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Integrated Care and Fall Prevention in Active and Healthy Aging

Patrik Eklund

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This chapter provides a summary of current evidence on fall-risk increasing drugs from the literature (recent systematic reviews) and expert opinion on this topic (statement paper of EuGMS Task & Finish group on FRIDs and results of Delphi study of the group). Furthermore, deprescribing of FRIDs is being discussed.

Osteoporosis is a major cause of morbidity and mortality around the world and is a silent disease characterized by low bone strength that results in an increased risk of fracture. The benefits of being physically active in advanced ages to reduce the loss of bone mineral density (BMD) and improve functional capacities are well known. Quantitative ultrasound (QUS) is a peripheral bone densitometry technique that is rapidly gaining in popularity for the assessment of skeletal status, along with fall risk assessment. This chapter consists of a brief review of the literature on osteoporosis and describes ongoing activities on bone density and fall risk prevention in Algarve, Portugal as part of EIP AHA´s action group on fall prevention with the presentation of a preliminary study. This study aimed to demonstrate that the postmenopausal female seniors who adhere to the recommendations for the regular program of physical activity after osteoporosis screening one year later show a slower decrease in BMD.

With the increasing proportion of older persons globally, healthcare issues are becoming more complex. Older persons often spend substantial time confined to bed, which leads to physiological deconditioning and increased risk of falls. Fall-related injuries lead to higher hospitalization costs and worsening of the quality of life of older persons. Thus, monitoring of falls and reducing the risk of falls is an increasingly important element of geriatric care. Examined in this chapter will be aspects related to falls induced by immobilization (bedrest confinement). Interestingly, spaceflight-induced physiological deconditioning predisposes astronauts to higher risk of orthostatic intolerance and, consequently, falls. Since bedrest confinement is an established model for studying the deconditioning effects of spaceflight, knowledge drawn from bedrest studies can provide insights into the underlying mechanisms leading to falls in astronauts and in bed confined patients and in particular in bed-confined older persons who are typically dealing with the deconditioning effects of aging.

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Falls are an important clinical, socioeconomic, and public health problem in the older adult population. Advancing age is a major risk factor for mild cognitive impairment (MCI) and Alzheimer's disease (AD). The preclinical phase of AD, which is regarded as an important window for early therapeutic intervention before the onset of MCI and subsequently AD, can serve as a critical period to reduce or prevent falls among elderly people at risk of AD. In this chapter, first, a discussion is provided on the degrees of fall-related injuries, pain, and severity of falls in elderly people at risk of AD. Secondly, a discussion is provided on the clinical, socioeconomic, and public health implications of falls. Studies that integrated neuroimaging techniques were also reviewed to identify brain biomarkers that can be targeted for the prevention of falls among the elderly. It is anticipated that the outcome of this chapter may have a critical role in the prevention of falls among elderly people at risk or suffering from AD.

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Increasing life expectancy and the growing number of elderly people have also increased the number of comorbidities common in this population in the same proportion, where the risk of falling is highlighted and has been increasing in a worrying and negative way. However, the practice of physical exercise can

This chapter presents an exploratory review on the evaluation, assessment, and monitoring in health and fall risk by common and the most used assessment tools. The main discussion of this chapter of evaluation in health and fall risk is divided into six categories—global health assessment, specific physical (and fitness) assessment, cognitive and psychological assessment, pharmacological assessment, fall risk specific assessment, and some complementary assessment—which show information and how to access. Whereas health evaluative experiences and practices are essential to drive a better and specific intervention, revealing its importance and necessity was also highlighted.

The purpose of this chapter is to give a perspective of patient safety culture by users of public health units through a qualitative analysis of open questions asked. The sample consists of 241 patients from the health region of Algarve. The open questions were the object of content analysis in thematic and categorical form, followed by lexical treatment using the Iramuteq software. From the patients' point of view, the evolution of patient safety is the result of an understanding of the meaning of the highlighted terms (safety, health, meaning), as well as of the intervention and improvement in these categories. It is known with these associations that for the patient, patient safety involves the existence of professionals for each individual (personal) and the existence of a receptive and empathic nature on the part of the professionals (human), as well as the need to demystify care for the understanding of patients (technician/knowledge) and the provision of care completely focused on the patient (attention).

comparable to process descriptions annotated with clinical guidelines. This chapter describes an algebraic framework for representation of functioning data typically found in contexts of integrated care processes in healthy ageing.

Preface

Falls and related injuries are multifactorial phenomena, incidences of which increase with age. Falls can be viewed as consequences functional decline and frailty. Older people are frail because of a variety of functional limitations which are more likely to be present than any other geriatric syndrome. Attribution of falls to clusters of root causes is not easily done. Assessments of functionality are very often performed following an accident. This implies a hindsight bias because results do not necessarily reflects pre-accidental performance capacities. Furthermore, these end-of-chain measures do little to reduce the likelihood of new falls and events. It seems rather unlikely that the pattern of latent failures will be identical for the next event as intrinsic and extrinsic parameters are changing in a constant flow. It is of greater importance to elucidate those processes and factors that stabilize complex systems of health conditions. This approach of positive capacities gives place for a more personalized preventive approach.

This book of 15 chapters provides relevant theoretical and practical frameworks in the area of falls prevention. The target audience of this book of chapters are researchers and practitioners working in care pathways involving good practices of falls prevention, e.g. in home care and community care settings. Moreover, this book will provide insight and support leadership concerned with management of falls prevention as being part of integrated care of older people.

The first chapter on "Twin Contributors to the Physiology of Ambulatory Wellbeing and Falls Prevention in Ageing Populations: Functional Senescence and Abnormal Pathological Change" has its focus on predominantly aligned processes of natural senescence aligned with normal ageing processes, alongside those pathologies which constitute abnormal pathological processes, which occur more often in older adults as a consequence of these processes of senescence.

The second chapter on "Integrating Social and Health Services for People, Community Homes, and Places" provides examples of how to connect assessment, interventions, and monitoring to a coherent framework approach that mitigates the risks and the impact of falls on an ageing society. The chapter explores how technological innovation, urban planning and regional policies that are culturally relevant can be incorporated in creating a circular economy while meeting the needs of an aging population and preventing falls and cognitive decline.

The third chapter on "Fall-Risk-Increasing Drugs: Background, Current Evidence on Deprescribing, and Future Perspectives" provides a summary of current evidence on fall-risk increasing drugs from the literature and expert opinion on this topic.

The fourth chapter on "Bone Density and Fall Risk Screening in Algarve: A Preliminary Study" demonstrates that the postmenopausal female seniors who adhere to the recommendations for the regular program of physical activity after osteoporosis screening one year later show a slower decrease in the BMD.

The fifth chapter on "Effects of Spaceflight, Aging, and Bedrest on Falls: A Perspective" covers aspects related to falls induced by immobilization (bedrest confinement). Interestingly, spaceflight induced physiological deconditioning predisposes astronauts to higher risk of orthostatic intolerance and, consequently, falls.

The sixth chapter on "The Role of Neuroimaging in Fall Prevention in Healthy Adults at Risk of Alzheimer's Disease" provides a discussion on the degrees of fall-related injuries, pain, and severity of falls in elderly people at risk of AD. Further, a discussion is provided on the clinical, socioeconomic, and public health implications of falls.

The seventh chapter on "Fall Risk and the Use of Exercise as a Fall Prevention Strategy" has its objective of identifying how, which and when, physical exercise can contribute in relation to the risk of falling in the elderly. Through analysis of articles and recent reviews, the chapter addresses the influence of strength, power, aerobic, and multicomponent exercises in their various components and possible influences on the risk of falling.

The eighth chapter on "Falls Prevention in Education and Training of Healthcare Students, Professionals, and Non-Professionals" is the first of two chapters on education. Education is a key factor to prevent falls. National recommendations have been published to guide the health care professionals' work in falls prevention. In addition, interprofessional collaboration between different organizations have been done to prevent falls. This collaboration has produced evidence-based falls risk assessment tools, falls prevention programs and materials advising older adults to prevent falls. Health care and educational organizations use these methods and materials to educate professionals and students in the risk assessment and prevention of falls among older adults. Finland is a good example how health care professionals from different settings and universities have worked together to increase the knowledge about falls and skills to prevent falls. Good collaboration can prevent falls nationally.

The ninth chapter on "Falls Prevention Education: Good Examples From Higher Education" takes a European perspective. The development of new knowledge and research must be echoed in education and training of health care staff and also in the society. There is an urgent need to develop an interdisciplinary and interprofessional Master of Gerontology ("Master of Active and Healthy Aging"), which brings together research and practice.

The tenth chapter on "Health and Fall Risk Monitoring Within Common Assessments" presents an exploratory review on the evaluation, assessment and monitoring in health and fall risk by common and most used assessment tools. The main discussion of this chapter of evaluation in health and fall risk are divided in six categories: Global Health Assessment, Specific Physical (and Fitness) Assessment, Cognitive and Psychological Assessment, Pharmacological Assessment, Fall Risk Specific Assessment, and some Complementary Assessment, which are focused in show information and how to access according to its references.

The eleventh chapter on "Patient Safety: The Patient's Perspective From Public Sector Health Institutions in the Algarve" gives a perspective of patient safety culture by users of public health units through a qualitative analysis of open questions asked. The sample consists of 241 patients from the health region of Algarve. From the patients' point of view, the evolution of patient safety is the result of an understanding of the meaning of the highlighted terms (safety, health, meaning), as well as of the intervention and improvement in these categories.

The twelfth chapter on “Fall Prevention Activities and Resources in Norway: A Review” conducts the relevant literature review to determine current knowledge and practices related to adult fall prevention in Norway. It includes scientific publications on studies and tools. The review extends to include the clinical studies and resources offered by the healthcare sector that was made publicly available on their websites.

The thirteenth chapter on “Falls and Fall Injuries as Societal Challenge in Namibia” shows how the implications of falls on public health practice in Namibia are that approximately half of older adults do not discuss their fall incidents with health care providers. The aim of the chapter is, therefore, to define the concept falls focusing in the Namibian context and outlining the causes, highlighting the most vulnerable groups, and identifying the preventive measures.

The fourteenth chapter on “Integrated Care in Prevention: Maturity and Upscaling” discusses the distinction between health and health economy assessments, and proposes a Common Assessment Framework for Active and Healthy Ageing (CAFAHA) as ideally desirable, even if not yet fully feasible, given the activities developed within European Innovation Partnership for Active and Healthy Ageing (EIP on AHA) since 2012, now moving into its subsequent framework on Healthy Ageing.

The fifteenth and last chapter on “Information and Process in Health” underlines the importance of cooperation and partnership in healthy ageing enhances and enriches the underlying information and process models within integrated care. This chapter describes an algebraic framework for representation of functioning data typically found in contexts of integrated care processes in healthy ageing.

The idea for this book emerged from activities in the Action Group A2 of Falls Prevention within the European Innovation Partnership for Active and Healthy Ageing (EIP on AHA). Preventing falls and fall injuries continues to remain a target for prevention in Europe and around the world, as shown and represented by chapters in this book.

Chapter 1
Twin Contributors to the Physiology of Ambulatory Wellbeing and Falls Prevention in Ageing Populations:
Functional Senescence and Abnormal Pathological Change

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ABSTRACT

Being able to theoretically underpin the gerontology of ageing is a fundamental part of designing and constructing bespoke research and care interventions for the exploration of fall prevention in practice. Within the context of home care and community-based settings being able to integrate fall prevention into the integrated care that older people receive, their ambulation, health, and wellbeing, and subsequently their longevity in senior years, can be extended and sustained in terms of quality and satisfaction. This chapter contextualises and frames falls and fall injuries as a societal challenge by deconstructing the characteristic physiological processes of senescence and identifying key areas for fundamental address in the prevention of falls 'in situ'. The chapter's focus is predominantly aligned to those processes of natural senescence aligned with normal ageing processes, alongside those pathologies which constitute abnormal pathological processes, which occur more often in older adults as a consequence of these processes of senescence.

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INTRODUCTION

With increasing numbers of older adults living beyond the age of 65 years, so too is there a corresponding increasing number of falls in the home, which constitute the most significant number of injuries in adults of this specific age group (Moreland, Kakara and Henry, 2020). Statistical analysis reveals that the risk of falls increases exponentially with age, which can lead to potentially long term issues and challenges with the maintenance of ambulatory wellbeing as a consequence of resultant physical disability or impairment, and consequently contributes to poorer outcomes in quality and longevity of life (Tornero-Quiñones et al, 2020). Fatalities arising as a consequence of falls in those aged over 65 years and can be attributed to up to one third of all accidental deaths in this age group (Mielenz et al, 2020). These rates of mortality are largely preventable in relation to those necessitating long term care within nursing home and residential care settings (Drake et al, 2021). It is the normal processes of senescence, which impact on the physiological decline of ageing adults (Katsuumi, 2018; Faragher, 2017). Being able to accommodate and account for these within complex individual physical and social care provides a sound rationale for the integration of falls prevention strategies in the overall health continuum for older adults, where modifications can be made to prevent risk of future falls (Khong et al, 2017). Since once an older adult has fallen once, they are statistically two thirds more likely to fall again over the next 12 months, this can be a significant means of avoiding elevated rates of morbidity and mortality in this age group (Bartosch et al 2020; Gazibara et al, 2017). This chapter constitutes a theoretical contribution to the gerontology of ageing, so that the target audience can potentially develop a comprehensive knowledge and understanding of the physiological processes of senescence. For those professionals seeking to align strategic interventions with what is practically achievable remains one of the greatest challenges in this field of gerontology (Schapmire et al, 2018; Skinner, Andrews and Cutchin, 2017). Encouraging active and healthy processes of ageing not only benefits individual members of society, it has wider economic implications for health services, which deal with the implications of normal physiological senescence as greater numbers of older adults live into old age and, as a consequence of this, are more likely to live with morbidities which impact on their ambulatory health and wellbeing (Alcañiz, and Solé-Auró, 2018).

Functional senescence is part of a normal process of physiological ageing. This encompasses the gradual deterioration of the organs and systems of the body alongside a progressively decreasing capacity for function by the body's processes of homeostasis (He and Sharpless, 2017). In terms of finality, the process of senescence leads to progressive dysfunction and eventual death. The fact that this is a normal trajectory for the ageing body also provides an insight into how disease and ageing synergistically contribute to the acceleration of death in older adults (Herranz and Gil, 2018). Providing an understanding of the basic physiological knowledge within the context of the process of senescence and disease, and their relevance to potential falls prevention initiatives is the overall aim of this chapter

INTERRELATIONSHIPS OF MULTI-MORBIDITY AND SENESCENCE

As part of the trajectory of chronological ageing, statistical evidence provides an insight into the correlation between increasing age and increasing abnormal pathology. In this sense ageing is a natural process of physiological decline characterised by processes of physical change (Tieland, Trouwburst and Clark, 2018). It is these processes of the ageing process which can be attributed to the often very serious consequences of illness, which amongst their younger counterparts, may be perceived and experienced as relatively minor. Comorbidities in ageing individuals are far more common in adults aged 65 years and older and these directly impact on the development, prognosis and consequent management of illness (van Onna and Boonen, 2016). Those systems such as the neurological, vascular, respiratory and musculoskeletal systems demonstrate clear processes of degeneration with age, and as ageing progresses, pathology is statistically far more likely to present as being symptomatically atypical, meaning prompt assessment, diagnosis and management can be significantly delayed (Bisdorff et al, 2013). Depending on the nature of these presenting conditions, some of which may be progressive or even metastatic, in instances of cancer, this can have devastating consequences, which might otherwise have been far more treatable, if diagnosed at an earlier stage of the disease process. Similarly, many conditions arising in middle age or earlier may progress to conditions which in combination with natural processes of senescence can be potentially far more serious (Dodig, Čepelak and Pavić (2019).

Indicators of pathological processes, which might ultimately impact upon holistic processes of health and wellbeing are characterised by medical histories which for example may detail those conditions which were contracted or experienced in earlier life and which are now inactive but which may have a direct impact on an older person's capacity to cope with disease processes or indeed the degree of immune response they illicit in relation to infection (Rice et al, 2017). These medical histories may also provide an insight into current disease processes which are ultimately controlled by pharmacological and lifestyle changes, such as Diabetes mellitus or hypertension (Sciomer, 2019). In relation to this there can be an array of associated side effects of pharmacological interventions, which also mask signs and symptoms of pathologies which would benefit from early clinical diagnosis and management. The majority of these conditions can have a degree of relevance to the prevention of falls in ageing populations, since many develop slowly and can be termed progressive in terms of their degenerative impact. Typical example is atherosclerosis, which necessitates regular clinical monitoring so that medication can be appropriately modified to account for different stages of pathological change. Other conditions such as Multiple sclerosis or Rheumatoid arthritis can have relapsing and remitting stages, where preventative care in relation to the potential for temporary or progressive changes in ambulatory health and wellbeing can be successfully managed (Briggs, Thompson and Conway, 2019; Mankia and Emery, 2019). This can have a direct impact on the overall longevity of these older adults where care interventions and preventative measures ought to be tailored to the individual needs of each (Stambler, 2017). The value of interprofessional and multi-disciplinary working arrangements between medical and allied healthcare practitioners cannot be underestimated here, and the capacity of these team members to accommodate functional change in ambulatory wellbeing is invaluable in the functional physiological avoidance of falls (Kenny et al, 2017).

COMPLEX MEDICAL HISTORIES AND FALLS IN AGEING POPULATIONS

Of those diseases, which more commonly manifest in ageing populations, many predispose older adults to falls, even those which may have started at an earlier stage in the life course trajectory (Brännström et al, 2019). In conjunction with this, the assessment, diagnosis and prompt management of conditions is made more complex by the fact that older people are far more likely to present with atypical or very non-specific signs, which are often overlooked and quite wrongly attributed to 'old age' (Buttigieg, et al, 2018). What is worthy of note here, is that there is no one specific disease state that is particular to age, although the likelihood of occurrence may increase as part of normal processes of physiological senescence. Those disease states regarded as relatively minor in younger adults or children, can therefore lead to more serious outcomes for older people, especially in relation to falls when older adults are statistically far more likely to develop neurological, skeletal or vascular pathologies, all of which have a potentially direct and negative impact on the quality and longevity of life (Cho et al, 2018). Given that these conditions rarely exist in abstraction from one another the higher numbers of pathologies evident in older adults can complicate diagnoses and predispose them to a greater likelihood of falling (Padrón-Monedero et al, 2020).

FUNCTIONAL DEFINITIONS OF ‘OLD AGE’

Operationalising a functional definition of ‘old age’, is fraught with the danger of labelling someone on the basis of the chronology of their age, rather than their stage of functional senescence. Since ageing incorporates the age related changes of functional decline (senescence) and those processes of pathological change which ought not to be normalised, since there is the potential for them to be identified as treatable and as a consequence curable or at least manageable. The associated decline in vitality and the reduction in physiological performance at a cellular level acan lead to a reduced capacity to cope with environmental stressors and a correspondingly reduced capacity to cope either physically or psychologically with processes and outcomes of disease. Ageing is a slow and iterative process, which is largely variable impact at an individual level. The homogenisation that the term ‘old age’ brings to a whole generation is neither useful clinically or socially and often leads only to unintentional ageism, which directly impacts on the ability of older adults to access healthcare resources to the same extent as their younger counterparts (Covey, 1992). The need for accurate diagnosis and management of pathology ought not to be secondary to the recognition and value judgement attributable to changes in the visible appearance of people and biased assumptions of their physiological or anatomical status as a consequence. What cannot be denied is that the normal ageing process leads to death and that ageing impacts on all chronologically old people to a greater or lesser extent. The progressive and gradual deterioration of functionality and a lack of capacity for regulatory homeostasis in response to external stressors ensures a steady and progressive decline. Cytologically, there is a natural decline in the number of functional cells and in terms of medical assessment there is often a degree of ambiguity in relation to which cells are actually malfunctioning due to physiological change or whether these can, with any degree of confidence be attributed to the ageing process. Ultimately, there is no medical intervention that can halt this process and as a consequence the optimal quality of life for patients ought sometimes to be prioritised before the extension of their longevity. This systematic vulnerability to both disease and external stressors of human physiology are what actually characterise what is traditionally attributed to ‘old age’. Disease and ageing in this sense, progressively and systematically cause the acceleration in a reciprocal and irreversible process.

FUNCTIONAL ANATOMICAL CHANGES IN AGEING

As an integral part of the ageing process, there are distinctive anatomical changes in organs and physiological alterations that primarily lead to:

- Compromised neurotransmission
- Decrease in intellectual performance (e.g. leading to failing memory and confusion).
- Decreased renal perfusion
- Deterioration of special senses (e.g. leading to poor vision and loss of hearing)
- Exacerbation of deformity (due to the rigidity of collagen)
- Poor breathing capacity
- Poor oxygen uptake
- Reduced cardiac output
- Reduction in movement potential
- Reduction in nerve conduction velocity

PROGRESSIVE NERVOUS SYSTEM CHANGE IN AGEING

The sensitivity of the sympathetic receptors to circulating neurotransmitters is altered by the process of natural senescence in ageing. The greater intensity of response in the cardiac and vascular systems in older people have led to this being termed a hyperadrenergic state. In relation to a functional optimal nervous system in older years, no system demonstrates more clearly the need to remain active and to maintain a healthy lifestyle which engages capacity for ambulatory wellbeing and the prevention of falls in later life. The neurological system is dynamic in the sense that it changes throughout adulthood but this trajectory of change increases exponentially after the age of sixty-five years. This manifests in a decreased awareness to the sensations of touch and vibration (Mahbub, 2020). Increasing numbers of neurofibrillary tangles which develop within nerve cell bodies as a consequence of ageing are evident in the hippocampus. This is seen across all older people but to an even greater extent in those patients living with dementia. Those who have dementia have an increased number of neuritic or senile plaques, which have come to characterise the anatomical and physiological changes of Alzheimer's disease (Sengoku, 2020). Senile plaques are thickened masses of degenerating neurites (constituted of small axons, some dendrites, astrocytes) with an amyloid (starchy glycoprotein) deposit in the centre. Plaques most commonly occur as a result of pathological ageing, as in Alzheimer's disease, although they have also been frequently observed in normal ageing, beginning in the fifth decade of life (Sharma et al, 2020).

From the perspective of biochemistry, the decrease in enzymes actively involved in processes of neurotransmitter synthesis has been recorded alongside a dimininishing number of receptor sites or transmitters within the central nervous system and the peripheral nervous system. The reduction in motor system functionality is linked to the progressive decrease of dopamine uptake sites, which can be directly attributed to the loss of axons in basal ganglia pathways as part of age related change. Higher order association areas lose a greater number of neurons than the primary motor or visual cortex during the process of ageing, which has led to theories of how forgetfulness develops in older adulthood. Even a minor degree of neuron loss and decline in the capacity of dendrites to produce new spines has an impact. Whilst structural losses can be attributed to age related decline, which is also associated with processes of synaptic remodelling. This is closely linked to an overall decrease in sensory perception, alongside the presence of arteriosclerosis.

The functional implications of these changes all impact on the reaction time of older people. These processes are often attributed to the overall slowing of reaction time and the process of voluntary motor movement. Linked to physiological changes in muscles, this is another clear indicator of the need for older people to maintain a degree of physical fitness, which contributes to the maintenance of optimal reaction time in old people (Toots et al, 2019). Exercise in itself is not proven to significantly improve reaction time though, since movement slowness is related to change in neural pathways rather than to the extent of muscle health alone. Reaction time can basically be defined as the length of time between stimulation and the motor response effected by it. It is also associated with nerve conduction velocity. In terms of growth and development at the other end of life's trajectory, reaction time progressively improves as a child develops more complex and developed motor skills. Scientific studies of complex reaction time detail that in research where there is a choice between two responses, that as the task becomes progressively more complex, then reaction time increases in line with the increasing age of the study participant. The complex neurological processes involved in maintaining balance, mean that the individual risk of falls is exponentially higher in relation to their age and this is accompanied by a variable change in reaction times during progressive ageing, once people reach the age of 60 years.

In the prevention of falls, older patients typically may be living with a number of chronic disease states, for which they may be taking an equal number of medications. These systemic issues are predisposing factors to falling, which have a wider impact than just that of the individual who experiences them. Despite this, the chronologically aged ought never to be regarded as an indistinguishable category of personhood for whom there is minimal potential for the prevention of falls or systemic deterioration. The role of the health and social care multi-disciplinary team is invaluable in fulfilling this in the most optimal manner possible for the elderly.

FUNCTIONAL COGNITIVE ABILITIES

The synergistic relationship between the sensory and motor system is the basis for theories of intelligence, where cognition can be defined as the process of knowing and intelligence pertains to the application of knowledge (Sari et al, 2020). Cognitive processes specifically include:

- Attention
- Decision making.
- Learning
- Problem solving
- Reasoning

Without a degree of cognitive ability, negotiating the process of human ambulation is impossible and movement development is completely diminished. It is the nervous system which is responsible for cognition via the processing of thought and memory, where memories can be classified according to whether they are immediate, short or long term in duration. Whereas declarative memory entails the immediacy of memory, which may only last seconds or at most minutes, longer term memories can be recalled years later as they result in structural changes to the synapses that have a long lasting impact on signal conduction pathways. Ageing ensures an active decrease in capacity to undertake complex cognitive skills which involve memory. In those adults who are living with movement decline, it is also exceptionally important to consider their potential for change in memory ability.

Alongside these considerations, are considerations of what are termed either fluid or crystallised intelligence. Whereas fluid intelligence pertains to the logical capacity to form novel associations, and can be readily measured via tests of reaction time and memory, crystallised intelligence is linked to experience and the learning associated with it. Whereas fluid intelligence peaks early in the second decade and then diminishes, crystal intelligence forms the basis of wisdom and is deemed to increase with time. The reason why some adults remain alert and active mentally and others disengage or show signs of dementia still remains largely unknown and highlights the need for further research, which inevitably will impact on the field of falls prevention research.

