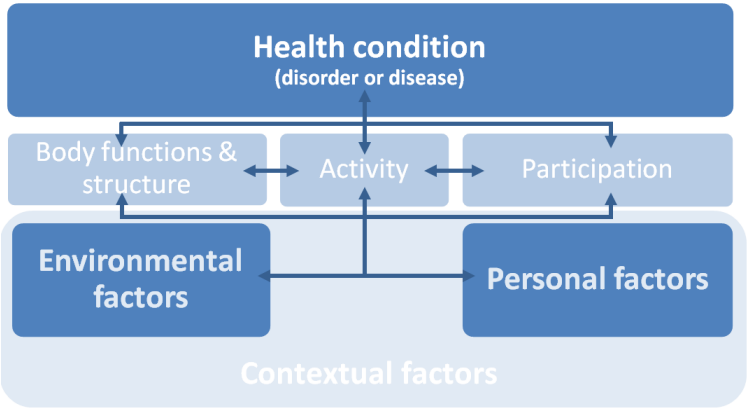
Comprehensive Geriatric Assessment (CGA)

- **Comprehensive Geriatric Assessment (CGA)** is a multidimensional and interdisciplinary evaluation used to assess older adults' medical, psychological, functional, and social capabilities and needs. The primary goal of CGA is to develop a coordinated and individualized plan to improve health outcomes and quality of life.

Key Components:

- **1. Medical Assessment:** Diagnoses, medications, and comorbidities.
- **2. Functional Assessment:** Activities of daily living (ADLs) and instrumental activities (IADLs).
- **3. Cognitive Evaluation:** Memory, decision-making, and mental health.
- **4. Social Support:** Living conditions and caregiver resources.

- **CGA is commonly used in geriatric medicine, oncology, and rehabilitation to guide care decisions.**
- The CGA and the biopsychosocial model of health are interconnected because both emphasize a holistic approach to healthcare.



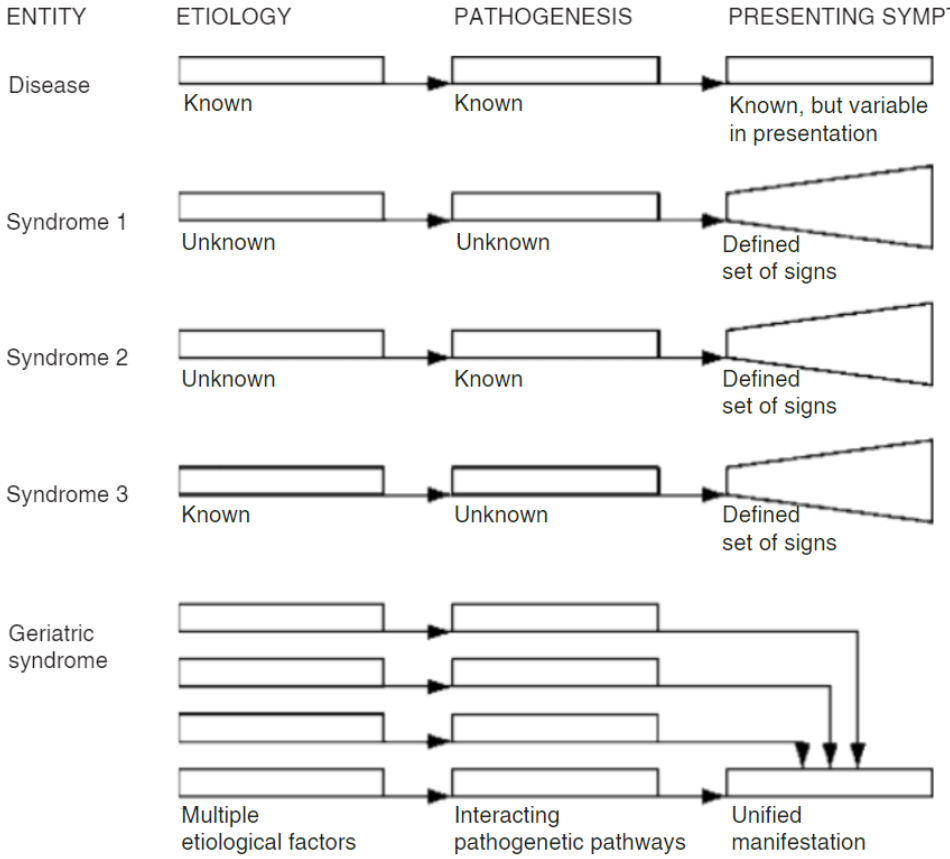
Other complex health issues in older age