SENSORY DEFICITS

Motor activity in adulthood is guided by the sensory ability developed during adolescence. Decline in sensory function begins in adulthood and is progressive in nature. It is important that these may or may not link to a general decline in function and not necessarily all people experience them. From a somatic perspective, some ageing adults demonstrate a clearly diminished ability to effectively detect touch, vibration, temperature and pain (Borzuola et al, 2020). The largest of the body's sense organs, the skin undergoes distinctive changes with ageing. From a structural perspective, the growth rate of the skin and its capacity to regulate temperature, injury response and to undertake growth diminish. Whilst extremes of temperature can be readily detected by older adults, their capacity to detect subtle temperature change is diminished. The sympathetic nervous system controls the degree of vasoconstriction and vasodilation to the skin and this is also impaired. Pain perception is still not fully understood in relation to the ageing process. Whilst deep pain diminishes with age, as yet research reports both an increase and a decrease in superficial pain sensitivity. What is abundantly clear, however, is the degree of vibrationary sensation diminishment which occurs in older adults usually starting at around the age of 50 but mainly in the feet and legs. The decline in sense of where joint positions are in space declines more evidently in women, particularly in relation to static joint position sensation at the knee joint, which may or may not be attributable to the functional impact of a gynaecoid pelvic girdle and the position the knees relative to the hips, but this has not yet been proven (Maitre et al, 2013). This can impair balance and may contribute to the increased incidence of reported falls in elderly women, which is a significant aetiological factor in all-cause mortality and morbidity.

MOTOR DEFICITS

The incidence of vertigo and dizziness are very common presentations in general practice in patients aged over 50 years. The vestibular system and in particular hair cells are demonstrably degenerating with the consequent symptomology of dizziness. In relation to the vestibular nerve, by the time a person reaches the age of 75 years, the overall amount of myelinated nerve fibres has been reduced to just 60% (Liu et al, 2017). Aas a consequence of this, reliance on the vestibular system alone can result in falls, an important consideration in falls prevention strategies. Healthy older people with less of a degree of sensory deficit, have less of a degree of postural sway than those who do and as a consequence are far less likely to fall.

OCULAR CHANGES

With a general increase in visual acuity increases in the twenties and thirties, which remains largely unaltered through to the forties and then declines, it is notable that by the age of 85 years there is an 80% less of visual acuity (Saftari and Kwon, 2018). It is the anatomical structural changes in the eye, which contribute to the apparent functional change. Accompanying processes of ageing, central vision may be impacted upon by the development of cataracts, which cause alteration of the lens. By the time people reach the age of 65, it is estimated that 60% of all people have a general reduction in their lens transparency (Donaldson et al, 2017). Cases of cataracts are more common in patients living with Diabetes mellitus.

VISUAL CHANGE IN RELATION TO THE POTENTIAL OF FALLS

Progressively the eye yellows due to the functional ageing process (Saftari and Kwon, 2018). The overall pupil size decreases and less light can enter the eye. By the time a person reaches the age of 60 years, the pupil has declined in size by at least 33%, with the resultant outcome that older people are far less likely to be able to detect low levels of light (Wolffsohn and Davies, 2019). If light becomes scattered over more of the retinal surface, then this results in glare. This glare then introduces external sources of light into the eye and because of retinal sensitivity loss, sudden flashes of light from headlights can transiently overstimulate the eyes. Alongside these manifestations, the contrast sensitivity and processes of adaptation to the dark decline dramatically with age. The loss of contrast sensitivity causes a loss of perception of depth, a major cause of falls on dark staircases and consequently a major aetiological factor in the increased incidence and prevalence rate of falls in the elderly (Rubiño et al, 2020). Whereas an adolescent might have functional adjustment to the dark in less than seven minutes, an 80 year old's eyes may well take up to forty (Wang, Hiang and Chen, 2020).

The gradual and progressive thickening of the lens and a consequent inability to focus is called presbyopia. With progressing age, from 40 onwards, there may be issues with adjustment from near sighted positions to long sighted perspectives. This can have important ramifications in being able to judge functional distance and can have an impact on falls and consequently falls prevention, where regular eye tests and the prescription of lenses for spectacles, where necessary, can be addressed. When there is a lack of functional capacity to adapt to change altogether, usually at the age of 60 or above, the person is said to have presbyopia (Mordi and Ciuffreda, 1998).

Whilst not especially relevant to the context of falls prevention, it is also important to remember the changes in hearing acuity, which occur as a consequence of the ageing process as an integral part of functional senescence. It is usually high frequency tones, which are first affected but the capacity for speech is less impacted upon, since speech is heard at a lower sound frequency, although in instances of presbybcusis, there might also be issues with speech processing and discrimination. This lack of discriminatory ability has more of a functional impact than hearing loss alone. Over 75% of all adults aged over the age of 75 years will experience this to a certain extent (ibid, 1998). Other associated sensory losses are in relation to the perceptions of taste and smell. It is pressure detection on the tongue which progressively alters, rather than tastebud functional decline, which is widely reported. Odour intensity detection capacity also decreases with age. There may also be issues of memory distortion and changes in relation to the psychology of eating, which impact on the perception of flavour and consequently the appeal of food for older people (Locher et al, 2009).

ADJUSTMENT TO ENVIRONMENTAL CONTEXT AND SETTING

It is the modification of motor behaviour, which has the greatest impact in the consideration of the aetiological prevention of falls. This can impact directly, along with musculoskeletal change on the capacity of people to remain mobile on uneven terrain or in situations or environments with which they are unfamiliar Lee and Ailshire, (2020). Sometimes older adults then need to use walking sticks or Zimmerframes, which can have an impact on self-image, as well as curtailing capacity for the individual movements they are capable of (Bertrand et al, 2017). Personality also impacts upon older peoples' perceptions of themselves in terms of their individuality and the homogenisation they sometimes feel as they are classified on the basis of their chronological age. This can also impact on their hesitancy to use aids to walking, which may be perceived as the preserve of the 'old aged' (Canada et al, 2020).

Functional Adaptations to Mobility in Ageing

Reaction time is commonly used to tangibly measure the capacity of an individual's central nervous system to pre-empt, initiate and sustain movement (Woo, Shin and Park, 2020). It has been found that in people aged 50 to 90 there is a directly linear increase in the time needed to plan for precise movements of the distal extremities.

Whilst there is no universally accepted definition of fitness, and this is as individual as everyone alive, there are some very general definitions, which describe fitness as a state of optimal wellbeing and the capacity to successfully meet the present and potential physical challenges of life. This has obvious implications during the process of ageing and consequently senescence. To be fit, therefore, is to be adapted, adjusted, qualified or suited to some purpose, function or aim. 'Fit' also describes a person in good physical condition, or 'healthy'. Physical fitness allows one, regardless of their age, to carry out daily tasks with a degree of alertness, without any sense of undue fatigue and with remaining energy to enjoy leisurely activities as well as being deliberately productive (Gadelha, 2018).

FACTORS INFLUENCING HEALTH AND FITNESS IN AGEING

Various additional variables out with chronological age can impact on relative fitness levels, such as growth and gender (Rea, 2017). What is clear, however, is that the capacity to undertake physical tasks iteratively declines with increasing age. Whilst this decline is primarily attributable to physical changes of senescence it is also evident that social and environmental factors are also greatly influential. This may be due to the decreased level of physical activity that older adults partake exercise performance levels can also be unduly influenced by environmental factors such as levels of pollution and air quality.

SOCIAL FACTORS IMPACTING ON PROCESSES OF AGEING

As well as the concept of longevity, social determinants of health have a great impact on the overall quality of lives lived, in contemporary society, namely:

- Educational opportunity – which provides a mechanism which people can become upwardly socially mobile and in turn be empowered and inspired to maintain a standard of living associated with positive health and wellbeing choices (Breen and Müller, 2020).
- Emergent technologies – which have ensured an access to both knowledge and the capacity to communicate never experienced prior to now.
- Public safety – which ensures that societal protection is evident in relation to the overall health and wellbeing of citizens and which can positively impact on quality of life and wellbeing (Prince et al, 2015).
- Social norms and attitudes, such as discrimination – being able to empower and provide a voice to what have been perceived as the most vulnerable members of society via democracy has enabled millions of people to live longer, more productive and healthier lives, instead of the oppression caused by discrimination on the basis of gender, sexual orientation, race or religion (Burnes, 2019).
- Social order – which impacts on the capacity of all people to live in areas that have a tangibly lower degree of exposure to crime, violence, and social disorder, all of which can make a radical difference to perceived and actual health and wellbeing status (Baumann et al, 2020).
- Social support and social interactions characterise human behaviour – in instances where people do not have these, they are at an increasingly greater risk of the development of anxiety and depression, which can have a cumulative and long term impact on perceptions and lived experiences of health and wellbeing (Briggs, Kennelly and Kenny, 2018).
- Socio-economics – the impact of available finances obviously impacts on the ability of people to access a regular income and to sustain a level of living that is commensurate with positive health and wellbeing (Petrovic, 2018).
- Transport infrastructure – being able to have access to travel, being able to drive and having having access to transport both enhance quality of life and achievable life experience. In some instances, this can also impact on the access to healthcare resources that people have, which can have a great impact on their capacity to regularly attend appointments or ensure their general health is optimal (Johnson et al, 2017).

PROGRESSIVE DEVELOPMENTAL CHANGE IN VASCULAR SYSTEM AGEING

Structural anatomical changes become evident in the heart, valves and vasculature with natural processes of ageing and normal senescence (Laina, Stellos and Stamatelopoulos, 2018). Within both the endocardium and the myocardium, elastic tissue, fat and collagen increase in the endocardium and myocardium of the heart, the outcome of which is a stiffer and far less compliant ventricular system (ibid, 2018). There is also an increased incidence of electrocardiographic abnormalities in the hears of older adults, with a demonstrable decrease beyond the age of 60years of cells in the sinoatrial node (Nishijima et al, 2018). Accompanying this, the valves become progressively more thick and calcified and this impacts on the closure and overall efficiency of the cardiac valves (ibid, 2018).

The proximal arteries have a tendency to dilate in parallel with increasing chronological age (Singam, Fine and Fleg, 2020). The increased amount of connective tissue and lipid deposition leads to a progressive thickening of the blood vessels. The consequent outcomes of this are an increase in vascular rigidity and a reduction in vascular compliance.

Within the cardiovascular system there are also notable changes in relation to ageing, which are not immediately apparent during rest. The increases at rest of the systolic and diastolic blood pressure can be attributed to the increased stiffness of the vascular system and decreased size of the peripheral vascular bed.

The compliance and elastic recoil of the pulmonary system are impacted upon by processes of natural senescence too, making it harder for respiratory muscles to move air into the system (Romano and Romano, 2020). The most evident being:

- Increased anterior-posterior diameter of the thorax
- Increased rigidity of the bronchioles
- Increased stiffness of the chest wall
- Structural changes in the elastic fibres of the lungs.
- Thickening of the mucous layer of the lungs
- Thoracic ankylosis and kyphosis

As a consequence of these changes, residual volume increases since more air is actively retained within the lungs. The amount of inspiratory reserve, expiratory reserve and vital capacity is reduced during both rest and active states. Alongside this, the surface area available for gas exchange also decreases due to changes in the function of the alveoli and substantial decrease in the number of pulmonary capillaries. Responses to ventilation in relation to increased levels of carbon dioxide or reduced levels of oxygen are also attributable to receptor, muscular or neuronal change. Ventilatory response in the elderly differs in older people can often be an indicator of exercise tolerance levels. There is evidence to suggest that training can effectively improve the changes in lung function which have been attributed to age (Seixas, 2020).

Older adults are generally happy with their level of fitness but underestimate their ability to exercise. As a consequence of this, they are less inclined to engage in exercise that is challenging to them, which again can have an impact in terms of how they react to exercise (Heiestad, Gjestvang and Haakstad, 2020). As a consequence this can place more physiological pressure on already vulnerable systems. where this develops to the worst extent older people may not be able to continue their daily activities of living with a functional state of dependency ensuing.

VISUAL INDICATORS OF AGEING

The gradual progression of grey and thinning hair, accompanied by skin wrinkling and decreased muscle tone and increasing fatty deposits, typically characterises old age. Physiologically comparable is the gradual deteriorating response to environmental stressors, with renal and digestive functionality progressively diminishing (Baker and Blakely, 2017. The functional response of the body to temperature regulation, dietary intake and oxygen supply means that the maintenance of a constant internal environment is more physiologically challenging. Alongside the progressive decline in the sheer number of cells older adults have, there is also a diminished functionality of those that remain. Beyond the context of the cells themselves, the extracellular fibres also change in terms of their quality, optimal strength and overall number. The arterial walls harden and there is an increased incidence of arteriosclerosis. This is primarily attributable to the thickening of elastin and the uptake of calcium across the cell membrane, which causes the characteristic thickening and hardening of the condition. Processes of mitosis become progressively reduced and diminished leading to the production of fewer replacement cells in the heart, bones and muscles (ibid, 2017).

In relation to the prevention of falls, these physiological changes are contributors to the physiological vulnerability of older people. Particularly where older adults develop more general issues in relation to their ambulatory health and wellbeing, where chronological age increases, the incidence of falls also exponentially increases. In relation to generalised pathological and age related change in the feet and lower limbs. The likelihood of tissue breakdown in the foot and lower limb is increased by ischaemia and peripheral oedema (Muchna et al, 2018). Healing can be further impaired by poor dietary intake, avitaminosis and poor tissue perfusion. Elderly people are more prone to develop neoplastic disease, as the incidence of neoplasm increases with advancing age. The disease state in the elderly is predominantly one of multisystem pathologies, many of which will be chronic degenerative processes that impair healing and negatively impact on the individual's overall wellbeing.

Overall constitutional deterioration predisposes older adults to the development of pneumonia, particularly in those cases where they have been confined to bed for a prolonged period or in instances where there is a concomitant decreased cardiac or pulmonary function or respiratory infection (Focillo, 2020). As a clinical outcome, pneumonia is also a common and frequently fatal complication following the occurrence of cardiovascular accident (CVA) or hip fracture, where major orthopaedic intervention is required and prolonged periods of immobilisation occur. Since generalised arteriosclerosis is more common in elderly patients, there can be extensive pathological change to the renal, coronary and cerebral vessels, resulting in pulmonary and peripheral oedema (Ungvari, 2018).

FALLS IN THE ELDERLY: THE FUNCTIONAL PHYSIOLOGY

The physiological impact of falls in the elderly can also lead to what is commonly known as 'post-fall syndrome' (Meyer et al, 2020). This leads to a reluctance to resume normal activities, stunted progress in the restoration of occupational normality and potentially anxiety and depressive episodes. The origin of these falls is often systemic in nature but can sometimes also be attributed to extraneous variables such as the external environment or the introduction of new drug therapies (Musich et al, 2017). In addition to this, from an anatomical and physiological perspective the origins of falls in the elderly can emanate from dysfunction or impairment, most commonly in relation to:

- Connective tissue disorders
- Dementia
- Endocrine disorders
- Myopathies
- Neurological deficit
- Vestibular function
- Visual capacity

THE FUNCTIONAL PHYSIOLOGICAL IMPACT OF POLYPHARMACY

As incidence and prevalence rates of multi-morbidity increase, so too do rates of polypharmacy (Kingston et al, 2018). Polypharmacy is defined as the concomitant use of five or more medications per 24-hour period by any individual, however many older patients use considerably higher numbers of medication (Delgado et al, 2020). Not only are prescribed medications used to treat the clinical symptomology of recognisable pathologies, they are often used to ensure that patients can live a more bearable life in relation to their potential to experience pain, as a consequence of natural processes of degeneration, so characterised by ageing and natural senescence (Veronese et al, 2017).

Since older adults can develop a pharmacokinetic and pharmacodynamics response to drugs as a consequence of increased physiological sensitivity, then they are also more likely to present with issues impacting upon their ambulatory health and wellbeing with symptoms such as dizziness (van den Anker, 2018). The need to reduce the amount of drugs taken due to the fact older people have decreased liver function and as such a correspondingly decreased capacity to optimally metabolise medication also places them at increased risk of adverse drug reaction (Drenth-van Maanen, Wilting and Jansen, 2020). Typical examples of these are local anaesthetics such as lignocaine or tricyclic anti-depressants, alongside stimulants such as caffeine. Systemic issues with renal clearance or renal dysfunction as part of the natural processes of senescence can also mean that drugs are not excreted effectively and remain in the system longer than they ought to – typical examples of these are those medications such as anti-hypertensive agents, which can directly result in postural hypotension and as a consequence of this, ambulatory unsteadiness and falls (Navaratnarajah and Jackson, 2017).

Added to the potential for complex dose regimen, for patients who might also have functional and/or untreated ocular decline, then the potential for drugs to be taken which are incompatible or even completely contradicted, is increased (Kim and Parish, 2017). Anti-hypertensive medications are not the alone as a significant drug group influencing the rate of falls in the elderly. Others include minor tranquillisers, hypnotics and sedatives, all of which can instigate postural instability, another precursor to falls. Considering their potential to depress central nervous system, this is hardly surprising. Those medications prescribed to reduce pain and swelling for musculoskeletal pain and injury such as non-steroidal anti-inflammatory drugs can also have side effects of fluid retention or oedematous lower limbs accompanied by dizziness, postural instability and a predisposition to fall. Postural hypotension can also be an unanticipated side effect of tricyclic antidepressants and diuretics, where blackouts, dizziness and fainting can be precursors to serious falls (Pan et al, 2018). Osteoporosis can be a side effect of the long term use of systemic corticosteroids, which can also lower immunity to infection and predispose patients to an increased likelihood of falls and bone fractures (Rice et al, 2017).

CONCLUSION

The process of normal ageing is fraught with the potential for additional diseases which can run concurrently with abnormal pathologies, which may remain undiagnosed or undetected. All have the potential to impact on the general health and ambulatory wellbeing of older adults, which can accompany natural processes of senescence to the ultimate degenerative state of death. Being able to embed a working knowledge of the functional anatomy and physiology of old age, regardless of original academic discipline or professional identity is fundamental to being able to intervene with strategies to ensure optimal safeguarding against unintentional falls. This chapter has provided only a brief introductory overview to the most common physiological and anatomical changes, alongside considerations of polypharmacy and the wider implications of co-morbidities in older people. Whilst this chapter is relatively functional in approach to the annotation of anatomy and physiology, it ought also to be noted that beyond this underpinning knowledge, older people ought to be facilitated and empowered to share their own perceptions, needs and wants of how they wish to age and how they would prefer to live lives as fulfilling as they wish. As healthcare professionals, our privilege is to address and act on the seminally scientific facts, alongside their voices of lived experience in the co-construction of new knowledge.

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KEY TERMS AND DEFINITIONS

Ageing: Ageing is the process of becoming older, which is characterised by a process of natural senescence in older adults.

Ambulation: Ambulation is the act, action, or an instance of moving about or walking.

Deterioration: Is the process of degenerating or becoming progressively worse.

Gerontology: Is the science and comprehensive multidisciplinary study of aging and older adults.

Morbidity: The term used to describe suffering from a disease or medical condition.

Mortality: Is the state of being subject to death.

Outcomes: The outcome of a phenomena is the way something turns out or the active consequence of something.

Physiology: The specific branch of biological sciences that deals with the normal functions of living organisms and their parts.

Polypharmacy: Polypharmacy can be defined as the concomitant use of five or more medications per 24-hour period by any individual person.

Psychology: Pertains to the mental factors governing a specific situation or process.

Chapter 2
Integrating Social and Health Services for People, Communities, Homes, and Places

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ABSTRACT

The challenge of an ageing population requires a paradigmatic shift in the way we provide social and healthcare services, demanding the need to prioritize the functionality and independence of older adults. The risk and subsequent fear of falling is one of the most high-risk states for older adults, as it generates a destabilizing effect on their health that is often hard to recover. It is essential to thoroughly address their risk factors and mitigators. This discussion needs to be made in light of a person-centered perspective that goes beyond fragilities to capitalize on the strengths of the older adults. The chapter provides examples of how to connect assessment, interventions, and monitoring to a coherent framework approach that mitigates the risks and the impact of falls on an ageing society. The authors explore how technological innovation, urban planning, and regional policies that are culturally relevant can be incorporated in creating a circular economy while meeting the needs of an aging population and preventing falls and cognitive decline.

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SUMMARY

The current challenge of an ageing population requires a paradigmatic shift in the way we provide social and health care services, demanding the need to prioritize the functionality and independence of older adults to improve their quality of life and ensure sustainability of systems. The risk and subsequent fear of falling is one of the most high-risk states for older adults, as it generates a destabilizing effect on their health that is often hard to recover. In order to set up a system that is capable of managing falls, it is essential to thoroughly address their risk factors and mitigators. Furthermore, this discussion needs to be made in light of a person-centred perspective that goes beyond fragilities to capitalize on the strengths of the older adults. The present chapter provides examples of how to connect assessment, interventions, and monitoring to a coherent framework approach that mitigates the risks and the impact of falls on an ageing society. We will explore how technological innovation, urban planning and regional policies that are culturally relevant can be incorporated in creating a circular economy while meeting the needs of an aging population and preventing falls and cognitive decline.

1. THE CHALLENGE OF AGEING IN EUROPE: AN OVERVIEW OF SOCIODEMOGRAPHIC CHANGES IN THE EU

The Ageing Report published by the European Commission in 2021 (European Commission, 2020) highlighted the total population in the EU is projected to shrink by 5% between 2019 (447 million) and 2070 (424 million), with differences in national population trends, that show in 11 Member States and falls in the others. Further reading of the Report highlights that the EU's demographic old-age dependency ratio (i.e. the ratio between people aged 65 years and over and those aged 20-64) is projected to increase significantly in the coming decades: From about 29% in 2010, it had risen to 34% in 2019 and is projected to rise further, to 59% in 2070. This will result in a shift from less than four working-age people for every person aged 65 years and over in 2010 to below two in 2070.

Life expectancy at birth for males is expected to increase by 7.4 years over the projection period, from 78.7 in 2019 to 86.1 in 2070 in the EU. For females, it is projected to increase by 6.1 years, from 84.2 in 2019 to 90.3 in 2070, implying continued convergence between males and females. the EU population is projected to decline from 447 million people in 2019 to 424 million in 2070, with a dramatic ageing process whereby the median age would rise by five years over the next decades.

The total cost of ageing (public spending on pensions, health care, long-term care, education and unemployment benefits), is expected to increase by 1.7 percentage points to 26.7% of GDP between 2016 and 2070. Within this scenario, long-term care and health costs are expected to contribute the most to age related spending rising by 2.1 percentage points between 2016 and 2070 (United Nations, 2019).

Demographic changes in the next 50 years not only mean that the population is getting older but also there will be less people contributing to the economic and financial prosperity of European countries, and State support to retired people will substantially increase. These demographic trends represent a multifaceted sustainability challenge for our societies: indeed, in Europe current policies will be faced with an increase by 4.1 percentage points of GDP between 2010 and 2060, from 25% to 29% that are age-related (pensions, health, and long-term care), with significant differences between countries (United Nations, 2019), thus threatening health equity. Raising the labour market participation of women and older workers could neutralise the effects of population ageing on the weight of pensions in the GDP.

Currently, the COVID-19 crisis is still running and its full medium/long-term consequences are uncertain, with the need to adapt economic policies to mitigate its short-, medium- and long-term impact.

In order to meet these challenges, it is pivotal supporting longer working lives by providing better access to lifelong learning, adapting workplaces to a more diverse workforce, developing employment opportunities for older workers and supporting active and healthy ageing.

Whilst this may address fiscal pressures it may not in itself decrease the burden and additional cost on health and social care systems in addressing age-related illnesses and diseases. Indeed, it may place additional burdens on the health and care systems as it looks to ensure older workers are fit and able to work. After all, they may also have age-related health needs, as well as any caring responsibilities that they can no longer provide if they are working longer.

Addressing these twin pressure points on society (age-related health and care needs, and fiscal gaps) will require Governments and Health and Care Providers to change the way health and care is planned and provided, by developing new models of social and health services. The 2021 Ageing Report interestingly outlines a "healthy ageing scenario", based on the relative compression of morbidity hypothesis and mimics improving health status in line with declines in mortality rates and increasing life expectancy. According to such scenario, future gains in life expectancy are spent in good health, reducing the morbidity rate and healthcare expenditure (European Commission, 2017).

A person's health and well-being will need to be considered in a holistic way, from prevention to treatment. We need to consider the social impacts as a key determinant of a person's health and well-being, from their living and leisure environment to their working lives. We will need to make greater use of health data, not just the individual's, but also other data collected at population level by health and social systems, so that health providers are better able to predict needs and trends. This approach engages individuals and society to prevent and better manage ill health, age-related diseases and social needs (Liotta et al, 2018a).

Joining up health and social services is critical: for example, if we want to address obesity it may be insufficient to focus on nutrition and food intake only, we may need to consider broader health and well-being plans covering physical activity that are tailored to specific socio-cultural contexts. We also may need to consider if there are any underlying conditions or potential causes (respiratory, cardiovascular etc) that could inform the types of physical activity a person could safely undertake. All this requires health providers to make greater use of the information it holds on a person, and how it uses and shares that information at the different levels (citizen and professionals across settings) to develop integrated care plans. This to allow the person to better self-manage their condition; to develop integrated treatment plans which will engage the right health and care professionals, as well as informal caregivers at the right time, providing the right treatment for the person (Clack & Ellison, 2019; Kickbusch et al., 2005)

2. EMERGING ECONOMIC AND HEALTH INEQUALITIES IN EU COUNTRIES

Although the financial crisis generated restrictions on healthcare spending (Schrecker & Bambra, 2015), survival rates of heart disease, stroke and cancer are all improving, in spite of increasing NCCD linked to worsening lifestyle factors (McNamara et al., 2017).

Such health inequalities are present in all countries, by gender, and across different age groups (Mackenbach et al., 2016; Beckfield et al., 2017), with a gap in life expectancy at age 25 between individuals with high level of education and low level of education around 2011 being—on average—7.7 years for men and 4.6 years for women (Organisation for Economic Co-operation and Development [OECD], 2017). The Health Inequality Report identifies three major determinants for this: health systems; economic policy; and the wider social determinants of health. The estimated cost of health inequalities in the EU is €980 billion per year, (Mackenbach et al., 2011). For example, increasing the health of the lowest 50 percent of the European population would improve labour productivity (Suhrcke et al., 2008).

Figure 1.

Life expectancy of people with low income and education is shorter than that of people from higher social classes in the EU (World Health Organisation [WHO] Europe, 2013; Commission on the Social Determinants of Health [CSDH], 2008). Supportive environments and disease prevention has been implemented by the partners of the EIP on AHA in the Blueprint for the Digital Transformation of Health and Care, where 2 of the 4 identified priorities focus on the use of digital solutions in supporting a proactive approach to health interventions:

- Data analytics for predictive risk stratification and prevention

- Proactive prevention through empowerment, self-management, monitoring and coaching.

2.1 From Reactive Disease Management to Proactive and Anticipatory Care

A paradigmatic shift from reactive disease management to anticipatory care, and early identification of risk for adverse health outcomes along the lifecourse is an effective and sustainable approach to address health inequalities (Forster et al., 2018). Besides the social determinants of health, also environment and community conditions play a role in outcomes, together with availability, accessibility and quality of health services (Beckfield et al., 2017; Eikemo et al., 2017; Huijts et al., 2014).

Engaging the community to identify needs, developing partnerships that are multilevel and multiorganization allow to carry out analysis, as well as to implement and evaluate evidence-based innovative interventions, thus ensuring sustainability. Artificial Intelligence provides the opportunity to extrapolate risk strata using big data from multiple datasources: the challenge we currently face is now to make datalakes interoperable, to allow correlation analysis and data sharing between professionals and inform citizens. This is reflected in 1 of the priorities of the Blueprint on Digital Transformation of Health and Care: Digital support for integrated care.

Digitally supported approaches that engage at risk individuals in the adoption of healthier lifestyles stimulate self-reported monitoring, as well as for communication between professionals and citizens (Jylhä, 2009; Norman & Bambra, 2007), while supporting interventions that are tailored to the different risk strata. Coherently, the Blueprint also identified the 4th priority: Digital solutions for connected health.

2.2 People at the Center: Meet the Personas of the Blueprint for the Digital Transformation of Health and Care

The European "Blueprint on Digital Transformation of Health and Care for the Ageing Society " (European Commission, 2017) reflects the common policy vision of European policy makers, civil society, professional organisations and industry guiding the efforts of the EIP on AHA Action Groups and Reference Sites to mobilise investments and ensure the commitment of all actors.

The Blueprint has been focusing four key areas of work:

- Data analytics for risk stratification and prevention;
- Proactive prevention through empowerment, self-management, monitoring and coaching;
- Digital solutions for connected health;
- Digital support for integrated care.

The demand-side perspective has been analysed through the set-up of 12 personas, representing "population segments" with different conditions, grouped into a range of categories, along a matrix of age frames and intensity of health needs. There are different time points along a person's life-course (pre-perinatal-childhood/young adulthood, working age, retirement and age under 80, and aged 80+), and several groups of needs intensity (generally well/good wellbeing, chronic conditions and/or social needs, and complex needs). Personas were developed along such matrix, in order to capture behavioural characteristic to take into account psycho-social forces and health choices influencing outcomes that could be improved by the adoption of digital solutions. The personas descriptions and their conditions were pivotal to extrapolate unmet needs and identify possible ICT solutions and categories targeting those needs, identifying and specifying key ICT enabling technologies and high-impact use-case scenarios for active and healthy ageing.

3. THE OPPORTUNITY OF THE DIGITAL TRANSFORMATION OF HEALTH AND CARE

3.1 Privacy Concerns for Data Analytics

The advent of new IT technologies applied to the health sector has introduced profound changes in healthcare processes:

- The technological evolution in healthcare provides new and powerful tools to support the redefinition of organizational-clinical processes, new diagnostic-therapeutic paths and new models of assistance to citizens / patients (Smart Health, eCare, etc);
- The evolution of the Medical Devices has led to the transition from single (stand-alone) medical devices to integrated and interconnected systems where sensitive data is exchanged and which could always be accessible (IT-MD Networks, MD sw, etc);
- The evolution of the management of systems and services in the health sector has opened up new scenarios for the data operability and usability, from Cloud Computing to the Internet of Think, from Mobile Health to Virtual Health.

At the same time, we realized the objective difficulty of allowing the data accessibility and while ensuring security and respect for privacy rights.

Indeed, new technologies introduce new risks for the operators and the end-user. These risks must be identified, assessed and managed both from an IT point of view (data and system security) and from a Medical Devices point of view (safety).

It is therefore necessary to apply new risk management models (identification, evaluation, measures and control) based on responsibility, and on the implementation of "system security" that is no longer only implicit in the device / technology.

Moreover, the entry into force of EU Regulation 679/16 (GDPR) has introduced important changes in the approach to Data Security.

This new approach, based on the concepts of accountability and risk management, pushes towards the implementation of a business management system based on Protection by default and by design, and on the adoption of adequate safety measures such as training, preventive maintenance and predictive, cybersecurity, business continuity, disaster recovery.

It is necessary, then, the healthcare companies are able to design and manage IT systems that:

- reduce the redundancy of information and the storage of data not strictly necessary for the purpose for which they are acquired, as required by the GDPR (protection by default);
- allow interconnection and interoperability between systems and with devices;
- guarantee safety and data security, but also the maximum usability of the information.

Therefore it is desirable to define a common Data Protection Strategy based on a process and systems standardization program at regional and national level, in which GDPR compliance is taken for granted.

3.2 Proactive Prevention Through Empowerment, Self-Management, Monitoring and Coaching

Technologies in health care will be a critical tool to transform health systems and services towards emancipatory models of person-centered and integrated care, adequate to older adults and aligned with the Health Ageing agenda (WHO, 2015). To promote a proactive prevention of poor health outcomes in geriatric care, older people should be included in the set up of their own therapeutic care planning. Specifically, the translation of person-centredness into practice needs to consider their personality, social networks, lifestyle, beliefs, interests and satisfaction with life (Smith & Gerstorf, 2006).

The significant increase of technology in health care has the potential to improve older adults' quality of life (Hamm et al., 2016). For example, technology might assist to bridge communication between older adults living at home with their healthcare team, as well as with the community and social services. Such connections have shown impact on reducing loneliness and isolation, supporting independence, facilitating self-management of illness and social conditions. Concerning their health, older adults are empowered trough technology to use wearable devices to monitor their health parameters and make changes towards improvement of their health status with the support of health professionals coaching. Such a process their awareness of healthy behaviors, supports health literacy and promotes their engagement in actives that can promote a successful ageing in place (WHO, 2015).

For these examples to become a reality, usability challenges of technological solutions in older adults have to be overcome. To accomplish the wished goals in fall prevention through technological interventions, designers should have a co-creation approach from early-design stages of intervention development. One possibility might be the creation of personas to assist in the co-design of person-centered interventions for community-based fall prevention. Personas portray older adult experiences and are an asset to communication and tailoring of individual needs and preferences. Such co-construction is expected to enhance acceptability of technological solutions among older adults (Bianco et al., 2015).

3.3. Digital Solutions for Connected Health

Health enabling technologies and sensor enhanced health information systems can innovate the way we live and manage our health, influencing interactions, and exchange of information. This is especially true when they are paralleled by adequate ICT and health literacy initiatives empowering citizens.

An active social life can slow health decline and improve physical fitness. Even if social activity is not considered to be formal exercise, socialization stimulates people to get up, and move out of the house. The development of a community of citizens/patients, supported by IT, may allow to share experiences of disease management and increase participation in social activities that improve their physical fitness and psychological condition. PERSSILAA (PERsonalised ICT Supported Service for Independent Living and Active Ageing) is a multimodal service model, focusing on nutrition, physical and cognitive function, supported by an interoperable ICT service infrastructure, utilising intelligent decision support systems and gamification. PERSSILAA, offered to older adults (> 65 years) through local community service, has proved effective in frailty prevention when been seamlessly integrated with health care services (O'Caoimh et al., 2017). PERSSILAA has been engaging older adults by personalized offer of a gamification layer. Serious games indeed can help patients to improve their health by enhancing physical fitness and coordinative abilities by combining increased motivation, game experience like fun and game flow and training. Serious games, particularly adventure and shooter games, already play an important role in health education, prevention and rehabilitation, e.g. to enhance health-related physical activity, improve sensory–motor coordination, change nutrition behaviour and prevent smoking (Wiemeyer & Kliem, 2012).

Studies trialling multi-domain interventions targeting at risk populations show that cognitive stimulation when deployed with other lifestyle measures and cardiovascular risk-factor assessment and treatment may reduce progression to dementia (Ngandu et al., 2015).

Cognitive training typically involves guided practice on a set of standardised tasks designed to reflect particular cognitive functions. Technology-based cognitive training and rehabilitation have demonstrated promising beneficial effects on various domains of cognition with moderate to large effect sizes (Ge et al., 2018). Neuropersonal Trainer® is a web-based platform for cognitive telerehabilitation through personalized gamified treatments for patients with neurological afflictions (brain damage, MCI, dementia, Alzheimer's, mental health, intellectual disability, etc.) (Solana et al., 2015). Game mechanics are mainly adapted to engage and motivate patients by transforming them into players by highlighting the skills acquired through scores and thus making the therapeutic process clear and funnier than usual. Further social dynamics borrowed by games can facilitate the development of networks between patients creating social connections and virtual communities that could be powerful clinical resources for elderly patients (Ascolese et al., 2016).

3.4. Digital Support for Integrated Care

There is no commonly shared understanding or definition of what the concept of integrated care means in more practical terms. In fact, integrated care schemes have been tried in different forms in several health systems around the world (WHO, 2016). It may thus not come as a surprise that there are challenges in interpreting the available evidence for integrated care. As a health intervention, integrated care does not easily lend itself to scientific evaluation and analysis. For instance, integrated care is not a single intervention that can be isolated from other elements of practice. In fact it can only be practiced in the "real world" rather than in controlled study environments. From a purely scientific perspective the validity of clinical trials on integrated care is thus bound to be questioned, and it has been argued that the scientific quality of the evidence base remains limited (WHO, 2010). Nevertheless, the evidence base that is now beginning to emerge from good practice in the field, albeit scattered, suggests a "value case" for integrated care, especially when underpinned by a context-sensitive implementation strategy and a carefully tailored digital support infrastructure (Kubitschke et al., 2017). Case studies evidence has shown, for instance, that reduction in the number of emergency admissions as well as in hospital length of stay for older people can be achieved (Local Government Association [LGA], 2016; Dorling et al., 2015). Further EU project evaluations have shown that care recipients, informal carers and service providers seem to value integrated services when compared with disjointed and patchy care delivery (Kubitschke et al., 2014). Also, it has been shown that - beyond care practitioners - informal carers and third sector organizations can be successfully brought into the information loop with the help of ICT. There are also indications that there might well be an "economic case" for integrated e-care, as also highlighted during the Covid-19 pandemic. But here again, much seems to depend on how solutions are put into practice. Digital solutions can facilitate the implementation of approaches to service integration that are tailored in terms of type, levels and form, as outlined by VIGOUR project (VIGOUR Project Consortium, 2021). Simply adding ICT to existing service delivery processes will not automatically generate sustainable e-care services. A context-sensitive and multi-dimensional innovation approach needs to be adopted, paying equal attention to the ICT applications to be employed and to the working models to be supported by the latter (Lindner et al., 2020).

4. OUTLINING RISKS AND MITIGATORS FOR FALLS

4.1 Multimorbidity and Polypharmacy as Mitigators for Falls in Older People

Multimorbidity is defined as the "the coexistence of two or more chronic diseases" in one individual, and is increasing in prevalence globally. Multiple chronic diseases are often resulting in polypharmacy (Afshar et al., 2015). Additionally, geriatric syndromes, including falls, diminished cognitive capacity, socio-economic deprivation, such as loneliness and/or missing informal assistance occur, all which have a strong impact on peoples' quality of life as well as the quality of health care offered to this group of patients (Roller-Wirnsberger et al., 2020). It seems that certain diseases may be associated with increased risk of falling, whereas multimorbidity per se could be correlated to chronic recurrent falling (Tchalla et al., 2014). Risk factors for injurious fall tend to aggregate, representing different levels of risk for falls. Multimorbidity and polypharmacy with fall risk inducing drugs (FRIDs) have been shown to increase the level of risk of falling with a hazard ratio (95% confidence interval) to 12.67 (7.38–21.75) (Ek et al., 2018).

When examining drug-induced risk of falls in the elderly not only how many but also which drugs are prescribed should be carefully considered (Woolcott et al., 2009; de Jong et al., 2013). Drugs differ, indeed, in their propensity to cause falls being benzodiazepines, antipsychotics, antidepressants, anticonvulsants and, though more controversial, opioids linked to a high risk. Also antihypertensive drugs may cause falls but with different level of danger among different classes being, for instance, 1 blockers more dangerous than ACE inhibitors. Remarkably, by interacting the one with the others different drugs may reciprocally potentiate their ability to cause falls. Other drugs may worsen the risks related to medication-induced falls by causing bone loss and increasing fracture susceptibility (Nguyen et al., 2018). As recommended by Centers for Disease Control (Centers for Disease Control [CDC], 2017a) a careful medication review is mandatory in older people to make sure that dangerous drugs are not prescribed and dangerous drug interactions are avoided. Specific tools such as Beers criteria (American Geriatrics Society, 2015), the STEADI Initiative resources (CDC, 2017b) and the many cholinergic burden calculators available online may help in this process.

The Patient Safety 2030 report (Mair et al. 2017) suggests that polipharmacy management could be addressed by developing a holistic systematic approach that extends across the professional, cultural, technological and procedural boundaries. To this purpose, the SIMPATHY (Stimulating Innovation Management of Polypharmacy and Adherence in The Elderly) consortium explored how healthcare management programmes can improve medication safety and prevent patient harm by addressing the appropriate use of multiple medications (polypharmacy), involving patients to enable shared decision making. This improves patient adherence and medicines related outcomes.

4.2 Physical Inactivity

Active and healthy ageing requires the promotion of physical activity and the encouragement of healthy towards exercise with a life-course approach, and an effort targeted to older adults (Vollenbroek-Hutten et al., 2016). Being Physical activity a life course approach of an healthy lifestyles, it is clear that it needs to be promoted and facilitated by the environment at each point in life. School, workplaces, cities, should be environments were people could exercise on a regular basis. It is of course necessary to create a culture that can include the need of promoting physical activity in each manifestation. In order to put this in motion, there is the need of a cultural revolution that allow to design our environments with this particular view in mind. Universities represent a key actors in the starting this revolution by the creation of educational programs that can help include the physical activity in the every day life. A3 group developed a common vision on how physical activity can be defined and measured in older adults, providing an insight into future directions for promoting physical activity among older citizens at an EU level. A checklist of 10 important criteria has been developed to achieve this goal (Apóstolo et al., 2018; Marcucci et al, 2019). In addition, this group has worked on the development of an interoperable, scalable ICT infrastructure to support screening, monitoring and trainings programs to encourage older adults to become more aware of their health status and support them in staying active (Jansen-Kosterink et al., 2019). In A3 partners experiences, technologies aimed at supporting aging in place must target health literacy, allow personalization in the design and in the use of the technology (Cataldi et al., 2019; van Velsen et al., 2015; De Luca et al., 2019a). This to overcome resistance from older adults towards new technologies. Further research should investigate the effect of these strategies on the adherence to technology to be used in daily life. A3 partners have indeed outlining a set of recommendations focusing on acceptance, barriers, and ethical concerns (Cabrita et al., 2019). Gamification layers can stimulate the adherence to innovative approaches to health promotion (de Vette et al., 2015).

4.3 Food Poverty and Malnutrition

Food intake is a key component of health that can contribute to prevent adverse health outcomes, especially related to a number of chronic diseases (Magni et al., 2017). Appropriate food intake influences the nutritional status and health: in order to outline and implement effective approaches, we need a joint effort for the translation of scientific information into practical interventions that have a tangible and measurable impact at both individual and population levels.

A3 group has been involving multiple stakeholders to outline a common vision (Illario et al., 2016) of the food and nutritional approaches to frailty prevention and management. Their objective is to carry out coordinated, inter-sectorial, multi-modal interventions to approach food and nutrition-related determinants of frailty and improve the health condition and outcomes of older adults in Europe. The common vision that they developed focuses on an integrated nutritional approach, "Nutrilive", that is represented by a structured Screening -Assessment- Pyramid - Model (SAM-AP) where the stratification of the nutritional needs of older adults are linked to assessment, self-monitoring and interventions supported by innovative Information and Communication Technologies (ICT). To date, partners have deployed several experiences where innovative approaches are validated, to manage malnutrition for active and healthy ageing with a lifecourse approach (Di Furia et al., 2016). Indeed, partners have been setting up a new hospital screening tool for malnutrition, shared with Styria Reference Site; an evidence-based nutrition documentation tool for transfer processes of patients across setting fully validated and implemented in

ICT structure- ready for scale up across regions; a Web-based platform to ease malnutrition screening programme implementation, and includes freely available:

- Validated screening tools
- iPhone & iPad app
- Videos and guidebooks (translated into major languages).

The platform is being considered by the medical Delta Reference Site.

Tailored support for Parkinson disease patients, freely available in google store, supporting an intervention based on these exer games from a personalised games suite, and also supporting personalised nutritional approach.

4.4 Dental Occlusion and Posture

The relationship between the dental occlusion and body posture represents a worldwide discussed issue. The ideal balanced posture allows the higher effectiveness of movement in absence of pain and in maximum muscle energy savings. Conversely, a “faulty posture” involves a greater effort on the support structures and the loss of efficient body balance. This clinical condition can become, over time, the cause of a symptomatologically active alterations in both static and dynamic equilibrium with myofascial pain in the neck and orocraniofacial areas (Ministry of Health of the Italian Republic, 2017).

The influence of dental occlusion on posture at different internal or external disorders has been widely explored in literature. The human body, in fact, can be considered a biomechanical system with different functional units deeply interconnected among them.

Postural control is a complex function that involves different sensory inputs from the visual, somatosensory and vestibular systems. These sources of sensory information must be integrated at the central nervous system to regulate the orientation and stabilization of the body segments.

An example of relationships between static body balance and occlusion is that in young adults with a normal functional occlusion the static plantar pressure is influenced by the maximum mouth opening. An improved postural stability was recorded in maximum intercuspation, during swallowing, in comparison to mandibular postural position, when relaxing the masticatory muscles after functional moments (Amaricai et al., 2020).

Thus, the examination of postural disorders must provide a pathway in the cranial-caudal sense and requires not only medical history and clinical evaluations but also specific instrumental investigations to identify its nature and extent through signs and symptoms of tension and pain in specific functional areas.

Specifically, an objective diagnosis of postural dysfunction related to occlusion is mainly based on the evaluation of mandibular asymmetry, dentoskeletal malocclusions and temporomandibular joint disorders as well as other perturbations that might modify the sensorial inputs for balance control (Julià-Sánchez et al., 2015).

Some investigations suggested that there is a plausible evidence between the masticatory and cervical muscles, with a reciprocal connection between the trigeminal and vestibular nuclei, hence supporting the influence of the stomatognathic system on body balance (Julià-Sánchez et al., 2019). The modification of mandibular position in the occlusion seemed to affect body posture, and vice-versa (Sakaguchi et al., 2007). An occlusal reequilibration may provide a beneficial effect on paired postural muscles as sternocleidomastoid, erector spinae, and soleus in young adults (Bergamini et al., 2008).

However, recent overviews showed that, even if some associations have been found between occlusal factors and postural alterations, there is not enough scientific evidence to predict cause-effect relationship between these two elements alone. (Michelotti et al., 2011; Manfredini et al., 2012; Perillo et al., 2008).

A widest range of elements interconnected with body balance should be taken into account instead of separate evaluations. So, patients from infancy to the elderly suffering from postural, occlusal, osteopathic or orthotic disorders should follow a wide screening for other possible associated pathologies which may make side effects worse with time (Silvestrini-Biavati et al, 2013).

Novel technologies have been recently used to assess static and dynamic occlusion and body balance and smart devices are spreading to remotely investigate and manage the individuals' muscle activity and pain via biofeedback.

The development of a homogeneous and evidence-based program for early diagnosis, monitoring and interdisciplinary treatment of occlusal and temporomandibular joint disorders related to orofacial pain and postural/gait imbalances from a young age should be considered mandatory by policy makers (Perillo et al., 2011). Finally, the creation of integrative and innovative health care framework in this field perfectly fits with the expected aims of the EIP on AHA to improve quality of life in an ageing society.

4.5 Cognitive Impairment

Falls and cognitive impairment (CI) are related and increase commensurate with age (Rebenstein, 2006). Both dementia (Meuleners et al., 2016) and its prodromal state, i.e. mild cognitive impairment (MCI) (Delbaere et al., 2012) are associated with an increased risk of falling. Between 40-80% of persons with dementia fall each year, twice the rate of those without CI (Tinetti et al., 2015). Falls increase the risk of institutionalisation in persons with CI (Myers et al., 1991) and reduce quality of life (Delbeare et al., 2010). While many aspects of cognition are implicated, impairment in executive function, leading to a slowing of gait speed, is most strongly associated (Kearney et al., 2013) with even subtle deficits in healthy older adults found to increase fall's risk (Mackenbach et al., 2016). Other risk factors include poor balance and reduced reaction times in those with established CI. Multiple intrinsic and extrinsic risks including psychosocial factors, poor vision, functional impairment and centrally-acting medications are also implicated (Mikkelsen et al., 2012). CI reduces awareness and insight into their deficits and those with more established CI often exhibit unsafe behaviours (Fernando et al., 2017). Neuropsychiatric symptoms including agitation, restlessness and disruptive or aggressive behaviours, are also factors that potentiate the risk. Not only is CI a risk factor for falls, falls may also accelerate cognitive decline such that a fall can lead to impaired mobility, delirium and consequently worsening CI. Screening for risk of falls could identify those likely to experience recurrent falls (Meuleners et al., 2016). Similarly, cognitive screening is essential to promptly identify CI and intervene to prevent falls.

Instruments sensitive to early cognitive changes such as the 6CIT (six-item cognitive impairment test) (Danielsen et al., 2016; Brooke & Bullock, 1999), the Q*mci* (Quick Mild Cognitive Impairment) Screen (Apóstolo et al., 2017; O'Caoimh et al., 2012; Carpinelli-Mazzi et al., 2020) and MoCA (De Luca et al., 2019a), are appropriate for screening for CI in busy clinical practice. These help target more detailed person-centred evaluations, such as comprehensive geriatric assessment and a multi-factorial falls risk assessments. Early diagnosis allows prompt pharmacological and non-pharmacological intervention. Traditional falls prevention measures, such as the Otago programme, which are known to reduce falls, are less useful in those with CI (Nasreddine et al., 2005). Instead both cognitive and physical interventions tailored to those with CI such as cognitive stimulation and tailored physical exercise programmes can reduce the risk of falls from the outset (El-Khoury et al, 2013), enabling the person to prevent their own falls (Lipardo & Tsang, 2018). Data is as yet limited but there are ongoing trials examining combined physical and cognitive training in early CI. Falls prevention measures are more likely to be successful in those with MCI as awareness of their limitations (Apóstolo et al., 2016) and the ability to learn and/or train is usually preserved. Improvements in integrated care pathways specifically for people with CI who fall, which are currently fragmented are needed to improve outcomes for this important subgroup of older adults (Wheatley et al., 2019).

4.6 Falls and Visual Impairment

A significant increase in the prevalence of impaired vision with age, especially in subjects 75 years of age and older (Klein et al., 2001), is a well documented phenomenon (Klein et al., 1998). It has been demonstrated that the risk of accidental falls is higher for individuals with visual impairment compared with those with normal vision (Coleman et al., 2007; Freeman et al., 2007; Wood et al., 2011). It was estimated that globally, at least 2.2 billion people have a vision impairment or blindness, of whom the majority of people are over the age of 50 years (WHO, 2019).

Falls are the second leading cause of accidental deaths after road traffic accidents worldwide (Saftari & Kwon, 2018). The increased risk of falls in older patients is mainly due to a physical, sensory and cognitive decline expected with aging. The ability of balance and gait control (Cho et al., 2004), musculoskeletal functions (Horling et al., 2008; Pijnappels et al., 2008), cardiovascular functions (Heitterachi et al., 2002; Ooi et al, 2000; Klein et al., 2013), vestibular functions (Ekvall Hanson & Magnusson, 2013; Menant et al., 2012), somatosensory functions (Craig et al., 2016; Lord et al., 2002) and visual functions (Saftari & Kwon, 2018; Black & Wood, 2005; Broman et al., 2004; Coleman et al., 2007) have been suggested to be the important factors responsible for the increase in fall risks in older adults.

The consequences of a fall can cause serious injury, physical deterioration and institutionalization (Iglesias et al., 2009). The majority of patients with a hip fracture do not return to the level of activity of daily living, which they showed before the fracture (Abdelhafiz & Austin, 2003). The high mortality rate for individuals in the first year after a hip fracture is also well described, with rates of 20–35% (Goldacre et al., 2002).

Many visual functions deteriorate gradually during the normal aging process (Owsley, 2001). This may be due to optical media abnormality, age-dependent neuronal morphological modifications and/or a neurotransmitter system imbalance in the visual processing pathway, especially in the primary visual cortex or even the higher cortical loci (Zhang et al., 2008). In addition, eye diseases such as age-related macular degeneration, retinal dystrophy, diabetic retinopathy and glaucoma can independently be the cause of vision impairment. Visual loss is a broad term and is not only represented by measure of visual acuity and visual field. In fact, other components of vision such as contrast sensitivity and depth perception may affect the risk of falling and of hip fractures (Dhital & Stanford, 2010).