- **Older age is also characterized by the emergence of several complex health states that tend to occur only later in life and that do not fall into discrete disease categories. These are commonly known as geriatric syndromes.**
- **They are often a consequence of multiple underlying factors and multiple organ systems, and the presenting complaint may not represent the pathological condition underlying it.**
- For example, an older person may present with acute cognitive decline or *delirium*, but this may be a consequence of underlying causes as diverse as an infection or electrolyte disturbance. Similarly, a *fall* may be a consequence of many underlying characteristics, including drug interactions, environmental factors and muscle weakness.

Geriatric syndromes

- In general terms, a "syndrome" has been defined as "a group of signs and symptoms that occur together and characterize a particular abnormality" or "the aggregate of symptoms and signs associated with any morbid process and constituting together the picture of the disease." Thus, in current medical usage, a syndrome refers to a pattern of symptoms and signs with a single underlying cause that may not yet be known.

- ***Geriatric syndromes***, by contrast, refer to "***multifactorial health conditions that occur when the accumulated effects of impairments in multiple systems render [an older] person vulnerable to situational challenges***." Thus, the geriatric usage of the term "syndrome" emphasizes multiple causation of a unified manifestation.



Schematic conceptual representation of clinical conditions defined by the terms "disease," "syndrome," and "geriatric syndrome," illustrating differences in numbers and complexity of relevant factors, including etiological risk factors, pathophysiological mechanisms, and presenting symptoms.

S.K. Inouye et al., J Am Geriatr Soc, 2007

Geriatric Giants

- There is still some debate as to which conditions may be considered geriatric syndromes, but they are likely to include:
  - *Frailty,*
  - *Urinary incontinence,*
  - *Falls,*
  - *Delirium,*
  - *Pressure ulcers*
- These appear to be better predictors of survival than the presence or number of specific diseases. Yet because of their **multisystem nature** that crosses many disciplines, they present challenges for traditionally structured health services and are often overlooked in epidemiological research.
- Innovative approaches to managing these comorbidities and syndromes of older age will need to be central to any societal response to population ageing.
- They also contribute largely to the so-called 'Geriatric Giants'.

Geriatric Giants is a term coined by geriatrician Bernard Isaacs (1981), and the expression refers to the principal chronic disabilities of old age that impact on the physical, mental and social domains of older adults: **immobility, instability, incontinence,** and **impaired intellect/memory**.
He considered them as «giants» because of «their high statistical frequency in older persons and the huge personal burden of sufferers, escalating the need for socio-medical interventions.»
Many of these conditions, commonly mis-perceived to be an unavoidable part of old age, can in fact be improved. An extended list now include:

1. Dementia
2. *Delirium*
3. Depression
4. *Incontinence*
5. Orthostatic Hypotension
6. *Falls & Dizziness*
7. Osteoporosis
8. Polypharmacy
9. Pain in the Elderly
10. Failure to Thrive
11. *Frailty*
12. Elder Abuse

Dementia(s)

- **Dementia is a syndrome characterized by progressive neurocognitive decline of sufficient magnitude to interfere with normal social or occupational functions, or with usual daily activities.**
- It is a broad diagnostic category that includes Alzheimer's disease, Lewy Body dementia, frontotemporal dementia, vascular dementia, Parkinson's disease, and Creutzfeldt–Jakob disease (among many others). It also includes rapidly progressive dementias that may be fully reversible if the etiology is correctly identified.

Epidemiology

- The global prevalence of dementia from all causes is estimated to be between 5% and 7% of adults over the age of 60.
- The incidence of dementia then doubles every 5 years after age 65.
- Alzheimer’s disease (AD) is the most common cause of dementia worldwide, and dementia rates start at 5-10% at age 70.
- By age 85, between 25% and 50% of people will exhibit signs of Alzheimer's disease.
- The percentage of all dementias due to Alzheimer's disease is at least 50% (with some estimates suggesting 60-90%).
- Females with dementia outnumber males by 2 to 1

Normal ageing and cognition. Decline in problem-solving, processing speed, and minor delays in word-finding can be common in normal ageing. Retrieval-type memory deficits are also commonly reported. In contrast to dementia, semantic memory and visuospatial functioning is generally preserved.