Vision loss is able to influence person's balance, movement and the strategies used to interact with the environment (Brundle et al., 2015). The most falls occur while walking or doing routine tasks (Talbot et al., 2005) - 60% at home, 30% in public places and 10% in healthcare institution (Scott, 1990). Hip fractures have been linked to visual impairment to subjects measures of vision such as reduced visual acuity, contrast sensitivity and visual field (de Boer et al., 2004).

Although there is considerable epidemiological evidence that older individuals with visual impairment are more likely to fall than those without, a Royal College of Physician audit showed that 50% of sites did not employ a standardized visual acuity assessment in these patients (Royal College of Physicians, 2009).

In conclusion, although the association between visual loss and falls would seem to be intuitive, it has remained a relatively understudied phenomenon until the last two decades (Dhital & Stanford, 2010). The development an efficacious and cost-effective multi-disciplinary intervention is desirable to act on the relevant factors associate with high risk of falls.

4.7 Falls and Vestibular Diseases

A significant increase in the prevalence of vestibular diseases with aging, especially in subjects over 65 years of age and more is a well-documented phenomenon. The risk of accidental falls is higher for people with vestibular diseases. Moreover, in recent years in the Western countries, the average life span has increased due to the improvement of sanitary conditions and the greater effectiveness of medical and surgical therapies, and so the survivor of over-aged subjects are more than it used to be before. Of course, as a result of the above mentioned considerations, we appreciate to an increase in traumatic episodes, in old age, linked to dysfunctions of the vestibular apparatus. The vestibular apparatus has an essential role in maintaining the erect posture and in movement's harmonious execution. Talking about balance disorders, the vertigo can be defined as a disturbance of spatial sensitivity with an incorrect sensation of movement of the body or of the surrounding environment, as well as the imbalance that is characterized by upright position sensation of oscillation of the upright position or instability / insecurity in walking (Goebel, 2000; Shepard & Salomon, 2000). Symptoms can frequently coexist or be sequential. Based on the characteristics of the symptoms, we can have two types of vertigo **subjective** or **objective**. With **subjective** vertigo, one feel like as actually moving. It has frequently a peripheral origin. In some cases, one may actually be swaying slightly. If a patient has **objective** vertigo, he feels like his/hers surroundings are moving. This phenomenon has generally a neurological origin. Causes of peripheral vertigo include: benign vascular (labyrinthine microcirculation) paroxysmal positional vertigo, labyrinthitis, Meniere's disease (this condition causes objective vertigo, hearing loss, pressure in the ear, and tinnitus. Meniere's disease can come and go, and you may experience symptoms for several weeks or months), trauma, ototoxic drugs. (Barbara et al., 2007; Marcelli, 2011; Haynes et al., 2002). The causes of central vertigo can include: vertebrobasilar vascular, demyelination, drugs (anticonvulsants, hypnotics), neoplasms, alcohol. (Migliaccio et al., 2004; Rinne et al., 1998). In the peripheral forms, vertigo can also be associated to hearing loss or tinnitus due to the proximity of the two sensory systems unlike the central forms, and to vegetative symptoms such as nausea and vomit. Frequently, especially in the elderly, we recognize non-specific disturbances of balance with instability conditions, movement uncertainty, syncopal episodes and falls. These symptoms are also justified by cervical pathologies. The most frequent symptom is paroxysmal positional vertigo suddenly arising, with unknown etiology that can frequently be the cause of falls (Kim & Zee, 2014; Brandt & Daroff, 1980; Yacovino et al, 2009). Most causes of vertigo are benign, but potentially disabling. In conclusion, the ratio of falls and dysfunctions of the vestibular apparatus is very high, especially in the elderly. A careful study of such organ function is required to improve its performance.

4.8 Environmental Challenges Requiring Design Modification in the Different Settings

Housing and outdoor spaces and buildings impact people's health and wellbeing, no matter how old people are. Improved housing conditions can increase quality of life, reduce diseases and prevent people from falls (WHO, 2018). Inclusive and safe outdoor spaces and buildings further foster social inclusion and participation in society. While constructing or retrofitting houses and public spaces, it is elementary to include people's needs and demands on the built environment. Functionality, mobility, visual and hearing issues demand the attention of the building industry to aspects such as width, surface, cleanness and signage. It is also essential in built environments to offer room to user-centred smart solutions for integrated care, independent living and participation, such as eHealth, falls detection and social connectiveness.

The theme of the safety of the built environment in relation to the aging of the population is articulated on the basis of many aspects concerning the quality of life and the quality of internal and external spaces. The risks of falling linked to the conditions and use of the spaces are associated with intrinsic risks - due to inadequate organization, construction and conformation but also to the sensorial aspects and those of using the spaces - and external risks due to specific impacts such as climatic (wind storms, heat waves), hydrogeological (floods, landslides) or seismic (collapses) risks. In these conditions, the risks of falling of the elderly population are accentuated starting from the known difficulties in normal operating conditions and from those of unexpected extreme dangers, to which it is more and fatally exposed than other user groups (Ulrich, 2001). From this point of view, political and technical-administrative decision-makers like designers must pursue an effective technical policy for a profound adaptation of spaces to the conditions of prevention and mitigation of the multiplicity of risks. An important goal must be identified in improving the accessibility and usability of spaces, escape routes, sensors for smart and "drop-proof" environments, but also the humanization of spaces (living spaces and care spaces). Those listed required interventions in a less performing built environment compared to old and new conditions of risk and exposure of the elderly population. Among many methods of intervention, it is necessary to grasp in advance the current transition towards operational digitalization in the phases of knowledge, design, construction, control, management and monitoring for the conception and use of spaces (Mincolelli et al., 2018). The digital approach foresees evolutionary processes in planning and design, in which the way of considering people health and the tools used to guarantee it are changed, also taking into account the psycho-emotional and social nature of people for an expansion of the requirements in references framework.

4.8.1 Home and Family

Research shows that fall risks can be prevented through home modification. Home modification is adapting the environment to the normal changes that age brings, in order to make everyday life easier, independent and safe, reducing accidents. This involves the manipulation of many environmental factors, that in literature are reviewed under four categories: spatial organization, interior characteristics, sensory characteristics, and use of the environment. Useful changes can be increasing lighting throughout the house, putting in night lights, moving the furniture around, uncluttering the floors, adding lower level shelves, adding supports such as handrails, and changing how or where activities occur. **Assistive devices** and gadgets are a smart way to make activities easier and reduce the chances of falling. Families need to be involved in individualized home fall-prevention and safety plan.

4.8.2 Hospital

New "therapeutic architectures" of hospitals must be characterized as agile and particularly equipped structures, which are related to nature and which have welcoming indoor spaces. In this way, the place of treatment should not be characterized as a space of discomfort and disease, but as an environment where comfort and humanization components of the treatment spaces is maximized (Morandotti, 2008). In this way, human body prepares itself for a health process in which the use of green spaces with a curative function is not secondary (Palombo, 1993). Each space must be considered taking into account its peculiarities, the purposes of visual (signage, color codes, graphics) and physical accessibility, of creating an atmosphere of trust and security, of reducing stress, of relaxation, of providing energy (Boccaccini & Lenzi, 2002). The favorable conditions for treatment require that also medical and paramedical personnel be put in a position, through the design of appropriate spaces, to carry out diagnostic and medical procedures through a human centered design: in this case is fundamental the activity of industrial design and design thinking (Paolini et al., 2017). Finally, with the development of the smart environment, smart objects and Internet of Things (Dohr et al., 2010), in each hospital it is possible to obtain objects interconnected with the network to cope with many critical issues.

4.8.3 Nursing Homes

The health care residences, introduced in Italy in the mid-90s, are non-hospital structures that have a strong health imprint, which - for a period ranging from a few weeks to an indefinite period - host people who are not self-sufficient, who cannot be cared for at home and who need specific multi-specialist medical care as well as comprehensive healthcare (Auser Nazionale, 2011; Arbizzani & Di Giulio, 2002). From this point of view, rest homes must make a qualitative leap in providing for a modification of indoor spaces in therapeutic terms, also with potential physical separation for the purpose of preventing conditions of possible infection or for specific hospital stays. This entails new concepts in the social and health organization, from hygiene to assistance, from management to technical-health equipment (Morena, 2014; Scarcella et al., 2014).

4.8.4 Co-Habitation Housing

The first experiences of co-habitation housing date back to the 1960s, when the multiple advantages of cohabitation were focused especially for self-sufficient elderly people. In the first instance, the ability to cultivate one's sociality and hobbies should be carried out in one's own home with appropriate indoor environment design solutions (Ahrentzel & Tural, 2015). Unfortunately, this is not always possible for multiple reasons including that of high costs. The reduction in costs that each user would have to bear to maintain his private home, can be invested in forms of co-habitation that have a return from social and health services up to the preparation of food (Chan & Ellen, 2017).

The co-habitation conditions offer elderly users the opportunity to be able to carry out their favourite activities, to use the most advanced technological devices and services, also in relation to the territory and the community to which they belong (Chan & Ellen, 2017). A dwelling is determined where one can grow old within a proximity or community welfare that responds to growing social needs (Roversi et al., 2018). New technical policies are necessary to create innovative housing structures (WHO, 2007), also starting from the public and state property to be redeveloped. In any case, the housing units should be conceived in an innovative key with common spaces for collective and relational activities and more reserved spaces for the private sphere, using refunctionalization and building and urban recovery procedures (De Giovanni, 2014).

4.8.5 Protected Housing Complex

The Protected Elderly Housing Residential Complexes (APA) offer housing possibilities for elderly people with planimetric solutions of reduced surface but characterized by high flexibility of the spaces, to better support the autonomy of those who live there. One-room and two-room apartments are designed taking into account the functional ergonomic characteristics for living even when users experience slight reductions in psychophysical capacities. The characteristics of the structure, with telematic, assistance and health services, represent the basic requirement for facilitating personal lifestyles (Fondazione Cariplo, 2014).

The typological scheme of the apartments must necessarily be simple, with a mainly open living area that determines a living room, as well as the sleeping area consists of a bedroom and a private bathroom. Each accommodation must be free of architectural barriers and equipped with technical and ICT devices that allow the elderly to lead a life in autonomy and in total safety (Housing Learning and Improvement Network, 2007). The protected accommodations are intended for the elderly, singles or couples, with limited frailties, with a sufficient degree of autonomy but who need a controlled and protected environment, programmatically adjacent and connected to the Health Care Residences who can provide specialized services in conditions of particular needs. Among the best known models, the Continuing Care Retirement Community, specific in the experience of the United States, should be mentioned, which offers quality housing solutions integrated by proximity, home and light residential services (Lombardo, 2007).

4.8.6 Community

To define the conditions of expanded usability of urban open spaces, going beyond the first experiments conducted by Ronald Mace in 1997, Universal Design (UD) has extended its field of action to products and services studied with the methodology of Design for all (Preiser, 2017). More recently, these design approaches are referred to the development of smart solutions for information systems, for the security and control of spaces and for the management of services and flows. The design of the common spaces determines the accessibility conditions for a correct interaction between the person and the environment, in order to completely eliminate architectural barriers and the introduction of security measures for the use of urban spaces (Lauria, 2017). Older people with greater self-sufficiency must be able to use the spaces of relationship to improve their living conditions, while weak or non-self-sufficient users must be able to have the necessary spaces to manoeuvre the various walking aids as well as socialization activities.

The usability requirement must be understood in a broad sense, as the possibility of physical and visual access to spaces, of the possibility of being able to intervene independently on some environmental factors, of immediate identification of places and routes (Baratta et al., 2019). The care of outdoor spaces, including green spaces and urban parks, takes a particular value for elderly citizens as the landscape with which they relate daily, becoming a place of stay, recreation and contact with nature (Pineau et al., 2014).

The "wellness paths" represent an element of the quality of community spaces, based on mindfulness, on the innovation of technologies to help break down physical and sensorial architectural barriers and to support the functions of the person. With reference to Active Aging, there is a need for permeable and accessible spaces, for “streets for people”, to raise the conditions of “well living” in the city, to be together, participate, share and cooperate (WHO, 2014).

5 INNOVATIVE APPROACHES TO PREVENT POOR HEALTH OUTCOMES AND INCREASE INDEPENDENT AGEING

5.1 Technological Innovations

The global market is witnessing the growing development of new technologies and devices that have the potential to assist older adults in their daily living, while preventing or delaying institutionalization (Kim et al., 2017). Technological innovations such as Assistive Technologies and Information and Communication Technologies are resources that may improve aging in place for older adults and decrease the caregivers burden (Blaschke et al., 2009). The development of new technologies including Robots, Internet of Things (IoT), Smart Home and Ambient Assisted Living (SHAAL) and Sensors (wearable sensors or incorporated in smart homes) enable the provision of assistance, companionship, health and behavior monitoring. Such technological solutions have shown the impact in the improvement of mental and physical health, and quality of life. Technologies can be used to promote successful ageing in older adults in both the health and social domains (Task Force on Research and Development for Technology to Support Aging Adults, 2019).

5.2 Urban Form and Social Isolation

Since the introduction of agriculture, men abandoned the nomadic life: technological development, innovations and infrastructural improvements enhanced productivity and started to grow residential settlements that continued to be centers of innovation. Staying together imposed profound changes the social life of our ancestors, giving rise to class-structured society, formalized systems of laws, and a hierarchical territorially-based government, that led to increased child mortality and high levels of disease. Cohen and Armelagos in 1984 suggested that was largely caused by malnutrition consequent to the switch from a mixture of meat, grains, and fruit to a diet dominated by grains. Communicable diseases like malaria, tuberculosis, leprosy, influenza, smallpox and others existed during humankind’s hunter-gatherer days, but it was only when the number of people in a given place became large enough that it was able to sustain direct life cycle bacterial and viral infections. Overcrowding, lack of clean water, lack of organic waste disposal, scarce personal and public hygiene, large number of people moving, poverty, famine war. For roughly 2500 years, cities have suffered powerlessly the devastating scourge of major epidemics and pandemics, which are “democratic” as they do not distinguish between rich and poor, with their dramatic social, economic and demographic effects changed history. From The Athens[1] typhoid fever to Ebola today, it’s easy to see how civilizations are shaped by diseases. Only in the nineteenth century reformist movements, with the avant-gardes of a particularly attentive middle class, together with emerging disciplines such as public health and urban planning, sharing the goal of improving the physical and social conditions of urban populations, supported the need for integrated public interventions that quickly reduced the incidence of infectious diseases and overpopulation. During the 1870s, in fact, a series of new laws led to improvements in public health and hygiene. These included the provision of clean water, proper drainage and sewage systems and the appointment of a Medical Officer of Health in every area. In 1875 the Artisans Dwellings Act allowed councils to clear slums and build better homes for working families. In 1876 the Sale of Food and Drugs Act banned the use of harmful substances in food, eg chalk in flour and Laws against pollution of rivers were introduced. In 1878 Epping Forest in London became a protected open space for local people to enjoy.

Current demographic trends outline a worsening of quality of life for older adults in the most settings, be them urban or rural, as there have been no policy to adapt the built environment, for example in terms of accessibility.

Once the health crisis was over and with the introduction of new drugs, public health focused on the treatment of specific diseases, and the relationship between urban planning and health was loosened and then completely lost. At this time, cities are facing the "rising tide" of non-communicable diseases such as obesity, diabetes, hypertension and cancer. The increase in non-communicable diseases is in part due to the constant increase in the average life, which leads as a natural consequence to the increase in chronic diseases, but also to wrong lifestyles imposed also by the shape of the places. The best-known example is the obesity pandemic, and the consequent increase in cardiovascular diseases, associated worldwide with the decrease in physical activity, discouraged by the shape of the places, with the separation of the functions of urban spaces, urban sprawl and the inefficiency of public transport. The new massive urbanization which in 2007 for the first time in history has seen the population living in the city exceed that of the rural areas is another important element that has powerfully conditioned the shape of the places in recent years. Unprepared to deal with the aging population and to address the new mass exodus, the great urban centers are growing poorly. Schizophrenic cities where imaginative and fascinating "art objects" are proudly placed, meanwhile public space are non-existent or abandoned and neglected, where rapidly growing suburbs are rapidly transforming into slums and "informal settings", where poor quality of the urban form turns into poor quality of life. If the form of the city reflects our idea of us, at this time it appears a sad, gray, and, above all selfish, idea. Cities become ugly, but above all bad and inhospitable, where people collides but never meets, where knowing each other and exchanging knowledge that generates sharing and care is in fact prevented by the barriers imposed by the places. The poor quality of a place generates a sense of estrangement, places to which nobody feels to belong. Lost the sense of a life rooted in a place, traveling, wandering, moving is the new life project of adults and young people, the obsessive dream of an elsewhere where something can happen, where there is still a possibility and a hope.

Above all, the "bad" city steals time, the time of our life, wasted, spoiled, subtracted, fragmented and dilated at the same time. At the end of the day, the list of activities carried out is such as to fill more hours than a day contains. The time to think, to reflect, to elaborate the meaning of the things that are being done and the experiences that are being lived is stolen from us. A hostile environmental context, where every aspect of life is difficult and tiring, isolates, separates and causes stress. The price of a poor urban form is social isolation. There are strong evidences that high level of social isolation negatively impact on health outcomes and disease management (Singer, 2018). Lack of social connection, whether perceived or actual, induces a stress response within the body, removing energy and resources to the physiological processes maintaining body homeostasis, with a powerful impact on the cardiovascular and the immune systems. Thus, poor social connection can elicit negative physical responses e.g., high blood pressure, insomnia) and mental distress (e.g., anxiety, depression) (Cacioppo & Cacioppo, 2018). A poor urban setting (i.e. lack of transportation, dangerous suburbs) is conducive to social isolation particularly in the older adult. Urbanization rates and increase longevity has indeed created a dilemma regarding healthy aging (Gusmano & Rodwin, 2011). The World Health Organization reports that "at the same time as cities are growing, their share of residents aged 60 years and more is increasing." City planners must recognize the increasing trends of population ageing and urbanization, and respond accordingly to the needs of older people, particularly the most vulnerable cohort: persons of 85 years and older. The impact of urban planning on poor health, social isolation, physical inactivity is now well document (Carmichael et al., 2019; Thomas & Sanderson, 2013). Urban form can also help to create a sense of place, sense of belonging and emotional connection. Disruptions of this sense of belonging by, for example, removal, relocation or other dislocations have been found to have adverse physical and psychological health consequences Taske et al, 2005). Specifically, in lower socioeconomic neighbourhoods (Tesch-Römer & Wahl, 2017) where green space is lacking and environmental pollution is highest, as well a lack of integrity of walking infrastructure, road and traffic safety, personal security and lighting (Kerr et al., 2012; Brownson et al., 2009; Ben Noon & Ayalon, 2018; Rowles, 1981). Neighbourhoods that enable informal social ties and social support networks that encourage and enable people to help each other can reinforce positive health behaviours (Greenshtein et al., 2020; Shaw, 2004). Thus, urban planning for healthy aging and fall prevention and maintenance of cognitive function are essential elements to be taken into consideration for wellbeing throughout the life span. For example, exposure to green environment seen from home was found also related not only to lower levels of depression/anxiety but also less stress level as reflected was related lower cortisol levels (Pun et al., 2018).

5.3 Social Connectivity in Culturally Appropriate Venues

In this view, a urban form that reduce meaningful "place in-between" where people can meet, talk, laugh, and make difficult access to leisure activities, induces social isolation thus influencing health. In search of strategy to counteract social isolation and its consequences on health, the role of leisure activities was investigated and results indicated that cultural and social engagement can be an important tools to increase and to maintain social connection. The existing evidence show that cultural participation may have strong and significant effects on life expectation, and more recent research seems to suggest that the impact is equally strong in terms of self-reported psychological well-being. In particular, it turns out that cultural participation is the second predictor of psychological well-being after (presence/absence of) major diseases, and in this respect has a significantly stronger impact than variables such as income, place of residence, age, gender, or occupation. The effect is particularly strong for the seriously ill and the elderly, where psychological well-being gaps between subjects with cultural access and subjects without cultural access is huge. Thus, an urban setting facilitating and encouraging cultural and social participation helps to fight social isolation and improves health. In this light, we need to rethink the connection between urban environment and public health.

Although the shape of places is recognized as an essential element for the maintenance and achievement of well-being and the topic is debated all over the world, cases of concrete application of the determinants of health in the design of the "environment" remain sporadic exceptions. In Europe and worldwide material and immaterial cultural heritage are driving Renovatio Urbis and development processes, Bilbao, Rouen, Paris, Berlin, Rome, Buenos Aires are well known examples of this strategy. Culture has the dimension that organizes social form, contributes to the well being of individuals and society by supplying a significant social identity, a sense of community. Thus, the cultural strategy of development goes far beyond the "sole" esthetic dimension, it is a fundamental part of a cultural welfare strategy and as such profoundly impacting on economic and social dimension.

Despite the fact that more than 20 years have passed since the Ottawa declarations and scientific data clearly demonstrate the opposite, health remains, in the view of politicians and administrators, fundamentally a problem of "illness" to be addressed with the use of health care services and to the consumption of drugs, therefore of health competence. The resources for the promotion and protection of health remain in fact very scarce compared to those engaged more or less accurately in health systems. On the one hand, this myopic vision does not alleviate, but rather constantly aggravates the economic and social weight of health, on the other hand it effectively denies the value of the person in its entirety. The motivations and causes of this "cultural" attitude go beyond the purposes of this reflection, however, a "cultural" change is the necessary premise to face the problem of health today. Because the challenge is exceptional: on one hand to understand the "organized complexity" of the organism and the place and on the other their interaction to identify risk and protection variables and their causal relationships with respect to the final results. In order to face the current health crisis, 21st century medicine, despite its extraordinary progress, needs to re-establish relations with other disciplines that help it to draw reliable conclusions on the health of the population and on the methods required to guarantee it within a complex environment often characterized by uncertainty.

6 FROM STRATEGY TO IMPLEMENTATION

6.1 Regional Policies to Create Culturally Relevant Sustainable Communities to Support Aging in Place

Regions play a crucial role in the development and implementation of policies regarding active and healthy ageing. This is particularly true when competencies on health issues (public health and healthcare policy, planning, management and provision) are at regional level. This is the case of several Member States in the European Union and is reflected in the results of the las process of the European Innovation Partnership on Active and Healthy Ageing Reference Sites recognition. In most cases, social welfare and social care policies are regional too.

Regions represent an ideal environment for the consolidation and maintenance of these fundamental social welfare pillars. In addition to public authorities and its institutions, a wide range of partners from academia, research institutions, private and voluntary sectors, as well as civil society contribute to foster innovation to boost personal autonomy, prevent dependency, improve sustainability and efficiency of health and care services, and back entrepreneurship supporting employments in the field of AHA.

Working together in innovative ways helps to achieve the expected aims of the EIP on AHA: to enable citizens to live longer and healthier; while improving the quality, efficiency and sustainability of social and health care systems, contributing at the same time to economic growth through the development of innovative and competitive products and services in Europe.

6.2 Creating Supporting Community-Based Networks for Persons as They Age Including Their Family and Formal Caregivers

The elderly need the support of their informal caregivers, healthcare providers, and community groups in order to reduce falls and falls risks. In fact, these stakeholders can assist older adults in self-management of fall prevention, based on individual preferences, local resources, and community based interventions. For this reason, it is necessary to disseminate falls prevention knowledge, expertise and resources through forums and meetings, promoting a comprehensive and systemic approach to falls prevention and to injury reduction. It is also necessary to promote cost-effective population-based interventions. In fact, targeted and evidence-based community programs have been shown to prevent falls as well as to provide a positive return on investment.

6.2.1 The "Long Live the Elderly!" Program Experience Could Be an Example to Overcome the Division Between Social and Health Services

The "Long Live the Elderly!" program (Comunità di Sant'Egidio, 2021) was born in Rome in 2004, as a response to the heat wave that in the summer of 2003 had caused thousands of unexpected deaths in Europe, in an attempt to prevent summer mortality. The philosophy of the program is that the emergency intervention in response to the heat wave is effective only if it is part of an active program throughout the year, which can thus, during an emergency, leverage procedures and relationships already established; in fact, the main risk factor that affects heat wave mortality is not only the psycho-physical condition of the subjects, but also social isolation. In fact, the main objective of the program is to counteract social isolation through active monitoring of the situation of older people over 80 (those most exposed to the impact of social isolation) and the creation of a network of individual and collective relationships that involves, in addition to the elderly over 80, all those who voluntarily make themselves available to collaborate.

The intervention model is based on:

a) contacting all over-80s in order to offer them a periodic assessment of their social and health needs, health promotion campaigns (eg "Tips for the heat"), assistance in handling bureaucratic issues or seeking formal assistance or informal and provide details of the office, active from 8:00 to 17:00, from Monday to Friday, to be contacted in case of need;
b) strengthen the network of communities around sick and / or socially isolated people by involving people who live or work close to them in voluntary assistance actions;
c) increase community awareness of the needs of the elderly.

The "Long Live the Elderly" program promotes a proactive approach to reach the entire targeted population, so as to prevent some individuals from being overlooked due to a lack of awareness of their care needs. Based on a list provided by the Municipality, all over-80s receive a letter and then a phone call to obtain their consent to be part of the program; the percentage of refusal is less than 5%. If the citizen accepts, a multidimensional assessment of his/her care needs is performed and the service begins. Based on the risk of a negative event, sized for each through a multidimensional assessment of frailty, an Individualized Care Plan (ICP) is drawn up and the citizen is included in the list of periodic telephone calls: the greater the risk of negative events, the more frequently it will be call the person, with a maximum frequency of once every two weeks, unless specific actions are required. In the event that an ICP is drawn up, the achievement of the objectives is periodically checked. The ICP can include the most different types of intervention (from planning structural adjustments to the apartment to reduce the risk of falls, to developing a treatment path that had been so far deficient; from identifying a paid assistant to completion of the paperwork necessary to obtain the disability allowance etc..). The program generally plays the role of the case manager, activating other formal services (for example home care) or informal (a volunteer who takes care of accompanying the person at a medical examination), although in some cases it can intervene directly.

The activities of the program intensify when a heat wave occurs: all over-80s assisted by the program are tracked by phone and, if necessary, the staff intervenes with a visit to the house, bringing food and / or medicine according to need, or by involving the citizen's network of relationships. Throughout the year, the operators act as a link between the older adults assisted by the program and the community, in order to increase the social capital of both. Healthy over-80s, however, are also contacted at least three times a year and during climate emergencies to monitor their situation.

The activities of the program have recently been enriched by integration with the community nurse. It is a nursing figure who mainly provides for the evaluation and monitoring of specific aspects of daily life (degree of frailty, nutritional status, risk of falling, adherence to polypharmacotherapy, quality of life). It also performs a health promotion function by addressing specific issues such as, for example, anti-flu and pneumococcal vaccination. Finally, it represents a support to the General Practitioner, with whom he relates directly, improving the effectiveness of his action through attention to clinical aspects collateral to the prescription of therapies or diagnostic tests. This approach allows to overcome the division between social and health interventions which constitutes the main obstacle to the creation of effective care services at community level for the older population.

The program is currently operational in several Italian cities (in addition to Rome, Novara, Genoa, Civitavecchia, Amatrice, Naples, Brindisi, and Cagliari) and has around 14,000 subjects with an age equal to or greater than 80 years. In Rome, the Program was able to limit the increase in mortality during the heat waves of 2015 and 2017 by about 50% compared to other areas of the city where the program was not operational, with a reduction in expected mortality by 13% (Liotta et al., 2018b; Liotta et al., 2018c). Furthermore, the "Long Live the Elderly" program appears to be able to reduce the hospitalization rate in a sample of the elderly by about 10% in the first six months of follow-up by around 40% the institutionalization rate (Marazzi et al., 2015).

It is worth of note to underline that the program can represent an entrance door for the taking in charge of people over the age of 80, in order to assess their need for assistance and direct it to the most appropriate services. On the other hand, the participation of many older adults in the social protection networks implemented by the program itself highlights how it also involves people of a younger age or in any case willing to give a part of their time to others, thus creating an important drive towards active aging (Golinowska et al., 2017).

A further element of interest is represented by the costs saved in terms of hospitalizations or in avoided residential structures which are overall higher than the cost of the program (equal to € 81 per elderly person per year) (Liotta et al., 2018c). Although these are initial evidence that require further checks on larger samples of the population, a promising prospect is foreseen for the implementation of innovative services.

6.3 Integrated Policies and Implementation Practices Under the Concept of Smart Healthy Age-Friendly Environments

To live and participate in society, it is necessary that working and living environments are usable, accessible and reachable for all people, either they walk, drive, use a walker or wheelchair, have hearing or vision problems. With the ongoing digitization of society, digital solutions could assist to better prevent non-communicable diseases, promote independent living, thus favouring health and wellbeing. However, single digital solutions are not the panacea to all issues. Citizens need to improve their digital skills, health literacy, citizenship engagement and democratic participation. Environments face challenges: house retrofitting, digital infrastructures, public spaces and transport and climate neutral solutions. Finally, health and care need reliable and accessible big data, integrated and person-centered solutions (new pathways) and solid business models. All these challenges are interconnected and need a holistic approach.

In 2018, Caritas Coimbra and AFEdemy delivered a Joint Statement to the European Commission and Member States, defining 5 policy priorities to broaden the shared vision on the digital transformation of health and care - SHAFE – Smart Healthy Age-Friendly Environments. To create this shared vision in all its facets, achieving goals of healthy living, social inclusion and participation, the SHAFE network wants to draw the attention of policy makers, organisations and citizens to better align ICT with the built environments. This alignment must focus on an enhancement of the user-centred design of the major concept areas of People (e.g. citizenship, long-life learning, social interaction) and Places (as houses, built environments, community spaces and outdoor facilities). The reasons for this pledge are multiple (such as lack of real cooperation between policy pillars of health, infrastructure and digital innovation, unclear return on investment or business case, (digital and health) illiteracy and lack of funding and coordination), however it could be summarized as a pledge to realise SHAFE by focusing on better coordination and implementation and to involve (end)users from the beginning. From origin, SHAFE has its roots on the holistic age-friendly environments concept, developed by the World Health Organization in 2007, however further developed now into the new era of digitalization and health. This joint approach could assist to better prevent people from noncommunicable diseases, promote independent living, and thus favouring health and wellbeing. SHAFE needs a multi-faceted approach and multiple stakeholders to become really implemented. Single players are not enough to realize social inclusion and healthy lives for all. Therefore, it involves a broad network of stakeholders: varying from older and younger citizens, to businesses, financers and public authorities. With the start of the Thematic Network in 2018, it already laid ground for the integral approach of multiple stakeholders; it is now evolving to additional organisational and individual pledges aiming to continuously grow the network. Thus, in 2020, the Stakeholders Network on SHAFE aims to achieve mainly Coordination and Implementation, specifically the following higher-level goals:

- Promote training of formal and informal caregivers (communities) on SHAFE, creating a toolkit and implementing training actions in multiple countries;
- Raise awareness on the need to enhance social care, building infrastructure and environment conditions in order to move Health and wellbeing provision to the home and towards prevention – to a Health and Wellbeing value-based approach;
- Jointly develop sustainable business cases with insurance companies and investors to foster future investments on smart healthy environments;
- Modernise education of urban planners, architects and ICT-developers in general to focus on PEOPLE and PLACES and focus research on lifelong learning, evidence-based design, smart healthy environments and empowerment;
- Support public authorities and health and social care providers on implementing SHAFE, especially regarding building or restructuring the built environment to include ICT solutions with integrated health and care provision.

6.4 The relevance of accessibility for an age-friendly environment

6.4.1 Accessibility: Framework and Definition

Accessibility means being able to be reached or obtained easily: the usability of a product, service, environment or facility by people with the widest range of capabilities. Every aspect of society, knowledge, motion or rest, culture, should have no limits for people of every health's degree: disable and non disable people need to be considered in a framework of inclusion and equality, in order to reach and produce social value and community empowerment (University of Cincinnati, 2021). Having an affordable approach means to make products and services easy and enjoyable in their features and interfaces. Removing physical and mental obstacles is pivotal to ensure to everyone the right to participate in cultural life, recreation leisure and sport, in political and public life as well as in placement and during the entire life-course.

6.4.2 Culture and environment: leisure and work

Closely related/linked to accessibility is the idea of universal design, and retrofitting the built environment to improve it. An environment should meet the needs of an entire population. Thinking about something accessible could be misunderstood: if you have no stairs, a place is reachable for a large number of people — no matter in what type of diversity they are living (Agenzia per l'Italia digitale, 2021). So, it is truly required to architects and designers to think about "different shapes of humanity", but it is equally important to have a person-centered perspective in designing things. It is a question of open-minded vision, where culture and education lead human growth.

6.4.3 Education, Media and Web

Learning should have no limits. To develop a user-friendly learning system, accessible contents need to be optimized for simply mental process — it is useful for every smart involvement. Information is more accessible and likely to be assimilated by learners when it is presented in a way that primes, activates, or provides any pre-requisite knowledge (National Center on Accessible Educational Materials, 2021).

According to The guidelines and Success Criteria of Web Content Accessibility Guidelines (WCAG) 2.1, anyone who wants to use the Web must have content that is:

- Perceivable: information and user interface components must be presentable to users in ways they can perceive. This means that users must be able to perceive the information being presented (it can't be invisible to all of their senses);
- Operable: user interface components and navigation must be operable. This means that users must be able to operate the interface (the interface cannot require interaction that a user cannot perform);
- Understandable: information and the operation of user interface must be understandable. This means that users must be able to understand the information as well as the operation of the user interface (the content or operation cannot be beyond their understanding)
- Robust: content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies. This means that users must be able to access the content

as technologies advance (as technologies and user agents evolve, the content should remain accessible) (World Wide Web Consortium, 2021).

If any of these are not true, users with disabilities — or ageing, will not be able to use the Web. Assistive technology can help and compensate every type of human need, with customization of interface (United Nations, 2021). Content creators should clarify vocabulary and symbols, syntax and structure, support general contents with explanations and examples; guide information processing and visualization; encourage the use of multiple media for communication and of multiple tools for construction and composition (Center for Applied Special Technology [CAST], 2018; United States Department of Justice, 2021). This kind of procedure will undoubtedly be appreciated by both small kids and elderly people (Piaget, 1972; Piaget et al., 1974).

Governments, public organizations, associations and foundations, enterprises and citizens can collaborate to enable people to live independently and give them the opportunity to participate in every aspect of life: education, arts & crafts, leisure; culture, fun and amusement. Accessible transportation, technologies facilitate access to environment, both in urban and rural areas. Intellectual environment and knowledge have structure and rules that still need to be expanded.

6.4.4 Physical Accessibility Enabled by New Technologies

Human is, by his intimate nature, not self-sufficient at birth, his lack of self-sufficiency if not compensated by maternal care would preclude the continuation of life. Over time a homeostasis is established between endogenous and exogenous factors that allow to maintain an adequate level of autonomy. Diseases are one of the factors that most seriously undermine the physical integrity of the humans, leading to the emergence of disability. We can defend ourself from the diseases with prevention and improvement of care but despite all the technological advances, including those of regenerative medicine, to date the return from any disease to healing accumulates in our body an impairment of different degrees but in any case never absent. Over the course of life, each person accumulates impairments which, depending on the severity, affect his physical and mental abilities, progressively increasing his disability until he reaches, in extreme degrees, complete non self-sufficiency. In this process of individual's health level potential decline, more than prevention and medical treatment, plays a fundamental and extraordinary role the possibility of intervening on the external living environment in which people live. The environment in which each person lives constitutes another variable that determines, to various degrees, their disability. The degree of obstacle that the environment represents, for the expression of their potential, it represents the handicap. It has long been understood the importance of acting on this factor to help to preserve as long as possible the residual abilities of the person. In the first instance the reduction of the Handicap was almost exclusively reserved to the removal of architectural barriers and to the adaptation of the safety characteristics of the life and working places. New technologies have subsequently introduced the possibility to intervene directly on the human body, by artificially reproducing structural parts or entire organs of it. The last frontier of this Handicap reduction process is the one offered by artificial intelligence that allows the production of a new generation of prostheses such as exoskeletons that applied to an individual can assist his movements. Another extraordinary example of the use of technology is the one of augmented reality applied to eye communicators that allow particular categories of patients, such as those suffering from motor neuron diseases (e.g. ALS), to be able to communicate and act with the outside world at an unthinkable level until recently. 5G, the latest breakthrough in information technology, allows users to take advantage of augmented reality through eye communicators and the extraordinary interconnection not only between devices but also between simple household appliances. The patient with ALS will be able to interact with the outside in many ways: at a communicative level, by converting the words written through the eye pointer into voice, or by sending emails. From a prassic point of view the user, through the eye communicator, with a lift connected to a rail system, can move around his home and maintain a minimum of self-sufficiency. In conclusion, while waiting for medical progress, the use of new technologies is a valuable aid in the fight against non self-sufficiency.

7 EMERGING ENABLERS AND BOTTLENECKS

7.1 Training and Education to Enable the Adoption of Digital Solutions

The European Commission has adopted on 17 January 2018 the Communication on the Digital Education Action Plan (European Commission, 2018). The Action Plan outlines how the EU can help individuals, educational institutions and education systems to better adapt for life and work in an age of rapid digital change by:

- Making better use of digital technology for teaching and learning;
- Developing relevant digital competences and skills for the digital transformation;
- Improving education through better data analysis and foresight.

7.2 Data Sharing and Interoperability

While facing the challenge of how to provide modern healthcare, novel ICT solutions and devices for prevention, monitoring, home and cross-border health management are fast spreading and evolving. Many of these innovative tools also offer the opportunity of enriching the overwhelming amount of available information that may further contribute to support health management, research, policy makers and innovation in the associated sectors.

Notwithstanding these opportunities, data resources, when conceived and made available as additional deliverables, have restricted access and interoperability, limiting the full exploitation of the potential outcomes, as well as integrative efforts and long-term reusability.

Several steps have already been undertaken, which include: (i) the adoption of new guidance on interoperability and standards for digital health and care, (ii) the strengthening of cross border health data (through the Connecting Europe Facility (CEF)), and (iii) new investments in large scale implementation of in digital health and social care programmes, both at national and regional levels.

Notwithstanding these efforts, there are still challenges that need to be addressed for maturing an interoperable eHealth environment considering all concerned levels and necessary competences. Among the main issues to be tackled there are the complexity of the overall information to manage, the project implementation plans which are not necessarily required for digitalized information sharing, the limited rules and standards to organize the varied data. Therefore, in the BIG Data era and in a “digital” world, the establishment of suitable standards for data and metadata collections still represents an *open* challenge for *open*, accessible resources.

Fortunately, these aspects are not being left out of consideration for future action plans, as also mentioned in the European directives, since they are the keys for data integration and interoperability. A sustainable healthcare management, going from the transition from a hospital-based health care model, to personalised medicine, independent living or integrated health and social care, favouring early diagnosis, prevention of diseases and proactive re-design of working and living environments will favour citizens, as well as policy makers and enterprises, offering still underestimated social and economical opportunities.

7.3 Assessment and Change Management of ICT Adoption

According to the World Health Organization (WHO), e-health is a very broad and multidimensional concept, including the offer of technologies for diagnosis, care and assistance; the technical infrastructure and IT equipment necessary for the provision of these services; but also the cultural aspects related to the emergence of this technological innovation (WHO, 2005). Digital transformation in health and care needs adequate tools that offer decision-makers sufficient knowledge about the potential, advantages and costs associated with its introduction and use of innovative ICT solutions. It is already established that innovative solutions adoption varies among different countries (Currie Seddon, 2014) and the needs for effective business models to implement and adopt them are increasing (Kimble, 2015). An one-size-fits-all implementation strategy for all of the health systems will most likely not succeed without either changing the technology and services or differentiate in the business models according to cultural and social contexts differences. E-Health solutions impact the patient's health outcomes and lifestyle, the quality of the service provision and the professionals' work, the equal accessibility to care by the citizens and data security. Underestimating the impact that the use of technology has on the system, without a change management planning, determines the failure of adoption processes. The main failure factor of innovation in healthcare is given by the underutilization from end-users (professionals and patients) of the new IT systems, leading to the so-called "IT productivity paradox", for which there is a lack of return on investment against very high costs (Jones et al., 2012). IT can only contribute to the care path if the innovative solutions are adequately integrated into the assistance processes, work routines and daily life of end users. Knowledge of the care experience, held only by the patient, is particularly valuable. This knowledge can be enhanced through participatory design, in which the customer is no longer the passive recipient of a new product but is an integral part of the design and of the innovation process as a whole (De Luca et al., 2019b). The EU agenda for effective, accessible and resilient health systems (European Commission, 2014) indicates Health Technology Assessment (HTA) (Gabbay & Walley, 2006) and ICT as priorities to contribute to innovation, efficiency and sustainability of health systems. The Model for Assessment of Telemedicine (MAST) is an example of declination of the HTA methodology to evaluate the efficacy and contribution to the quality of care of telemedicine applications (Kidholm, 2012). The integration between healthcare and citizens' well-being has been addressed by the EIP on AHA in recent years. The update of the Blueprint for the Digital Transformation of Health and Care provided a methodology to develop persona types, representing citizens needs in a matrix developed along life-course and complexity. Persona types share some unmet needs, related to dependency and caregivers stress, adherence to more or less complex treatment regimens, including healthy lifestyles, often safety and accessibility concerns and diverse degrees of social isolation. This approach facilitate the identification of organizational, digital and sociocultural elements requiring customization to ensure adoption at a specific loco-regional level (European Commission, 2017). MAFEIP is an analytical decision-making model that integrates data from multiple sources to evaluate the impact of an innovative interventions, with broader aims of telemedicine, on the years of life acquired, on the quality of life related to health and on the costs of health and social care (Boehler et al., 2015). It is clear that further development of the assessment methods is necessary. This aspect is crucial for the development and adoption of innovative approaches and technologies for effective and sustainable contribution to citizens' health and social innovation.

8 CONCLUSION

In the framework of an ageing population, we are being faced with multiple challenges that include chronic conditions, as well as the increase of related acute events. Falls are one of the events occurring at older age with the highest impact, in terms of health outcomes, as well as of health care resources, that could be effectively prevented and managed implementing a proactive, interdisciplinary approach supported by innovative solutions.

Indeed, falls in older adults are linked to several elements, such as polypharmacy, sarcopenia, inadequate food intake, built environment that could be helpful in early identification of the risk of fractures and ri-fractures. Addressing all these elements requires interdisciplinary and multi-organization collaborations, to identify the indicators than we need to assess for timely and personalised interventions. Collecting and sharing the data underlying risk stratification is the first step to implement tailored interventions that can be personalised and allow, for example, the detection of behavioural patterns capable of influencing health outcomes and prevent falls, and mitigate falls consequences.

Fall prevention represents a paradigm of policy interventions for public health that are implemented at a level and intensity of action that also tackle health inequalities. They are an example of how innovative, multilevel approaches can ensure economic benefits at a national level, as well as the right of all citizens to the highest attainable standard of health, irrespective of place of birth, gender, ability, or socioeconomic background.

The use of health impact assessments applied to fall interventions might be one of the frameworks through which the potential health impact of a shared policy might be evaluated to assess its health consequences.

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Chapter 3
Fall-Risk-Increasing Drugs:
Background, Current Evidence on Deprescribing, and Future Perspectives

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ABSTRACT

This chapter provides a summary of current evidence on fall-risk increasing drugs from the literature (recent systematic reviews) and expert opinion on this topic (statement paper of EuGMS Task & Finish group on FRIDs and results of Delphi study of the group). Furthermore, deprescribing of FRIDs is being discussed.

KEY MESSAGES

- The use of fall-risk-increasing drugs (FRIDs) is one of the most prominent fall risk factors
- Deprescribing FRIDs is an essential component of the multifactorial intervention to prevent falls and injurious falls
- EuGMS Task and Finish Group on FRIDs was established to tackle the lack of knowledge on FRIDs and develop deprescribing aids for both healthcare professionals and older adults at risk for falls
- STOPPFall, a European consensus deprescribing tool, was created by the EuGMS Task and Finish Group to provide a first step towards harmonizing practice and guidelines on drug-related falls internationally
- To further optimize prevention of medication-related falls, the following is warranted:
    1) greater awareness and knowledge of all stakeholders
    2) development of effective and personalized deprescribing aids

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3) development of effective implementation strategies for FRIDs deprescribing, that take the patient perspective into account
4) promote high-quality research and innovative research techniques, such as modern data-driven methods, considering the complexity of deprescribing interventions and heterogeneity of older persons

GENERAL BACKGROUND: FALLS AND FALLS PREVENTION

As the world ages, falls are a growing public health concern with a substantial impact on individuals as well as the society. Approximately one out of three of adults aged 65 years and older fall at least once a year, and over 60% percent of those who fell in the past year report being injured (Ganz & Latham, 2020; Milat et al., 2011). Of all fall incidents, around 10-15% lead to a fracture and 5% serious soft tissue injury or head trauma (Berry & Miller, 2008). Falls are even more common in older and institutionalized populations; approximately one out of two institutionalized persons and persons aged 80 years and older will experience one or more falls yearly (Berry & Miller, 2008). Furthermore, fall incidents have been associated with many negative health effects in older persons, including greater functional decline, social withdrawal, symptoms of anxiety and depression, and fear of falling (Berry & Miller, 2008). Also, due to all adverse health-related effects, fall incidents have a drastic impact on healthcare expenditure. In Western countries, approximately 0.85-1.5% of the total healthcare expenditure are fall-related costs (Heinrich et al., 2010). Predominantly falls result from interacting risks, and certain medication classes are a significant risk factor for falls (de Vries et al., 2018; Seppala, van de Glind, & Daams, 2018; Seppala, Wermelink, & de Vries, 2018).

Several clinical practice guidelines for falls prevention have been published across the globe, with varying content and recommendations (Montero-Odasso et al., 2021). Therefore, a standardized global falls prevention and management guideline is currently being developed, as well as, WHO technical package Step safely: strategies to prevent and manage falls across the life-course is being expected to be published in 2021 (Montero-Odasso et al., 2021; WHO,). One of the most recent clinical practice guidelines by the US Preventive Services Task Force (USPSTF) recommends exercise interventions and selectively offering multifactorial interventions to prevent falls in community-dwelling adults 65 years or older who are at increased risk for falls (Force, 2018). Furthermore, the recent meta-analysis by Tricco et al. showed that also injurious falls are preventable (Tricco et al., 2017). Multifactorial interventions contain an initial assessment of risk factors for falls and subsequent customized interventions for each patient based on risk factors identified in the assessment (Force, 2018). Since the use of fall-risk-increasing drugs (FRIDs) is one of the most prominent fall risk factors, a medication review with the aim of deprescribing FRIDs, is considered to be an essential component of the multifactorial intervention (de Vries et al., 2018; Seppala et al., 2020; Seppala, van de Glind, & Daams, 2018; Seppala, Wermelink, & de Vries, 2018). In general, it is recommended to screen all older adults annually for high fall risk (American Geriatrics Society and British Geriatrics Society, 2011). A multifactorial intervention, including a medication review, is warranted in case of markers of high risk, including a history of two falls or more in the past year, a visit to an emergency department for a fall in the past year, or problems with walking or balance (American Geriatrics Society and British Geriatrics Society, 2011). An updated algorithm to identify older persons at high risk of falls is currently being developed by the task force of the global falls guideline initiative (Montero-Odasso et al., 2021).

FALL-RISK-INCREASING DRUGS

Older people are more vulnerable to adverse drug reactions (ADR), such as falls, due to age-related changes, including reduced renal excretion and hepatic metabolism, resulting in different pharmacokinetics and -dynamics of medication. Traditionally, several medication classes of psychotropics and cardiovascular medication classes have been considered the main groups inducing increased fall risk. The use of FRIDs is common among older adults ranging from 65%-93% in older adults with a fall-related injury, and the use of FRIDs appears to be increasing in the past decade(s) (Hart et al., 2020; Shaver et al., 2021). FRIDs can contribute to fall risk through different routes, i.e. adverse drug reactions. For example, antihypertensives may lead to balance and gait impairment, dizziness, and postural hypotension, which are all underlying pathways for the adverse drug reaction 'falls' (Tinetti et al., 2014), and benzodiazepines may induce sedation, dizziness, and balance problems (Ham et al., 2017). Furthermore, earlier studies have shown that individual patient characteristics may determine the association between FRIDs and fall risk in an individual since the risk appears to be dependent on patient characteristics such as history of previous fall injuries (Tinetti et al., 2014). Also, in general, risk of ADRs is strongly related to characteristics such as multimorbidity, polypharmacy, age, and frailty (Alomar, 2014).

Even though FRIDs use is a common and established risk factor, health care professionals and older adults, including caregivers, lack knowledge on medication-related fall risk. Due to a common interest among European experts on FRIDs to tackle this lack of knowledge and harmonize both clinical practice and guidelines on drug-related falls, a European working on FRIDs was established in 2016. It started as a task force of EIP AHA action group 2 on falls prevention, founded by the chair of the group, prof. Nathalie van der Velde, MD, PhD, and Lotta Seppala, MD, secretary (EuGMS, n.d.). The task force was officially accepted as a EuGMS Task and Finish Group in 2017 and currently contains 30 members from 14 countries (EuGMS, n.d.). Its main objectives are to update the knowledge related to FRIDs and disseminate this knowledge on FRIDs and deprescribing interventions to health care workers, students, and the older adults at risk. The ultimate goal is to minimize the use of inappropriate FRIDs in persons at risk, and to succeed in this, the Task and Finish Group has, for example, created a European consensus list of FRIDs (STOPPFall), organized several international symposia on FRIDs, and developed a leaflet for older adults about medication and falls. Eventually, the goal of the Task and Finish Group is to co-develop drug deprescribing interventions that are personalized and effective in falls prevention and to harmonize practice on FRIDs deprescribing across Europe. With a representation in 14 countries across Europe, the Task and Finish group has an effective network with high potential to develop tools and recommendations and implement these. Furthermore, it works in close collaboration with EuGMS Special Interest Group on Pharmacology and Special Interest Group on Falls and Fractures and has provided chairs and the working group members for the polypharmacy and FRIDs working group of the anticipated global falls prevention and management guideline (Global Guidelines for Falls in Older Adults, n.d.).

The Task and Finish Group started the work by updating the current knowledge. In the comprehensive systematic reviews and meta-analyses, they confirmed the association between psychotropics (antidepressants, antipsychotics, benzodiazepines) and fall risk (Seppala, Wermelink, & de Vries, 2018). In addition, consistent associations with falls were reported for loop diuretics, antiepileptics, opioids, and polypharmacy (four or more medications) (de Vries et al., 2018; Seppala, van de Glind, & Daams, 2018). However, the focus of these studies was on commonly prescribed medication classes and their fall risk in a relatively healthy older population, since in general, cohort studies on aging lack suitable data in terms of less prescribed medication classes and personalised treatment effects (Seppala et al., 2020).

This underlines the need to build a broader knowledge beyond the results obtained from systematic reviews. Furthermore, some current national falls prevention guidelines in Europe have not been updated in recent years, and they vary considerably as to which medications they include as risk factors for falls (Seppala et al., 2020). Therefore, the Task and Finish group decided to create the European consensus deprescribing tool STOPPFall (Screening Tool of Older Persons Prescriptions in older adults with high fall risk), in collaboration with the EuGMS SIG on Pharmacology and an international advisory board. This international Delphi expert effort can be considered an important step towards harmonizing the practice and guidelines on drug-related falls in Europe (Seppala et al., 2020). The STOPPFall contains a consensus list of FRIDs and accompanying practical guidance to simplify and structure FRIDs deprescribing in clinical practice. The 14 medication groups that reached consensus are presented in Table 1. In general, the initial step to reduce the harm caused by FRIDs is to prevent their inappropriate use in the older population (Seppala et al., 2019). Thus, it is recommendable to systematically check for a history of falls and a high risk of falling before prescribing FRIDs for older people (Seppala et al., 2019).