Dementia(s)

Prevention

- About 35%-40% of dementia cases are attributable to **modifiable factors** across the lifespan (Livingstone et al., Lancet, 2017).
- The 2020 Lancet Commission on Dementia Prevention, Intervention and Care includes **12 potentially modifiable risk factors** across the lifespan that can contribute to dementia:

Early life (<45 years)

1. Less education

Midlife (age 45 to 65 years)

2. Hypertension
3. Obesity
4. Hearing loss
5. Traumatic brain injury
6. Alcohol misuse

Late-life (age >65 years)

7. Smoking
8. Depression (note: depression likely has a bidirectional relationship with dementia risk, as it can be both a risk factor for dementia and a prodrome of dementia)
9. Physical inactivity
10. Social isolation
11. Diabetes
12. Air pollution

- There remains debate as to how many cases of dementia with modifiable risk factors can truly be prevented even with risk factor modification.

The World Health Organization (WHO) Dementia Prevention Guidelines

The World Health Organization (WHO) Dementia Prevention Guidelines recommends the following to reduce the risk of dementia:[9]

1. Physical exercise (there is some conflicting data[10])
2. Tobacco cessation
3. Reduce harmful drinking
4. Lose excess weight in midlife
5. Adhere to healthy diet (a Mediterranean-style diet may reduce dementia risk)
6. Cognitive training can be tried for adults with normal cognition or mild impairment (but the quality of evidence to support this is low)
7. Social participation and support are important throughout life (but limited evidence to support)
8. Hypertension, diabetes, and depression should be managed according to existing guidelines (but it is not clear whether doing so will specifically lower dementia risk)

Late-life depression

- **Geriatric Depression (also known as Late-Life Depression, or LLD) is a subtype of depression characterized by changes in mood, lack of pleasure, and often somatic symptoms in older adults.**
- It is one of the major geriatric giants. It is most defined as depression occurring in adults aged 60 and over.

Epidemiology

- The community prevalence rates of late-life depression is 11.2% for combined symptoms of major and minor depression.

Comorbidity

- Late-life depression is complicated by higher rates of medical comorbidity, cognitive impairment, and mortality.

Risk Factors

- Medical comorbidity, cardiovascular disease, low education, and increased age (Sözeri-Varma, 2012)

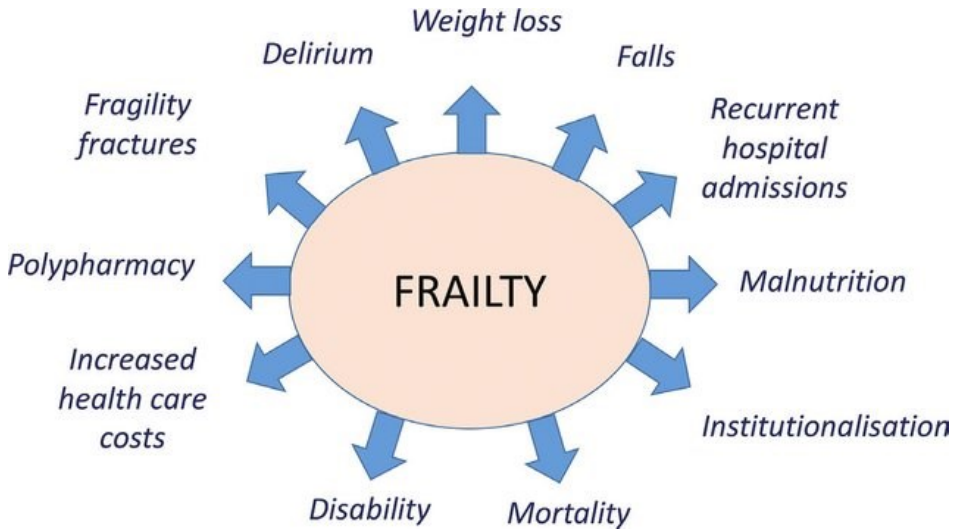
Pathophysiology

- The vascular depression hypothesis suggests that cerebrovascular disease predisposes, precipitates, or perpetuates depressive symptoms in late-life. Vascular disease (e.g. - atherosclerosis, strokes, white matter disease) are thought to affect fronto-striatal circuitry, resulting in executive dysfunction, depression, and cognitive impairment.