Table 1. Fall-risk increasing drugs according to Delphi consensus effort

• Benzodiazepines and benzodiazepine related drugs
• Antipsychotics
• Antidepressants
• Diuretics
• Alpha-blockers used as antihypertensives
• Centrally-acting antihypertensives
• Vasodilators used in cardiac diseases
• Opioids
• Antiepileptics
• Anticholinergics
• Alpha-blockers used for prostate hyperplasia
• Overactive bladder and incontinence medications
• Sedative antihistamines

DEPRESCRIBING FRIDS

Medication review, with the aim of deprescribing FRIDs, is considered to be an essential component of the multifactorial intervention to prevent falls, which has been proven effective in reducing the rate of falls (Gillespie et al., 2012). The majority of possible adverse effects leading to falls, such as presence of orthostatic hypotension or sedation, are reversible after deprescribing (van der Velde & van der Cammen, 2006). However, there is a lack of evidence related to the effectiveness of deprescribing as a single intervention to prevent falls (Lee et al., 2021). The recent systematic review by Lee et al. found no effect of pure FRIDs deprescribing on fall outcomes as a single intervention (Lee et al., 2021). Also, Cameron et al. concluded that a medication review, as a single intervention, may make little or no difference to the rate of falls or risk of falling in long-term care facilities (Cameron et al., 2018). Nevertheless, in an ongoing meta-analysis of the FRIDs working group of the global falls prevention and management guideline assessing medication reviews, we did see a trend for a lower number of fallers in long-term care. This possibly indicates that in a frail subgroup of older persons, deprescribing might be effective also as a single intervention. Nevertheless, given the multifactorial nature of falls, deprescribing interventions should not be implemented as a stand-alone strategy to prevent falls but as a part of multimodal strategy (Seppala et al., 2020). Medication review is a complex intervention in which the potential beneficial effects of therapy must be balanced against potential and experienced adverse drug reactions. It is recommended to be performed in case of high risk of falling (Seppala et al., 2019). Fall incidents can thus serve as an important trigger for undertaking such a task. As mentioned earlier, studies have shown that the effect of FRIDs on fall risk is likely dependent on patient characteristics (Tinetti et al., 2014). Thus, these patient characteristics, including frailty status, polypharmacy, co-morbidities, patient's preferences, and other geriatric syndromes, should be considered when performing a medication review (Beuscart et al., 2021). The review needs to be a holistic assessment incorporated into a comprehensive geriatric assessment to produce a personalized medication strategy that also includes patient's perspectives (goals and wishes) (Beuscart et al., 2021). Moreover, about 20% of falls result in serious injuries, such as fragility fractures and intracranial bleeding (Berry & Miller, 2008). Therefore, in the overall medication review, the known drugs to enhance injury risk, such as skeletal fragility, should also be taken into account (Seppala et al., 2019).

In general, when conducting a medication review as a part of a multifactorial intervention, deprescribing of FRIDs can be performed safely in older people at high risk of falls' (Iyer et al., 2008). Few adverse withdrawal effects occur, and if symptoms re-occur, they can be safely treated by restarting the withdrawn medication or if possible a safer alternative (Iyer et al., 2008). Nevertheless, this does not appear to be current practice. According to a recent systematic review, FRID use did not decrease at 1 and 6 months following the fall-related healthcare episode in observational studies (Hart et al., 2020). Furthermore, in a study implementing the Centers for Disease Control and Prevention's Stopping Elderly Accidents, Deaths, and Injuries initiative among primary care providers, most patients with high fall risk received the majority of recommended assessments and interventions, except medication modification (Eckstrom et al., 2017). In general, the barriers and enablers for deprescribing can be categorized into environmental (e.g., regulatory, financial, policy), healthcare organization, provider, and patient/public related factors (Sawan et al., 2020). Lack of knowledge and skills is a significant barrier to healthcare professionals' capacity to implement effective fall-prevention approaches (Tinetti et al., 2006). Many physicians perceive the withdrawal of FRIDs to be challenging and find uncertainty about the possible adverse consequences uncomfortable (Bell et al., 2015). On the other hand, older adults are also hesitant to stop their medication, fearing withdrawal reactions and relapse of their disease (Reeve et al., 2013). Finally, if deprescribing of FRIDs is attempted, compliance is often poor, especially for psychotropics (Boye et al., 2017). For the long-term success of deprescribing, provision of education, monitoring, support, and documentation are crucial (Reeve et al., 2014).

To support clinicians in the complex task of deprescribing FRIDs, the Task and Finish Group has first described in statement paper the generic steps for FRIDs withdrawal, from medication review to symptom monitoring after deprescribing (Seppala et al., 2019). These generic steps of medication management of older fallers are listed in Table 2. To further simplify and structure FRIDs deprescribing, the STOPPFall FRIDs list was combined with a STOPPFall deprescribing tool with practical guidance (Seppala et al., 2020). A freely available online deprescribing decision support tool was built for each consensus medication class from Table 1 (EuGMS, n.d.). The tool works in a stepwise manner containing all the steps of the medication management of older fallers from Table 2 and providing specific information for each medication class. Also, it includes relevant references and links to general deprescribing guidelines.

Table 2. Steps in medication management of fallers

1. **Medication review,** a structured, critical examination of a patient's medicine, with the aim of identifying FRIDs use
2. To **identify** possible appropriate **indication for FRIDs prescribing**
3. In case of existing indication, **switching to a safer alternative, to smaller dosage or change in dosing time or interval**
4. In case of no safer alternative is available, **perform a shared decision-making with patient and possibly another specialist**. The possible withdrawal or dose reduction decision should be based on disease and adverse event risk and patient's goals.
5. If you have decided to withdraw or reduce the dosage based on any of the steps from 2-4, you should always create a **plan for the deprescription** including the following components:
• **If a stepwise withdrawal is needed** and how this will be performed
• **How often and for which symptoms should be monitored**. At least monitor for change in fall incidents and symptoms such as dizziness and possible negative outcomes such as the onset of symptoms for which the medication was prescribed

FUTURE PERSPECTIVES

In summary, falls and related injuries are a major public health concern with a substantial impact on individuals and society. Exercise interventions and multifactorial interventions are recommended interventions to prevent falls in community-dwelling adults 65 years or older who are at increased risk for falls. Since the use of FRIDs is one of the most important treatable fall risk factors, a medication review with the aim of deprescribing FRIDs is an essential component of the multifactorial intervention. As there was no international consensus on which medications are considered as FRIDs, STOPPFall was built through a European consensus Delphi process by the EuGMS Task and Finish Group on FRIDs, in collaboration with the EuGMS SIG on Pharmacology and international advisory board, and combined with a practical deprescribing tool designed to assist in clinical decision-making. Furthermore, it can provide an initial step towards harmonizing the practice and guidelines on medication management in falls prevention in Europe. However, further steps are needed to optimize the care for an individual and reduce the fall-injuries related burden on societies by:

- Dissemination of knowledge to all stakeholders
- Inclusion of medication-related falls as a part of the curriculum for all healthcare students in compliance with the European Undergraduate Curriculum in Geriatric Medicine
- Inclusion of patient and other stakeholders perspectives in deprescribing interventions
- Development of implementation strategies aimed at structured FRIDs deprescribing in clinical practice
- Further personalization of FRIDs management
- High-quality research and innovative research techniques, such as modern data-driven methods, which take the complexity of deprescribing interventions and heterogeneity of older persons into account

Increased knowledge and skills in FRIDs withdrawal through knowledge dissemination and decision aids can tackle the current reluctance to withdraw FRIDs. For optimal knowledge dissemination and implementation, up-to-date recommendation of medication-related falls prevention and management available across the globe is warranted. The anticipated World falls prevention and management guideline will correspond to this need (Montero-Odasso et al., 2021). Such a guideline should subsequently be successfully implemented at a national/local level. When developing recommendations, patient perspective should be taken into account as this could enable the empowerment of older individuals to participate in shared decision making actively. High-quality research will enable us to understand who is at risk of drug-related falls and to better target the population for deprescribing interventions, and further develop interventions that are effective and personalised.

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KEY TERMS AND DEFINITIONS

EuGMS: European Geriatric Medicine Society.
FRID: Fall-risk-increasing drug.

Chapter 4
Bone Density and Fall Risk Screening in Algarve:
A Preliminary Study

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ABSTRACT

Osteoporosis is a major cause of morbidity and mortality around the world and is a silent disease characterized by low bone strength that results in an increased risk of fracture. The benefits of being physically active in advanced ages to reduce the loss of bone mineral density (BMD) and improve functional capacities are well known. Quantitative ultrasound (QUS) is a peripheral bone densitometry technique that is rapidly gaining in popularity for the assessment of skeletal status, along with fall risk assessment. This chapter consists of a brief review of the literature on osteoporosis and describes ongoing activities on bone density and fall risk prevention in Algarve, Portugal as part of EIP AHA´s action group on fall prevention with the presentation of a preliminary study. This study aimed to demonstrate that the postmenopausal female seniors who adhere to the recommendations for the regular program of physical activity after osteoporosis screening one year later show a slower decrease in BMD.

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INTRODUCTION

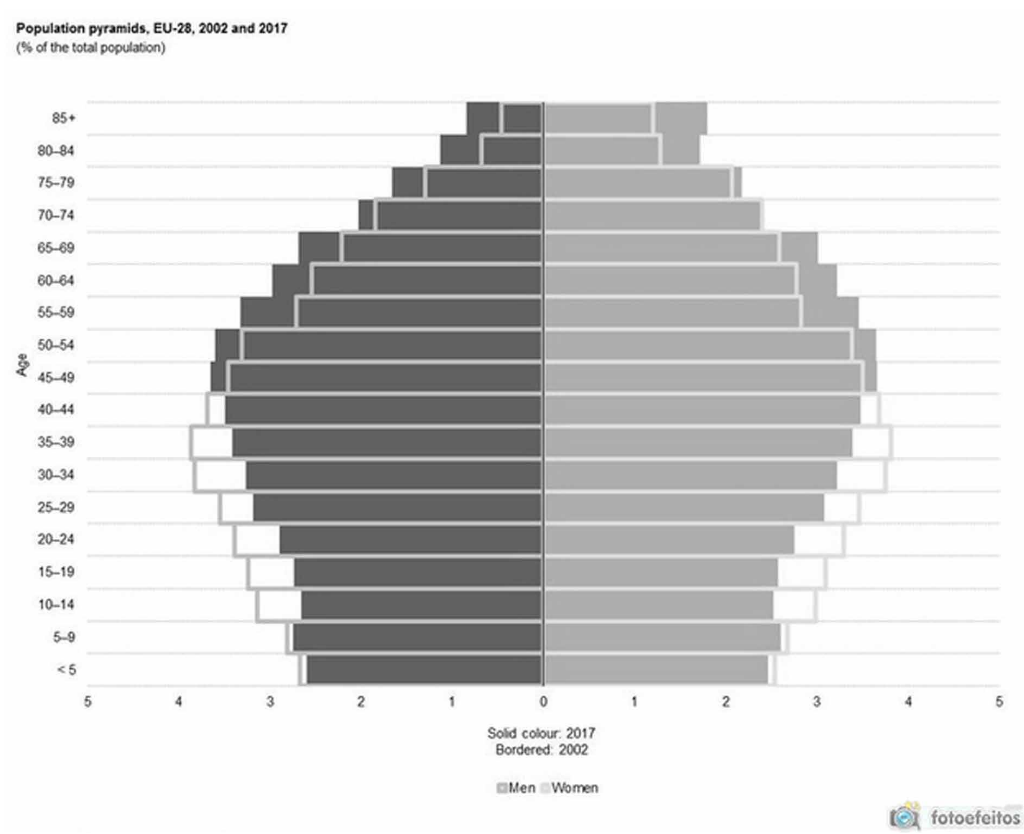
Osteoporosis is a major cause of morbidity and mortality around the world (Melton III *et al.*, 2013; Sözen, *et al.*, 2016) and is a silent disease characterized by low bone strength that results in an increased risk of fracture (Lippuner, *et al.*, 2006), particularly in elderly (Cauley, *et al.*, 2007).

The term elderly refers to any individual aged 65 or over. Individuals aged between 50 and 64 years who have physical or clinical limitations that prevent the practice of physical activities or affect the ability to move are also considered elderly people (Riebe, *et al.*, 2018).

There has been an exponential increase in the elderly population in recent years and it is expected to continue to increase in the coming decades (Werner, 2010). During aging, marked changes can occur, at a physiological, psychological or mechanical level, which can manifest themselves in the state of health, function and quality of life. An inherent characteristic of the aging process is sedentary behavior that tends to increase with age (Instituto Nacional de Estatistica, 2020).

Demographic changes in Europe (figure 1) as in all over the world are a difficult challenge to solve for younger generations than the previous ones, as they will take care of the aging population with the decrease in their quality of life.

Figure 1. Source Eurostat (online data code: demo_pjangroup; Note Break in series 2017: estimate, provisional)



Most elderly people spend about 65 to 85% of their day in a sitting position, making them the most sedentary population. This chronic sedentary lifestyle leads to negative repercussions on metabolic functioning, cardiovascular and musculoskeletal health, body composition and mechanical functionality in daily life tasks. In this way, the independence of the elderly is severely compromised (Wultems, *et al.*, 2016).

It is not yet known why calcium and exercise together have a greater osteogenic effect than any of them alone. It is generally accepted that growing bones have the ability to adjust to an increased load through various mechanisms (Bielemann et al., 2013).

Therefore, the increased load stimulates bone modeling that results in changes in the shape of the cortical bone and increased trabecular BMD which, in turn, causes an increase in bone strength. (Hemayattalab, 2010).

Adolescence is a critical period for the acquisition of bone mass, and epidemiological studies have suggested that obtaining a high peak of bone mass during growth may decrease the risk of suffering osteoporosis and osteoporotic fractures, therefore, later in life (Gómez-Bruton, Gónzalez-Agüero, Gómez-Cabello, Casajús, & Vicente-Rodríguez, 2013).

EFFECT OF AGE ON BONE MASS & FRACTURES

Osteoporosis is defined clinically as the presence both of a fragility fracture and of low bone mass. Operationally, osteoporosis is defined as a bone density more than 2.5 SD below the mean peak BMD (T score < -2.5) and osteopenia is defined as BMD between 1 and 2.5 SD below the mean peak value (T score <-1 & > -2.5) while BMD with T score > -1 is reported normal. The fracture risk correlates well with the bone mass & BMD and increases 2 fold with each SD decrease in BMD (Genant *et al.,* 1990; WHO, 1994) (Figure 2).

Although significant advances have been made in the treatment of osteoporosis, much attention is still focused on preventive strategies (Nishizawa, *et al*., 2019) and demographic patterns and secular trends look set to ensure that, globally, the magnitude of this problem will increase substantially over the next few decades (Instituto Nacional de Estatistica, 2006).

Osteoporosis is a serious disease that affects millions of people worldwide (Figure 3). Without prevention or treatment, osteoporosis can progress without pain or symptoms to bone breakage (fracture). Fractures usually occur in the hip, spine and wrist (Cooper *et al.,* 1992).

The health care system all over the world are missing the screening of osteoporosis and education on osteoporosis the International Osteoporosis Foundation reports a fracture every 3 seconds accounting for 5500 fractures worldwide and resulting in more than 2 million fractures in the United States (Burge *et al.,* 2007).

The socio-economic impact caused by osteoporotic fractures upon societies and families are enormous and increasing, if we take in consideration that preventive measures take by national health systems aren´t enough in our days in the near future the system will collapse. The European Union estimated at EUR 32 thousand million (only considering direct costs) with annual cost of osteoporotic fractures (Reginster & Burlet, 2006). We must take into account that these estimates are just that, and usually governments do it by underestimation and when comparing with other diseases the cost are superior (Sözen, Özışık, & Başaran, 2016).

Figure 2. Decrease in peak bone mass with age and increase in fracture risk with increasing age (Adapted from Valsamis et al., 2006).

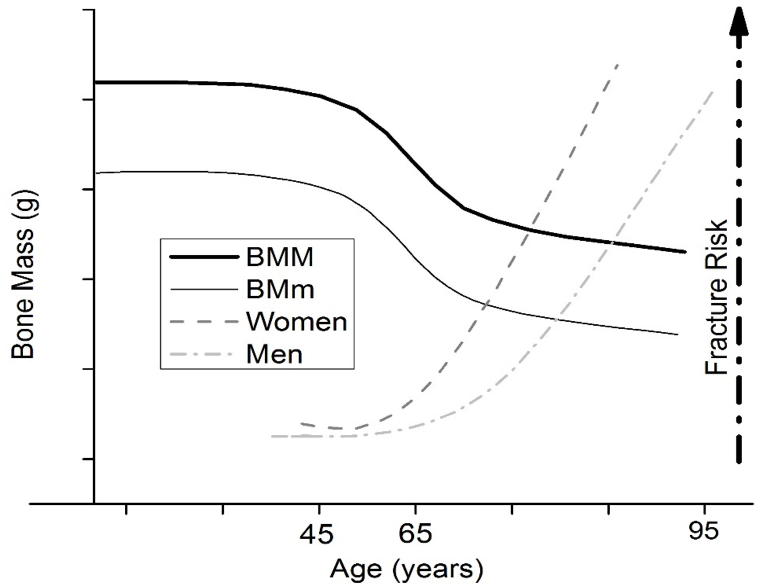
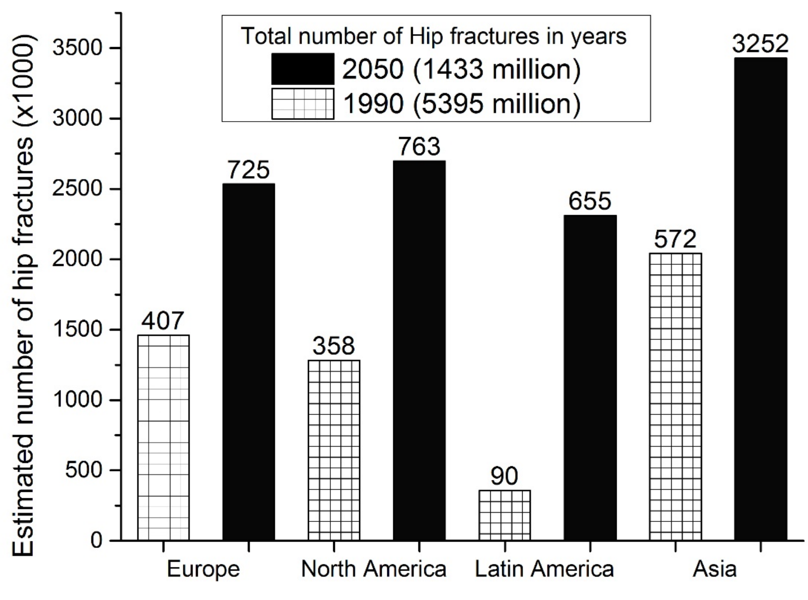


Figure 3. Projections of osteoporotic hip fractures incidence worldwide (Adapted from Cooper et al., 1992)



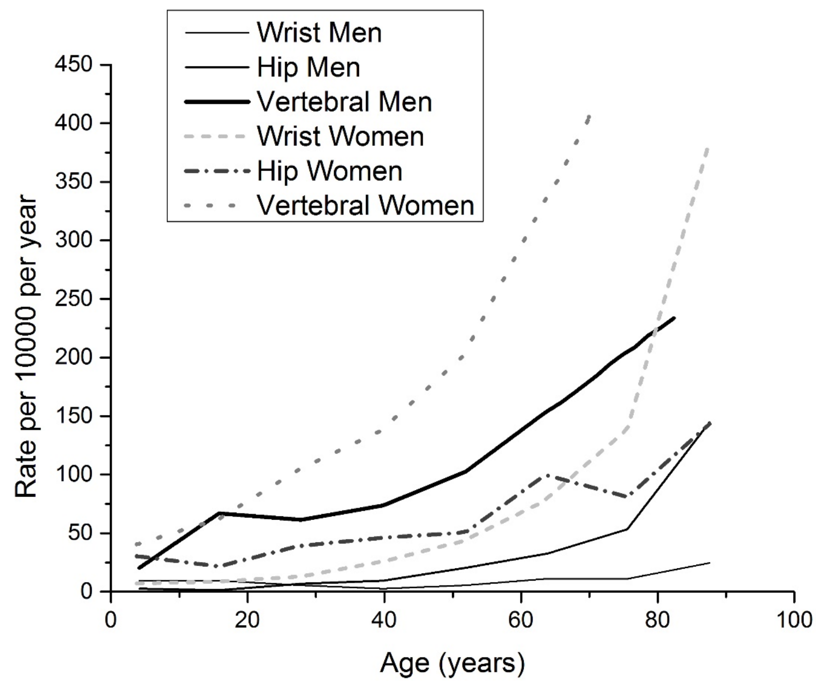
It is well known the benefits of being physical active in advanced ages to reduce the loss of bone mineral density (BMD). Quantitative ultrasound (QUS) is a peripheral bone densitometry technique that is rapidly gaining in popularity for the assessment of skeletal status (Ray, Chan, Thamer, & Melton, 1995; Thomsen, *et al.*, 2015), in the impossibility of massifying the screening with the movement of individuals to a DEXA equipment, considered as the gold standard technique (Punda e Grazio, 2014).

The correlation between these two techniques is well demonstrated, thus ensuring the diagnostic accuracy . Measurement of BMD is used to diagnose osteoporosis, assess fracture risk, and monitor response to therapy (Lippuner, Golder, & Greiner, 2005) and has been shown to be a good predictor of fracture risk and is increasingly being used to screen for osteoporosis (Ganhão, *et al.*, 2008).

Age-Specific and Sex-Specific Incidence of Radiographic Vertebral, Hip and Distal Forearm Fractures

Hip fracture rates vary considerably between populations. After age adjustment, fracture rates of the femoral neck are more common in Scandinavians and North America than those observed in European, Asian and Latin American countries in the south (figure 4) (*Sambrook et al.*, 2006).

Figure 4. Age-specific and sex-specific incidence of clinical vertebral, hip, and distal forearm fractures
(Source: adapted from Sambrook et al. Lancet 2006;367:2010-8)



The number of hip fractures has been increasing in Portugal, it was 5.600 in 1989, 6.718 in 1994; 8.500 in 2000, 9.523 in 2006, according to the National Health Directorate. They calculated that 40.000 osteoporotic fractures occurred in Portugal in 2006, with over 30.000 being non-hip fractures (Direção Geral da Saúde, 2005). The scenario for the future was portrayed, as everywhere, as even worse: it is expected that until 2060 life expectancy at birth will increase by about 10 years in Portugal (Center *et al.*, 2007), which is expected to fuel an increasing burden of osteoporosis. Branco, Felicissimo, e Monteiro (2009) in their study refer that vertebral, forearm and humerus fractures were also estimated to be increasing.

Few data were available in Portugal regarding the socio-economic impact of osteoporosis and osteoporotic fractures. Available studies are from small regions (hospital area coverage), only for hip fractures, and mainly retrospective with several other limitations.

It was described that 50 to 60% of Portuguese victims of hip fragility fractures lost their ability to walk after discharge, only 30 to 40% returned to pre-fracture functional status (Caldas, 2013; Santos, 2010) and more than 75% became totally dependent thereafter (Costa *et al*., 2009).

The Algarve is a region of Portugal, being the southernmost among all regions of the country, with the fifth largest population and the fourth largest area. The city of Faro as its capital, the District of Faro, with an area of 5 412 km^2 and a permanent population of 451 005 inhabitants (Census, 2011) (0.06% of the population of Europe and 6.27% of the population of Portugal). It is the most important tourist region in Portugal and one of the most important in Europe. In 2020, the Algarve is the second region in Portugal with the greatest purchasing power, behind only the Lisbon Metropolitan Area, with a GDP per capita of 83% of the European Union average (Comissão Europeia, 2020).

The Algarve has become one of the Portuguese regions with the largest number of foreign residents, mainly from other European countries. In 2018, 69,000 of the inhabitants were not Portuguese (Journal do Algarve, 2018).

Pina et al. (2008), in their study entitled "Hip fractures cluster in space: an epidemiological analysis in Portugal", refer district of Algarve, with an hip fracture incidence rates for women among the highest of Portugal and along all the municipalities.

FRACTURES USUALLY OCCUR IN THE HIP, SPINE AND WRIST

Melton and collaborators (1992), estimated that one in three women aged 50 years or over will experience osteoporotic fractures, of which, one in six (15.6%) will suffer a vertebral fracture, one in six (17.5%) will suffer a hip fracture, one in six (16.0%) will suffer a wrist fracture, overall one in three (39.7%) will suffer at least one of these fractures.

At all times, old bone is decomposed more quickly than the formation of new bone tissue, with bone loss occurring. Bone loss can lead to low bone density (osteopenia), weakening of the bone, and eventually osteoporosis. Osteoporosis (or porous bone) is a disease in which the bones become weak and fragile. Porous bones are more likely to fracture (figure 5).

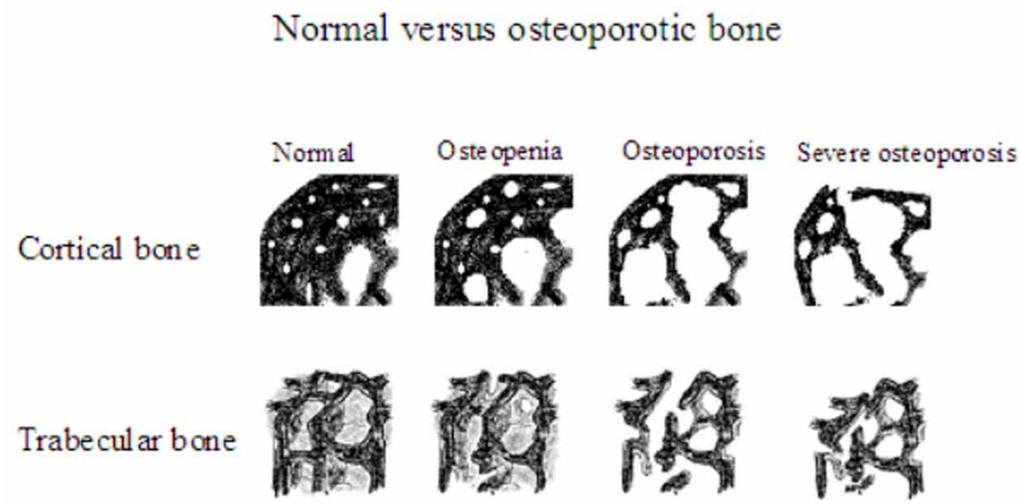
The decrease in the loss of bone mineral density in the senior population is associated with a reduction in the practice of regular physical activity throughout the woman's life.

The aim of this study was to demonstrate that female post-menopausal seniors who adhere to the recommendations for physical activity after osteoporosis screening after one year show a decrease in BMD decrease.

METHODS

The sample consists of 76 post-menopausal women aged between 48 and 84 years old, divided into three groups according to their level of physical activity; It was applied an osteoporosis risk questionnaire (Ganhão et al., 2006), a healthy life styles questionnaire (Batista et al., 2016). The study had two moments of assessement in the years 2015 and 2016.

Figure 5. Normal vs. osteoporotic bone
(Source: https://sci.washington.edu/info/forums/reports/osteoporosis.asp, consulted, 1 February, 2021)



The body weight was assessment using a digital scale (Tanita, CS601), without shoes and with light clothes or underwear and recorded at the nearest 0.1 kg. Body height was measured to the nearest 0.1 cm, with a stadiometer (Seca), according to standard procedures, an as described by the kineanthropometry group (Lohman et al., 1988).

Calcaneal measurements were performed using the Sahara device (Hologic), which measures bone mineral density in the heel. The World Health Organization (WHO) osteoporosis classification criteria were applied (WHO, 1994).

All the participants signed a consent to participate in the study.

RESULTS AND DISCUSSION

The sample of ours presents average values of height and body mass within those of the Portuguese average for the age group under study (INE, 2020). The vast majority are overweight for their height. When we look at the T-Score values of the total sample, it does not have major changes (table 1).

When the sample is subdivided into three groups (Active, Sedentary, Regular Physical Activity Program), it is possible to observe differences between groups in the percentage of demineralization after one year was higher in the group of sedentary women than in the group of active women. Most active women keep T-Scores close to -1 (osteopenia), on the other hand, sedentary women approach -2.5 (osteoporosis).

The results found in our study are in line with the results that Silva et al. (2014), in a systematic review on the effects of physical activity on bone mineral density in healthy pre-menopausal women.

Postmenopausal women participating in a regular physical activity program (T Score = -0.55) have higher bone mass density than their non-participating peers (T Score = -1.77).

Table 1. Descriptive statistics (minimum, maximum, mean and standard deviation) for the entire sample (n = 76), morphology, BMD and T-Scores.

	Minimum	Maximum	Mean	Standard deviation
Weight	51.70	101.10	69.93	11.6
Height	135.80	170.40	155.04	7.01
BMI	15.70	38.70	28.76	4.56
BMD 2015	0.22	0.81	0.47	0.13
BMD 2016	0.20	0.80	0.44	0.11
T-SCORE 2015	-3.40	1.80	-1.20	1.13
T-SCORE 2016	-3.41	1.79	-1.27	1.13

Table 2. BMD and T-Scores results (minimum, maximum, mean and standard deviation) for the sample's subgroups according to lifestyle

Life style		BMD 2015	T-SCORE 2015	BMD 2016	T-SCORE 2016
Sedentary	N	24	24	24	24
	Mean	0.41	-1.70	0.30	-1,77
	SD	0.10	0.92	0.10	.91
Active	N	30	30	30	30
	Mean	0.47	-1.22	0.45	-1.29
	SD	0.10	0.99	0.11	0.98
Regular Program of Physical Activity	N	18	18	18	18
	Mean	0.55	-0.47	0.50	-0.55
	SD	0.14	1.28	0.11	1.28

In figure 6 it is possible to observe that the group that has a history of physical activity and that currently adheres to a regular physical activity program provided by the municipalities, has lower values of osteoporosis, osteopenia, in the opposite sense, the sedentary group has a a high number of osteopenic participants and a small number of women within normal values. These values are in line with the vast majority of studies (DGS, 2015; Center et al. 2007), although they are not as negative as we look at the number of fractures of the hip reported in the national study by Pina *et al*. (2008), in the same study, it states that the Algarve has the highest number of fractures in the country, despite the most hours of sunshine.

The value of bone mineral density in postmenopausal women is conditioned by the peak bone mass reached at the end of puberty. From this moment on, the concern must go through maintaining it or avoiding its decline by engaging in regular physical activity practices. Sedentary women are at increased risk of fractures. Although the gradual loss of BMD is inevitable, it is possible to observe the difference it presents for different groups, namely between sedentary people and who maintain regular physical activity (figure 7) (Weaver, *et al.,* 2015).

Figure 6. Results by life style of the participant by classification of bone mineral density according to the intervals recommended by WHO

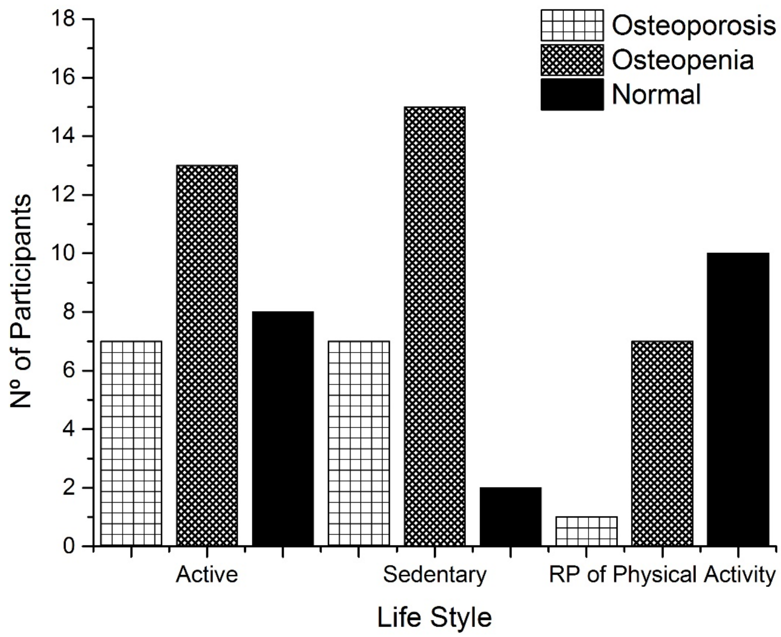
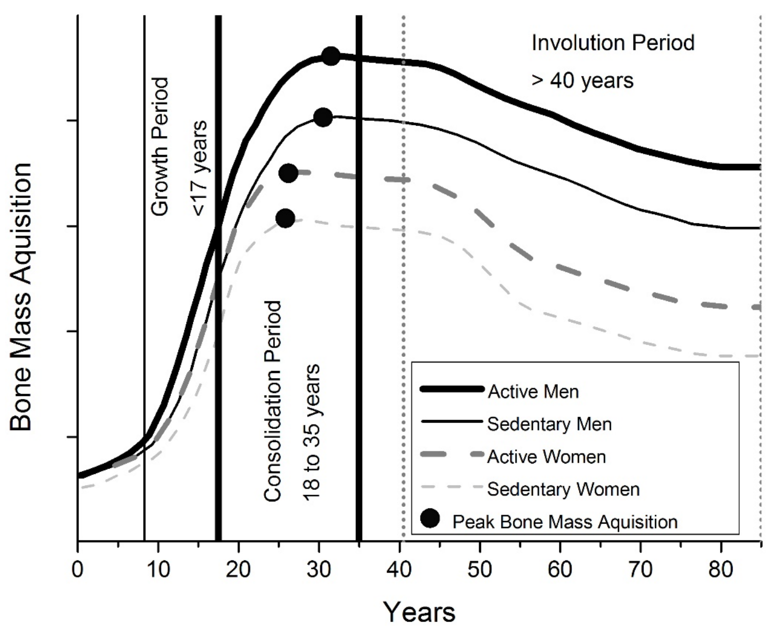


Figure 7. Schematic description of the effect of physical activity on bone mass throughout life
Adapted from Blanchet C, Chaire L, Chagnon A, Thibault G. Activité physique et santé osseuse. Avis du comité scientifique de Kino-Québec. Québec: Gouvernement du Québec, Ministère de l'Éducation, du Loisir et du Sport; 2008:1-42.



As supported by most authors (Wultems et al., 2016; Gourlay et al., 2015) the of peak bone mass (reached in your 20s or 30s) is an important determinant of bone strength in older age. Regular and frequent practice activities with loading during growth, particularly before and during puberty, maximizes the accumulation of minerals in the bones.

Regular exercise with weights and nutritional advice attenuates the decrease in bone mass and therefore delays the weakening of the bones associated with aging (Statham & Aspray, 2020). After the age of 35, the process of bone turnover slows down, resulting in a loss of bone mass of 0.3 to 1.0% per year. With age, the bones gradually thin and become more fragile (Ensrud, et al, 2007).

Physical activity is a relevant factor to increase or reduce bone loss due to changes in bone structure and geometry caused by mechanical loads (Bielemann, Martinez-Mesa, and Gigante, 2013) and also plays an important role in the development and maintenance of mass bone.

Systematic reviews of the literature have shown that high-impact sports appear to be more osteogenic than non-impact sports, such as swimming in children and young adults (Karlsson, Nordqvist, & Karlsson, 2008; Morseth *et al.*, 2011)

There is consensus in the literature that physical exercise has a positive effect on osteogenesis. This osteogenic effect is statistically significant, with an important effect on bone health and overall health. Exercise has an osteogenic effect and health benefits at any age.

Physiological and global therapeutic approach to each individual.

Physical exercise should be appropriate for each person, ideally under prescription, and monitored throughout life to improve adherence.

It is imperative to implement a national plan that promotes the practice of physical activity throughout life. This national plan must integrate the national health plan as an integral part of primary care.

IMPLICATIONS

improving education and screening for osteoporosis among individuals in primary care is a step forward to reduce de impact of osteoporosis in society. Throughout implementation of national policies and the municipalities that promote physical activity as an healthy life style and that guarantees a better aging.

The goal of optimal bone health screening is important to identify as early as possible to keep bones healthy and fracture free. And simultaneously begin to engage patients in discussions about risk factors and bone health. Screening for osteoporosis is a low-cost method that can assist primary cares in meeting quality improvement measures and improve patient outcomes.

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Chapter 5
Effects of Spaceflight, Aging, and Bedrest on Falls:
Aging Meets Spaceflight!

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ABSTRACT

With the increasing proportion of older persons globally, healthcare issues are becoming more complex. Older persons often spend substantial time confined to bed, which leads to physiological deconditioning and increased risk of falls. Fall-related injuries lead to higher hospitalization costs and worsening of the quality of life of older persons. Thus, monitoring of falls and reducing the risk of falls is an increasingly important element of geriatric care. Examined in this chapter will be aspects related to falls induced by immobilization (bedrest confinement). Interestingly, spaceflight-induced physiological deconditioning predisposes astronauts to higher risk of orthostatic intolerance and, consequently, falls. Since bedrest confinement is an established model for studying the deconditioning effects of spaceflight, knowledge drawn from bedrest studies can provide insights into the underlying mechanisms leading to falls in astronauts and in bed confined patients and in particular in bed-confined older persons who are typically dealing with the deconditioning effects of aging.

INTRODUCTION

With the increasing proportion of older persons in the world, health care issues are becoming more complex and health care delivery more difficult. Acute care for older persons must confront the interaction of pre-existing factors such as sarcopenia malnutrition and/or with the effects of bedrest confinement during hospitalization which poses difficult health care challenges. Heinrich and colleagues (2010) carried out a systematic review and concluded that up to 1.5% of total health care costs arise due to falls and falls-related injuries. Not surprisingly, understanding the underlying mechanisms of falls and how they can be reduced are pivotal issues in geriatric health (Bousquet et al., 2017; Broadbent et al., 2017; Blain et al., 2016).

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While a consequence of frailty is falls (and falls related injuries), bedrest confinement during health care treatment *per se* leads to further deconditioning in older persons, who typically are coping with deconditioning due to aging and thus leave the hospital (or bed confinement) in worse shape than when they began treatment. Therefore, there is a need to understand the negative effects of bedrest confinement on physiological functions (e.g. muscle volume and structure loss, plasma volume loss, etc.) and on the increased risk of falls. Furthermore, falls lead to higher hospitalization cost, including increased nursing and medical staff, greater spending by insurance companies, and worsening of the quality of life of older persons. Thus, it is clear that monitoring of falls and more importantly, reducing the risk of falls is an important element of geriatric care. As the proportion of older persons is increasing globally, there is a need to address this immediately to ensure that both the quality of life and the well-being of our senior citizens is effectively addressed.

Older persons subject to bedrest induced immobilization should receive careful medical and social screening, including risk of falls. Upon discharge, such older persons have enhanced risk of falls and this falls risk should be monitored in the community. Social gerontological guidance should be implemented such as empowering older persons to adopt healthy behaviors to maintain healthy lifestyles (e.g. increased physical activity, nutrition) and community elements related to social care of the older persons should be incorporated.

This chapter discusses the similarities between deconditioning due to the aging process and spaceflight induced deconditioning related to the microgravity of space. Bed confined individuals and in particular older persons who typically spend large amounts of their time (approximately 80%) in hospital confined in bed, experience a deterioration in their physiological functions in a manner similar to that which astronauts` experience. Knowledge learned from spaceflight deconditioning can thus be used to help physiological deconditioning as occurs in bed confined individuals and especially in older bed confined persons who are already subject to physiological changes due to aging. Conversely, understanding the consequences of bed confinement may aid in developing countermeasures to both the deconditioning of space flight and bed confinement. In addition, this chapter aims to present a case for understanding and managing the vulnerability of older people towards falls. As falls often arise due to physiological deconditioning associated with aging and aggravated by bedrest confinement, this chapter will focus on key aspects in integrated care of older persons who are subject to the risk of loss of physical activity and mobility, functional and cognitive decline (FCD), frailty and malnutrition. These factors **leading to falls** and other risks **are magnified by the consequences of health-related bedrest confinement**. Specifically, current **knowledge will be examined in related to falls** in all phases of hospitalization and recovery beginning with the admission phase (including screening), through immobilization care during hospitalization as well as recovery after return to community to support return to enhanced mobility and **prevent falls** and improve quality of life. It will also provide examples of how strategies and exercise programs used for maintenance of astronaut health in space could also be used for older persons on Earth ("Geriatrics meets Spaceflight!", Goswami, 2017). That is, how the training programs, along with nutritional supplementation, used by the astronauts can be used for bed confined older persons. The role of exercises, along with nutritional supplementation, during bedrest confinement will be elaborated in detail in this chapter.

BACKGROUND

Effects of Spaceflight

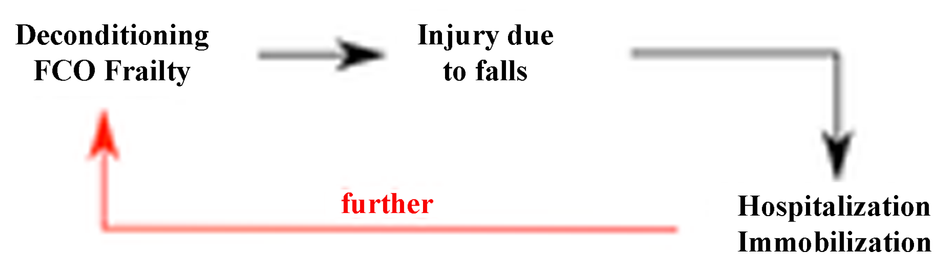
Spaceflight and in particular the microgravity of the space environment have important effects on many key physiological systems. These include the musculoskeletal system, the cardiovascular system, cerebral autoregulatory and sensorimotor systems (Blaber et al., 2011; Buckey et al., 1996; Goswami et al., 2015a). The return to Earth and normal gravity, results in a number of significant reactions which can include increased heart rate, dizziness upon standing up (decreased orthostatic tolerance) and a reduction in exercise capacity (Buckey et al., 1996). Alterations in cerebral autoregulation and/or cardio-postural interactions induced by spaceflight have been partially attributed to lead to post-spaceflight induced orthostatic intolerance.

Physiological Deconditioning in Aging and Due to Bedrest Confinement

Aging is well known to be associated with a decline in physiological deconditioning. Indeed, aging-associated physiological deconditioning on Earth is similar to what is seen in spaceflight (Goswami, 2017; Vernikos and Schneider, 2010).

In older persons, many conditions and diseases including cerebral or peripheral vascular disease, cardiac arrhythmias, metabolic or endocrine disorders, and autonomic neuropathy, can contribute to orthostatic intolerance (dizziness and/or loss of consciousness upon standing up), particularly during a change in posture from lying/ sitting to standing up (Goswami et al., 2017). Furthermore, illness or injury in older persons frequently requires **hospital-based care which often includes bed confinement.** As alluded to above, bedrest confinement during hospitalization represents a significant source of physiological deconditioning. The reduction in physiological function - which occurs during hospital induced bedrest confinement - especially in older persons, can contribute to a vicious and continuous negative spiral of increasing deconditioning and even frailty, reductions in orthostatic tolerance and, consequently, elevated risk of falls and falls related injuries and rehospitalization (Mühlberg and Sieber, 2004; Mahoney, 1998; *Figure 1*).

Figure 1. Relationship of functional cognitive Decline (FCD) and/or frailty, falls, bedrest confinement, and risk of further falls. Reproduced from Goswami N (2017) Falls and Fall-Prevention in Older Persons: Geriatrics Meets Spaceflight! Front. Physiol. 8:603.



In addition to the reductions in muscle function contributing to falls in older persons, other factors can also lead to the increase in the number of falls in aged persons (Blain et al., 2016; Bousquet et al., 2017). Some of these include: bed rest induced hypovolemia (Convertino, 2007), negative metabolic and functional effects (Agostini et al., 2010; Pisot et al., 2016; Soavi et al., 2016), postural hypotension (Weiss et al., 2004), and dizziness upon standing up (orthostatic intolerance, Dittmer and Teasell, 1993) as well as potential deficits in brain structure and function (Grogorieva and Kozlovskaia, 1987; Leblanc et al., 1990; Traon et al., 1998; Perhonen et al., 2001; Pisot et al., 2008; Lipnicki and Gunga, 2009; Rittweger et al., 2009; Dolenc and Petric, 2013; Marusic et al., 2014, 2016; Cassady et al., 2016). Indeed, quite a large number of falls reported in senior homes arise due to posture changes when older persons stand up from a reclining position (Rapp et al., 2012). Additional factors that lead to higher risk of falls include polypharmacy. Particularly important medications that cause falls in older persons are anti-hypertensives and diuretics (Gangavati et al., 2011). While each of these factors could potentially cause falls, it is more likely the combination of all these etiologies that leads to alterations in cardio-postural control, and/or reduction in cerebral perfusion, that leads dizziness upon standing up and falls.

Postural Changes Induced Responses (Cardio-Postural Interactions)

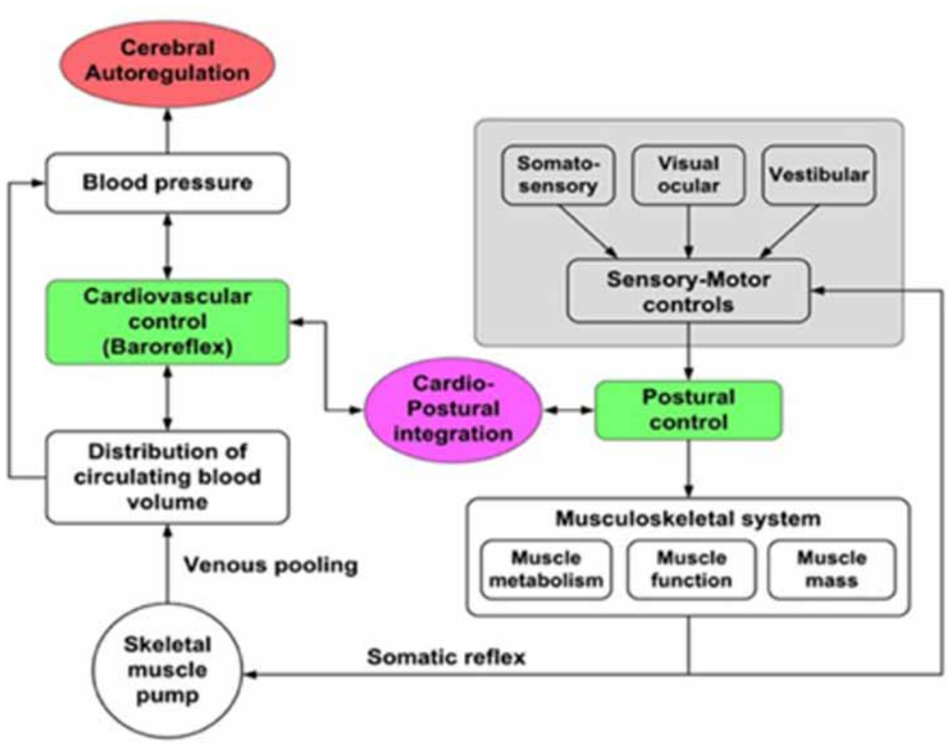
Standing is a delicate balance between detection of postural disturbances by the body and its ability to respond to the effects of such disturbances with proper responses. These abilities are worsened with increasing age and, therefore, older persons often have imbalance and greater risk of falls (Blaszczyk et al., 1994; MacKey and Robinovitch, 2006; Hsiao-Wecksler and Robinovitch, 2007). Age associated worsening of the somatosensory and motor systems functioning leads to further problems with the standing balance (Lord et al., 1991; Hurley et al., 1998). Blaber and colleagues (2009) and Goswami et al. (2012) have developed a cardiovascular-postural interaction research model. It can be used to assess the how effective the cardiovascular and postural systems (*Figure* 2) are during changes in posture (e.g. sitting to standing).

Overall, assessment of changes in cardio-postural interaction could be done pre- and post- bedrest confinement, which can influence sensory motor input and/ or cardiovascular system. The strategy to assess cardio-postural interactions is also important for improving ambulatory recovery and to understand the effects of innovative interventions in preventing falls in older persons or during bedrest confinement.

Bedrest as a Model to Understand Spaceflight Induced Deconditioning

Bedrest is used as a ground-based analog model for investigating the effects of spaceflight on human physiological systems (Goswami et al., 2015a; Jost, 2008; Pavy Le Traon et al., 2007). Bedrest confinement is a largely controllable experimental set-up that allows for investigation of physiological deconditioning during reduced gravitational stress. Bedrest has been frequently used by global space agencies to study the underlying mechanisms of physiological deconditioning that occur during spaceflight (Arzeno et al., 2013; Cvirn et al., 2015; O'shea et al., 2015). In these bedrest studies, typically healthy persons (often young males) are restricted to the supine position over various durations of time which can range from several days to several weeks.

Figure 2. The proposed research model of cardio-postural interactions. The component are: Sensory motor input required for postural control (Right); Cardiovascular parameters involved in regulation of blood pressure (heart rate, blood volume, vascular resistance) (Left). Cardio-postural integration is shown here as a hypothetic model of baroreflex activation of skeletal muscle pump (Center). Reproduced from Goswami N, Blaber AP, Hinghofer-Szalkay H and Montani J-P (2017) Orthostatic Intolerance in Older Persons: Etiology and Countermeasures. Front. Physiol. 8:803.

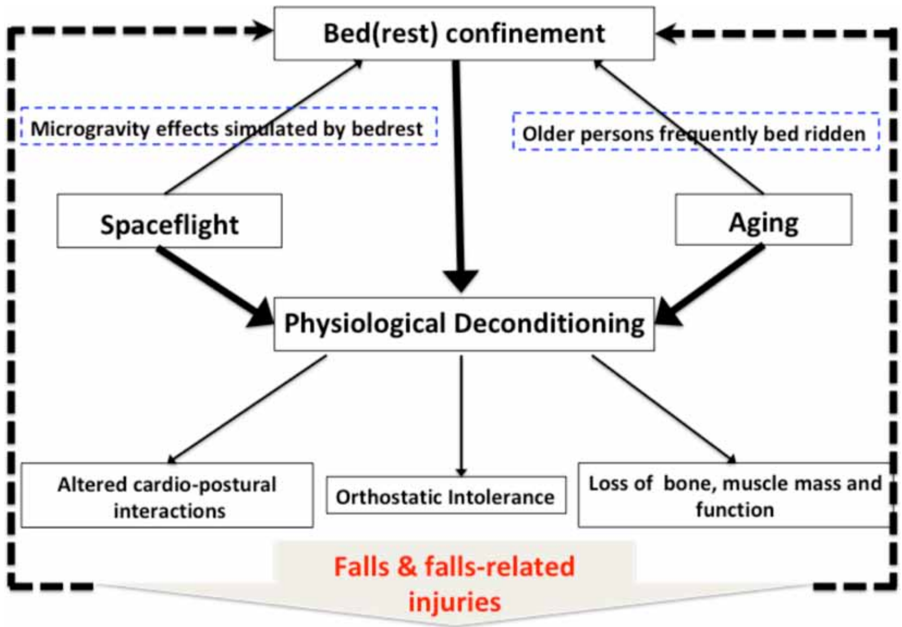


As older persons in hospital can spend as much as 80% of their time confined to bed (Pedersen et al., 2013), data from bedrest studies - albeit from younger persons - can also help in furthering our understanding of the deconditioning process during hospitalization in older persons in acute and chronic care setting (*Figure 3*) and for development of countermeasures post-bedrest to reduce falls risk (*Figure 4*).