Frailty

- The definition of frailty remains contested, but it can be considered as a **progressive age-related decline in physiological systems that results in decreased reserves of intrinsic capacity, which confers extreme vulnerability to stressors and increases the risk of a range of adverse health outcomes**.
- Frailty, care dependence and comorbidity are distinct but closely related. One study found comorbidity in 57.7% of cases of frailty and care dependence in 27.2% of cases, with neither being present in 21.5% of frail cases (Fried et al., 2004).
- A large European study estimated the prevalence of frailty at age 50 years to 64 years to be 4.1%, increasing to 17% in those aged 65 and over (Santos-Eggimann et al., 2009). This same study found the prevalence of being prefrail at these ages was 37.4% and 42.3%, respectively. However, both frailty and prefrailty varied markedly among countries, being more prevalent in southern Europe. These findings are consistent with estimates from Japan and the Republic of Korea, where the prevalence of frailty in both countries has been estimated at around 10%. Frailty may be even more prevalent in low-and middle-income countries.
- Frailty is more common in women and in people with lower socioeconomic status.

Frailty



Consequences of living with frailty (one-to-many)

Possible thresholds for poor performance (and disclosing frailty?) across several domains

Frailty measures	Calculation	Threshold for poor performance (referenced for published norms)
Walking speed	**Six Minute Walk Test** [38]	**>80th% distribution of differences between predicted and actual 6MWT** [38]
Grip strength	**Dominant hand grip strength measured in sitting** [39, 40]	**< 10th% age-gender norms** [40]
Self-reports of unintentional weight loss	**Yes/ No**	**Yes (1)**
Self-reported physical activity [36]	**Accumulate 150 to 300 min (2 ½ to 5 h) of moderate intensity physical activity, or 75 to 150 min (1 ¼ to 2 ½ hours) of vigorous intensity physical activity, or an equivalent combination of both moderate and vigorous activities, each week.**	**1 = Less than median recommended time per week spent walking, and no moderate or vigorous activity** [36]
K10_tiredness score (Q. 1) [37]	**Single response item scored 1–5, with 1 = none; 5 = all of the time**	**4 or 5** [37]
Modified Functional Movement Screen (FMS) elements (0–3, with 0 being pain precluding activity, 1 being unable to attempt test, 2 being partial attempt; 3 successfullycompleted test) [31, 41]	Sum of scores for deep squat, hurdle step, in line floor lunge, opposite side arm / leg extension in four-point kneeling	≤12
Capacity to walk a flight of stairs [38]	Self-report Yes / No	No (0) [38]
GPCog [42]	Summed scores	≤8 [42]
BMI [43]	Underweight	≤18 [43]
BMI [43]	Overweight / obese	≥26 [43]
Lean muscle mass [44]	Calculated for males as 0.407* weight (kgs) + 0.267* height (cms)- 19.2; and for females as 0.252* weight (kgs) + 0.473* height (cms)- 48.3 [44]	≤24.5 [44]
Chronic health conditions	Total number of current chronic conditions	≥1
Health concerns	Any	1
Pain	Any pain * length of time suffered (years)	≥2
Total nutrition score [35]	Sum of (Yes scores to daily consumption of 5+ serves vegetables; 2+ serves fruit; mostly eat wholegrain or alternative grains; one serve day meat or alternatives; 2 serves dairy, limited intake of sugary drinks, processed foods and takeaways)	≤6
Water intake [35]	Not answering 'plenty'	0 [35]
Modified K10 [37]	Total score minus exhaustion component (Question 1)	≥12
Health concerns	Any	1
Continence concerns [33] (score 1 for each reported problem * degree of bother) [bother scored 1 = not at all to 5 = a lot]	Total score of urge incontinence, stress incontinence, frequency, problems emptying bladder, urinary leakage, discomfort, bulging pelvic floor, faecal incontinence	≥3
Unplanned health service use in past 12 months	Sum of number of unplanned hospitalisations, Emergency Department contacts	> 1
Living status	Alone	1
Total sleep quality score (PSQI) [34]	Summed scores	≥8 [34]
Near miss falls in last 6 months and/or falls in the last 6 months	yes, no	1 = yes (any)
Balance for 5 s (eyes open, standing on R or L leg) [45]	5 s is compliant for each leg (summed for Right + Left leg)	1 is < 10 s [45]
Balance for 5 s (eyes closed, standing on R or L leg) [45]	5 s is compliant for each leg (summed for Right + Left leg)	1 is < 10 s [45]

Falls and dizziness

Epidemiology

- Falls are commonly in the elderly. About **30%** of adults living in the community (> 65 years old) will have a fall each year. This increases to 40% in those greater than 85 years old. Nursing home residents will have an average of 1.6 falls from their beds each year. Almost half of all residents in nursing homes will have a fall more than once.
- Long term, falls result in increased disability, functional decline, loss of independence, reduced quality of life, fears of falling, depression, and social isolation.

Falls and fractures

- About **12-42% of falls will result in a falls-related injury**, and 20% will require medical attention. **10% of falls will result in a fracture**, of which 25% are hip fractures, which have a 20% mortality rate within 1 year.

Falls and dizziness

Falls Risk Factors

Adapted from: Public Health Agency of Canada. Seniors' Falls in Canada: Second Report. 2014

	Biological	Behavioural	Socioeconomic	Environmental
Risk Factors	• Age • Gender (females > males) • Acute illness • Balance and gait deficits • Chronic conditions and medical co-morbidity • Chronic disability • Cognitive impairment • Vision impairment • Muscle weakness • Reduced fitness	• Alcohol • Fear of falling • Inappropriate assistive device • Inappropriate footwear and clothing • Falls history • Poor nutrition and hydration • Medications • Risk taking behaviour • Vitamin D	• Living alone • Poor living conditions • Lack of social supports • Lack of transportation • Low education • Literacy • Language barriers	• Stairs • Home hazards • Lack of home equipment • Obstacles • Tripping hazards • Slippery or uneven surface • Inadequate building codes • Community design • Building maintenance • Footwear • Winter weather

Fall prevention

- Can we prevent falls? How?
- Which evidence is available?

Evidence

Cochrane Database of Systematic Reviews | Review - Intervention

Interventions for preventing falls in older people living in the community

Lesley D Gillespie, M Clare Robertson, William J Gillespie, Catherine Sherrington, Simon Gates, Lindy Clemson, Sarah E Lamb Authors' declarations of interest

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Abstract

Available in English | Español | فارسی | Français | 日本語 | 한국어 | Русский | ภาษาไทย | 简体中文 | 繁體中文

Background

Approximately 30% of people over 65 years of age living in the community fall each year. This is an update of a Cochrane review first published in 2009.

Objectives

To assess the effects of interventions designed to reduce the incidence of falls in older people living in the community.

Authors' conclusions:

Group and home-based exercise programmes, and home safety interventions reduce rate of falls and risk of falling.

Multifactorial assessment and intervention programmes reduce rate of falls but not risk of falling; Tai Chi reduces risk of falling.

Overall, vitamin D supplementation does not appear to reduce falls but may be effective in people who have lower vitamin D levels before treatment.

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Evidence

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Interventions for preventing falls in older people in care facilities and hospitals

Ian D Cameron, Suzanne M Dyer, Claire E Panagoda, Geoffrey R Murray, Keith D Hill, Robert G Cumming, Ngaire Kerse
Authors' declarations of interest

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Abstract

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Background

Falls in care facilities and hospitals are common events that cause considerable morbidity and mortality for older people. This is an update of a review first published in 2010 and updated in 2012.

Objectives

To assess the effects of interventions designed to reduce the incidence of falls in older people in care facilities and hospitals.

Authors' conclusions:

In care facilities: we are uncertain of the effect of exercise on rate of falls and it may make little or no difference to the risk of falling. General medication review may make little or no difference to the rate of falls or risk of falling. Vitamin D supplementation probably reduces the rate of falls but not risk of falling. We are uncertain of the effect of multifactorial interventions on the rate of falls; they may make little or no difference to the risk of falling.

In hospitals: we are uncertain of the effect of additional physiotherapy on the rate of falls or whether it reduces the risk of falling. We are uncertain of the effect of providing bed sensor alarms on the rate of falls or risk of falling. Multifactorial interventions may reduce rate of falls, although subgroup analysis suggests this may apply mostly to a subacute setting; we are uncertain of the effect of these interventions on risk of falling.

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