Astronaut's Training Protocols and Regimens: Could They be Used in Aging Care?

Astronauts devote a substantial amount of time in spaceflight focusing on physical training – together with nutrition and other measures - with the goal to ensure optimal health in space and to reduce deconditioning due to microgravity, and post-spaceflight orthostatic intolerance (Hackney et al., 2015; Petersen et al., 2016). Aspects such as resistive exercises have been shown to be effective in reducing physiological deconditioning that occurs in space (see detailed discussion in Pedersen et al (2016)). Additionally, data from young bed confined persons suggest that resistive vibration exercises can reduce muscle atrophy (Belavy et al., 2009).

Figure 3: Bedrest induced physiological deconditioning and its effects. Reproduced from Goswami N (2019). Spaceflight meets Geriatrics!. Front. Physiol. Conference Abstract: 39th ISGP Meeting & ESA Life Sciences Meeting. doi: 10.3389/conf.fphys.2018.26.00022



The question arises: *Could activity programs to maintain health carried out by astronauts in space be applied to older persons – particularly during bedrest confinement - to counteract physiological deconditioning*? This question illustrates how data generated from bedrest studies (ground-based analogs of physiological deconditioning) could have application in geriatric care. A search of the literature has shown that there is some evidence that in older persons both physical functionality and mental health are maintained by physical activity (Olanrewaju et al., 2016). However, the effectiveness of various forms of physical activity in combating bed confinement induced physiological deconditioning, especially in older persons, has not been studied in detail. For example, physiotherapy is used in hospitalized patients to prevent thrombotic events and/or contractures that can occur during prolonged bedrest. However, its effects on strength - and function - of the muscles are currently not known.

Another aspect to consider is the implementation of physical activity devices/ exercise machines in counteracting the effects of bed confinement. While ambulatory older persons can easily access cardiovascular training and muscle strengthening devices, bed confined patients often are not able to do so. For instance, in ambulatory geriatric care, devices such as vibration plates and power plates are routinely used but this is not the case in bed confined persons. Using resistive vibration exercises - reported to maintain muscle strength and function in bedrest studies involving bed-rested young persons (Schneider et al., 2009) - in bed confined older persons is yet another example of how evidence from bedrest studies (ground-based analogs of spaceflight) could lead to applications in geriatric care.

Role of Nutritional Supplementation in Astronauts and Older Persons

Data from spaceflight show that resistance exercise, along with proper nutritional intake - especially with the inclusion of Vitamin D - is effective in maintaining physiological functionality in astronauts during spaceflights of up to six months (Smith et al., 2012). In older persons, inadequate food intake and nutrition has been shown to be strongly associated with frailty risk (Martone et al., 2013). Malnutrition generally leads to greater functional decline, increased/ early dependency leading to frequent institutionalizations, greater number of re-admissions following hospital discharge, overall greater morbidity and mortality, and larger financial burden on the healthcare system .

Low dietary intake plays a key role in malnutrition (Saunders et al., 2015). Current literature shows that adequate energy and protein intake together with vitamin D and calcium improves muscle function and maintains muscle and bone health (European Commission, 2012; Saunders et al., 2015). To what extent, however, nutrition *alone* can provide benefits in senior citizens is largely unknown (Muscaritoli et al., 2016). For instance, while young bed rested women who performed alternating aerobic and resistive exercises could restore their aerobic capacity during bedrest confinement (Schneider et al., 2009), this effect was not seen when *only* nutritional supplementation was provided. Furthermore, a Cochrane review summarized that nutritional supplementation can decrease costs related to geriatric care but there is not enough evidence to conclude that the treatment of malnutrition leads to decreases in hospital re-admissions (Muscaritoli et al., 2017). Exercise *in combination* with nutritional supplementation appears to be key in maintaining muscle mass and physiological functionality. Strandberg et al. (1985) observed that in older persons nutritional supplementation, in combination with resistive exercise training, leads to improvements in muscle mass. Moreover, Daly and colleagues (2014) reported that in older women a diet high in protein improves both muscle mass and strength when it is combined with resistive exercise training.

Plasma Volume Changes During Spaceflight and During Bedrest Confinement

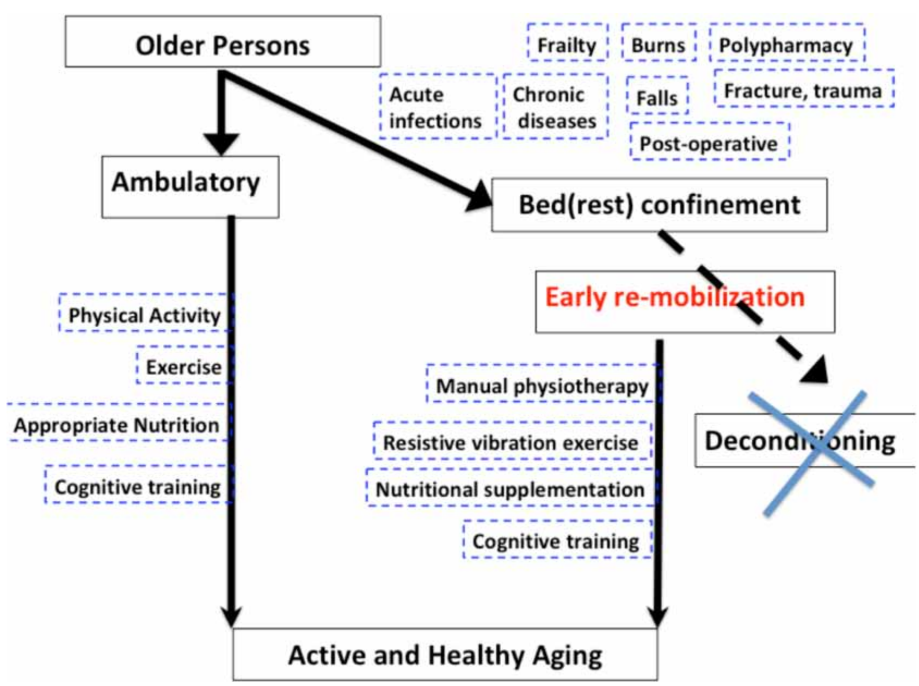
As spaceflight induced cephalad fluid shifts result in significant plasma volume reduction in astronauts during spaceflight, salt ingestion shortly before landing – to prevent the development of post-spaceflight orthostatic intolerance - is currently carried out in astronauts (Campbell and Charles, 2015). Similarly, as bedrest leads to plasma volume losses, plasma volume replenishment with fluid loading and salt tablets has been reported to prevent post-bedrest orthostatic hypotension after 6-degree head down bed rest of up to 12 days (Waters et al., 2005). Currently, however, the exact effects of plasma volume loss during bedrest confinement are neither clear nor well investigated. It is, therefore, suggested that plasma electrolytes should be regularly assessed in bed confined older persons (Stuempfle and Drury, 2007). This will allow any correction of fluid and electrolyte loses that occur during bedrest confinement.

Does Timing of Interventions Matter?

In the acute care setting, remobilization after bed confinement of older persons is often delayed in many hospitals which can lead to a permanent loss of functionality, loss of autonomy and/or the ability to lead an independent life, and resulting in increased risk of mortality (Singh et al., 2008). Started early enough, remobilization interventions can overcome the decline of physiological function, leading to complete recovery of conditioning. Some authors have reported that there is indeed a need to carry out early interventions in older persons confined to bed (Singh et al., 2008; Martínez-Velilla et al., 2015); without these interventions an accelerated degradation in muscle mass and bone as well as loss in physiological functionality could occur (Singh et al., 2008). Moreover, delayed interventions may result in only partial recovery. The delay in commencement of physical exercise interventions is often due to non-standard decision making and/or care provider experience. The delay in implementation of interventions could lead to lack of return to full physical functionality, further de-conditioning and hospital re-admissions and extended dependency care (*Figure 3*). As pointed out in *Figure 4*, combinations of interventions such as those incorporating physical exercise and/ or nutritional supplementation and cognitive training can be used.

Based on the above discussions about deconditioning in astronauts and post-spaceflight orthostatic intolerance, insights from space medicine with regards to these issues that are important in geriatric care can be obtained. Furthermore, by linking the physiological responses to spaceflight and the consequences of bedrest confinement, strong synergy of information can be developed. The parallels that can be drawn between spaceflight, aging, and bedrest confinement are extensively discussed in the elegant review by Vernikos and Schneider (2010).

Figure 4. The need for early re-mobilization in bedrest confined persons to minimize risk of falls. Shown in the figure are also some innovative countermeasures that can be used to ensure reduction in falls, falls-related injuries thus supporting active and healthy aging. Countermeasures to prevent orthostatic intolerance include physical activity – with and without nutrition (Muscaritoli et al., 2017) - and cognitive training (Goswami et al., 2015). Reproduced from Goswami N (2019). Spaceflight meets Geriatrics! Front. Physiol. Conference Abstract: 39th ISGP Meeting & ESA Life Sciences Meeting. doi: 10.3389/conf.fphys.2018.26.00022).



CONCLUSION

There is an urgent need to understand the links between health status, FCD and frailty. Previously independent older persons can suddenly be bed confined and, as as discussed in this chapter, suffer effects that can result in the reduction or loss of an independent lifestyle. In addition, progression to frailty must be reduced among the pre-frail and interventions should be carried out in at risk older persons to prevent frailty and falls (European Innovative Partnership Active Healthy Aging (EIP-AHA) report, 2013). Physical activity interventions and the life style modifications presented in this chapter could serve as the basis for the development of interventions to counteract the (negative) effects of bed confinement as well as for combating the onset of frailty and risk of falls in older persons.

Furthermore, this chapter illustrated how integration of knowledge of physiological deconditioning that occurs in spaceflight and also as persons age allows for each of these physiological conditions to provide new insights into the other which can lead to establishment of new and innovative tools to overcome the effects of both spaceflight and the aging process ("Spacelflight meets Geriatrics!", Goswami (2017)). An important example of how ground-based analog of spaceflight induced physiological deconditioning can be used in clinical geriatrics is the use of resistive vibration exercise (RVE). RVE, which has been reported to maintain muscle function and strength in bed rested young persons, could potentially be used in older bed confined persons to prevent the physiological deconditioning induced by bedrest and to promote early remobilization (Schneider et al., 2009). This chapter also provided specific evidence that data obtained from ground-based analogs of spaceflight such as bedrest and also from directly from living in space can be used as guides for supplementing - and optimizing - the effects of physical exercises via the addition of nutritional supplements. Therefore, an integrated approach to therapy, especially in older persons, could be developed to counter bed-confined deconditioning (see Hackney et al., 2015).

The call-out box outlines the important aspects of this chapter:

- Combining knowledge regarding physiological effects of spaceflight induced deconditioning with those of evidence from bedrest confinement studies could lead to an integrative understanding of deconditioning (*Figure 3)* and to development of innovative countermeasures (Figure 4).
- Astronauts during spaceflight schedule regular sessions of specialized exercise training to reduce the deconditioning effects of microgravity.
- Resistive exercise used by astronauts could be used to counteract deconditioning in bed confined older persons.
- Older persons could also use nutritional supplementation, together with physical activity, to restore muscle strength and function and prevent cardiovascular system decline, and consequently falls (*Figure 4*).
- Early remobilization after a period of confinement to bed in older persons can prevent orthostatic intolerance, falls and falls-related injuries.

FUTURE RESEARCH DIRECTIONS

In the future there is a need to carry out careful screening of age-related risk factors, especially at admission in hospitalized older patients. The schema below summarizes the need for early screening of frailty and risk of falls and the need for early re-mobilization to ensure falls reduction and to ensure Active and Healthy Aging *(Figure 5*).

Figure 5. The need for early screening of frailty and risk of falls and early re-mobilization to ensure falls reduction. This will ensure Active and Healthy Aging. Reproduced from Goswami N (2017) Falls and Fall-Prevention in Older Persons: Geriatrics Meets Spaceflight! Front. Physiol. 8: 603.

Screening for age related risk factors for falls such as nutrition, cognitive and functional decline during admission → assessment of impact of bedrest confinement during hospitalization on falls → discharge management for preventing falls into community → life style changes including health empowerment in older citizens as well as informal caregivers.

In addition, aspects such as social gerontology should also be incorporated into future research. This aspect is important for reducing falls in older persons , upon discharge from hospitals and afterwards. Finally, there is an urgent need to educate formal and informal caregivers as well as key stakeholders in geriatric care about falls prevention. This is elaborated further in the chapter related to education of falls prevention ("*Falls prevention education – good examples from higher education*") in this book.

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Chapter 6
The Role of Neuroimaging in Fall Prevention in Healthy Adults at Risk of Alzheimer's Disease

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ABSTRACT

Falls are an important clinical, socioeconomic, and public health problem in the older adult population. Advancing age is a major risk factor for mild cognitive impairment (MCI) and Alzheimer's disease (AD). The preclinical phase of AD, which is regarded as an important window for early therapeutic intervention before the onset of MCI and subsequently AD, can serve as a critical period to reduce or prevent falls among elderly people at risk of AD. In this chapter, first, a discussion is provided on the degrees of fall-related injuries, pain, and severity of falls in elderly people at risk of AD. Secondly, a discussion is provided on the clinical, socioeconomic, and public health implications of falls. Studies that integrated neuroimaging techniques were also reviewed to identify brain biomarkers that can be targeted for the prevention of falls among the elderly. It is anticipated that the outcome of this chapter may have a critical role in the prevention of falls among elderly people at risk or suffering from AD.

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INTRODUCTION

Falls are important clinical, socioeconomic, and public health problem in the older adult population. Falls have been linked to premature institutionalization, injury, functional reduction, decrease in autonomy, and injury-related mortality (Tinetti & Williams, 1997). The World Health Organization (WHO) (2019a) identified fall as the second major cause of accidental or unintentional injury deaths worldwide. Annually, it is estimated that 646, 000 individuals die from falls, with over 80% occurring in low- and middle-income countries (WHO, 2019a). The greatest number of fatal falls have been noted to occur among adults older than 65 years of age (WHO, 2019a). Globally, adults above the age of 70 years, particularly females, demonstrate significantly increased fall-related death rates compared to younger people (WHO, 2019b).

Previous epidemiological studies have identified a number of potential intrinsic and extrinsic risk factors for falls in community-dwelling elderly people (Deandrea et al., 2010). Intrinsic risk factors for fall include advanced age, history of falls, gait and balance problems, muscle weakness, poor vision, sleep disturbances, and chronic diseases such as arthritis, stroke, diabetes, dementia, Parkinson's, and incontinence (Deandrea et al., 2010; Hopewell et al., 2018; Rajagopalan, Litvan, & Jung, 2017). On the other hand, extrinsic risk factors for falls include environmental factors i.e. lack of hand rails, wet, slippery or uneven surfaces, poor lighting, use of walking aids, poor footwear, and clutter (Todd & Skelton, 2004; Rajagopalan et al., 2017). It is estimated that close to 15% of falls occur as a result of major external event that would result in falls in most people (Hopewell et al., 2018). Even though similar percentage of falls occur from a single identifiable event i.e. syncope (Hopewell et al., 2018), most occur as a result of multiple interacting factors (e.g. balance problems, poor vision, and slips on an uneven surface) (Campbell & Robertson, 2006). Generally, the risk of fall tends to increase with more risk factors (Hopewell et al., 2018).

Cognitively impaired people have been reported to experience falls up to more than two times than cognitively normal individuals, often leading to more serious consequences (Allan, Ballard, Rowan, & Kenny, 2009; Taylor, Ketels, & Delbaere, 2012). Despite that the reasons underlying the higher prevalence of falls remain unclear, neurodegenerative changes in mild cognitive impairment (MCI) and Alzheimer's disease (AD) may heighten the risk of falls due to alterations in executive functions, ability to solve problems or make decisions, and ability to perform simultaneous tasks (Taylor et al., 2013; Sheridan & Hausdorff, 2007). Individuals with AD dementia have been reported to have an increased risk of serious falls (Sheridan & Hausdorff, 2007). There is also evidence that gait changes and falls are associated with non-AD dementias (Verghese et al., 2002). The rate of falls is estimated to be almost three times more evident than that observed among non-demented elderly (Weller & Schatzker, 2004). In a longitudinal study which compared falls in AD and normal aging, 36% of the participants with AD were noted to have had falls compared to 11% of the age matched controls (Weller & Schatzker, 2004). Higher rate of institutionalization was also reported among fallers, suggesting an interrelation between AD, falls, and loss of independence (Sheridan & Hausdorff, 2007).

The preclinical phase of AD which is considered an important window for early therapeutic intervention before the onset of MCI and subsequently AD (Sperling, Aisen, Beckett, Bennett, & Fagan, 2011) can also serve as a critical period to prevent falls among elderly people at risk of AD. Neuroimaging methods can provide important information regarding the structural and functional changes associated with the risk of AD, and falls among the elderly population. Structural brain properties, which include gray matter (GM) and white matter (WM) volumes offer important information that can be interrogated using quantitative measures derived from structural anatomical images of the brain, with high spatial resolution and isotropic voxels. DTI provides an opportunity to interrogate microstructural integrity of WM tracts. Fluid Attenuated Inversion Recovery (FLAIR) images are also invaluable in the evaluation of WM hyperintensities. Gradient echo (GRE) pulse sequence is another non-invasive MR imaging technique that is sensitive to iron-containing fluid (i.e. blood) in the brain thereby showing signal loss (Cordonnier et al. 2010). With functional MRI (fMRI), the blood oxygen level-dependent (BOLD) response, which indicates a measure of the proportion of oxy- to deoxy-hemoglobin for instance in a regional sampled blood volume, can be indirectly measured to provide information on brain activity (Ogawa et al., 1990). Finally, positron emission tomography (PET), a radiation-based imaging modality allows the interrogation of cerebral blood flow, metabolism, or the use of radioligands to determine whether disease biomarkers are present in the brain (Klunk et al., 2004).

In summary, the application of neuroimaging measures is important to identify biomarkers capable of predicting the risk of falls in this population. The aim of this chapter is to review the role of these novel neuroimaging techniques in fall prevention in older adults who are at risk of AD. To achieve this goal, first, discussion is provided on the degrees of fall-related injuries, pain, and severity of falls in elderly people at risk of AD. In addition, discussion is provided on the clinical, socioeconomic, and public health implications of falls. Furthermore, evidence from studies that integrated neuroimaging techniques were explored to unravel brain biomarkers as a means for early identification of elderly individuals that are prone to fall in order to put in measures for prevention. It is anticipate that the outcome of this chapter may have a critical role in the prevention of falls among elderly people at risk or suffering from AD.

DEGREES OF FALL-RELATED INJURIES, PAIN, AND SEVERITY OF FALLS

Degrees of Fall-Related Injuries

Globally, injury is a public health problem and has become one of the leading causes of death with evolving lifestyles (Chen et al., 2018). Severe trauma and long-term disability may be caused by injury (Hofman et al., 2005). In people with dementia, particularly AD, cognitive function and performance tend to decline over time, which may lead to an increased risk of injuries (Chen et al., 2018). Injury-related hospitalization has been reported to be linked to the following risk factors: dementia, female gender, age 65–74 years, and seeking medical attention for an injury at a clinic or emergency room within the last year (Chen et al., 2018). Indeed previous studies (Meuleners, Fraser, Bulsara, Chow, & Ng, 2016; Meuleners & Hobday, 2017) reported a higher risk of injury-related hospitalization in people with dementia relative to those without dementia. However, there are mixed results on the role of gender regarding injury-related hospitalization. For instance, Chen et al. (2018) reported that women were 1.1 times more likely to be hospitalized due to an injury compared to men. Meuleners et al. (2016) also affirmed that females with dementia were more vulnerable to a higher risk of falls and unintentional drug poisoning compared to males. On the contrary, Meuleners and Hobday (2017) concluded that demented females had a lower risk of injury-related hospitalization when compared to their male counterparts. Presumptive preclinical AD has been reported to be a risk factor for falls in the elderly, suggesting that subtle non-cognitive changes that predispose the elderly to falls are not only associated with AD, but may also precede detectable cognitive changes (Stark et al ., 2013). According to Chen et al. (2018), people with dementia were about 2.3 times more likely to be admitted for suffocation compared to those without dementia. Evidence shows that individuals within the range of 65 years and above are more likely to die as a result of suffocation (mostly due to food) compared to those in other age groups (Kramarow, Warner, & Chen, 2014; Berzlanovich, Fazeny-Dörner, Waldhoer, Fasching, & Keil, 2005). Risk factors for food-related suffocation often include liquid (i.e. alcohol) or semi-solid food, sedatives, antipsychotics, and poor dentition (Kramarow et al., 2014). In agreement with a previous study (Mitchell, Harvey, Brodaty, Draper, & Close, 2015), unintentional drug poisoning was also reported as another injury subtype that can lead to hospitalization in people with dementia (Chen et al., 2018). The risk was shown to be about 1.5 times more in people with dementia than those without dementia (Chen et al., 2018). In the elderly, causes of such unintentional overdose have been found to be associated with regular use of [3] two medications, drug-drug interactions, over-the-counter medications or supplements, wrong route of administration, poor or lack of monitoring or supervision of drug concentrations, lack or inadequate knowledge regarding drugs, poor storage of drugs, adverse reactions, and sharing of drugs with others (Elliott, 2006; Douglas, Letts, & Richardson; Klein-Schwartz & Oderda, 1991; Morgan et al., 2012). Compliance problems may be a critical issue in people with dementia; this include following the drug intake, poor knowledge about drugs, and inability to identify or handle adverse drug reactions (Morgan et al., 2012; Woolf, Fish, & Azzara, 1990). This is often borne out of decline in memory, computational capability, judgment, and attention (Cerejeira, Lagarto, & Mukaetova-Ladinska, 2012), leading to increased risk of hospitalization secondary to unintentional drug poisoning (Chen et al., 2018).

Accidental falls, abuse, suicide, homicide, self-inflicted injury, and road traffic accidents (RTAs) have also been listed as common types of injury among those with dementia. As previously indicated, elderly people suffering from cognitive impairment were more likely to fall about two times more than those without cognitive impairment (Taylor, Lord, Delbaere, Mikolaizak, 2012). Furthermore, those with MCI have been reported to be highly susceptible to falls (Lach, Harrison, Phongphanngam, 2017) and have a relative risk of about 1.72 times more vulnerable to fall when compared to those without cognitive impairment (Delbaere, et al., 2012). Studies conducted in Kyoto, London, Stockholm, United States (US), Amsterdam, and Ireland reported that 5% to 55% of the elderly suffering from dementia were abused, and this percentage was noted to be significantly higher than that observed in the general population which reported a range of 3.2% to 27.5% (Cooper, Selwood, & Livingston, 2008; Yan & Kwok, 2011). In the US, between 500,000 to 2.5 million individuals aged 60 and above were reported to suffer from abuse, and it was found to occur from either in the hands of their spouse or children (Friedman, Avila, Tanouye, & Joseph, 2011). Even though abuse may be physical, psychological, or sexual (Cooper et al., 2009), the most common form of abuse is psychological abuse (~27.9–62.3%) (Dong, Chen, & Simon, 2014). The risk of suicide cannot be ruled out entirely in people with dementia, particularly in the early stage of dementia, when they realize their tendency to become dependent or disabled over the course of their disease (Chen et al., 2018). Vulnerability to RTAs in people with dementia is usually as a result of their cognitive impairment which tends to have an impact on attention, perception, problem solving, judgement, decision-making skills, and vision (Taylor & Tripodes, 2001; Wagner, Müri, Nef, Mosimann, 2011; Petersen, Siersma, Nielsen, Vass, & Waldorff, 2016). However, there are mixed results regarding concluding on the link between dementia and the risk of RTA. Some studies reported that individuals with MCI or dementia are 2–10 times more likely to die from RTAs while driving or riding motorcycles relative to those without dementia (Petersen et al., 2016; Friedland et al., 1988; Tuokko, Tallman, Beattie, Cooper, & Weir, 1995). Contrarily, others reported that there is no significant difference in the rates of RTAs between those with and those without dementia (Orriols et al., 2014; Man-Son-Hing, Marshall, Molnar, & Wilson, 2007).

Pain and Severity of Falls

In older adults, pain is a common occurrence with up to one-third of community-dwelling people above the age of 60 experiencing regular pain (Shega et al., 2010). In people with dementia, it is estimated that at least 50% of them regularly experience pain (Achterberg et al., 2013). Pain can originate from any situation, however, the major cause is injury (Hanoch, Kumar, & Elavarasi, 2016). Globally, the prevalence of chronic pain among community-dwelling elderly individuals is estimated to range between 25% and 50% (International Pain Summit Of The International Association For The Study Of Pain, 2011), and the prevalence increases with age, reaching a plateau at around 70–75 years (Gibson & Schroder, 2001). Falls often result in injury which is undoubtedly associated with pain. In a systematic review, Stubbs et al. (2014) reported that older adults with pain are at increased risk of recurrent falls, suggesting that increasing age may play a role. This is also supported in a previous study (Meuleners et al., 2016). In older adult, chronic pain measured according to number of locations, severity or pain interference with daily activities have been reported to be associated with greater risk for falls in older adults (Leveille et al., 2009). In a study of older adults, it was also found that those reporting pain with moderate to severe level of pain-related interference with activities were more likely to report any falls or multiple falls compared to those not reporting pain (Blyth, Cumming, Mitchell, & Wang, 2007).

According to the WHO (2019a), an estimated 37.3 million falls that are severe enough to require medical attention occur annually. Severity of fall and injury risk depends on a number of host and environmental factors which can include fall height, impact position, surface stiffness, muscular strength, and bone strength (Cheng, Cheng, Robinovitch, & Lotz, 2003). The loss of muscle mass and strength which characterizes sarcopenia, a geriatric syndrome have also been linked to incidents of increased fall among the elderly. For instance, in a recent study, Gadelha et al., (2017) reported that individuals suffering from severe sarcopenia presented higher risk of falling, and fear of falling was higher in all stages of sarcopenia when compared to non-sarcopenic individuals. The outcome of the study clearly indicates that sarcopenia negatively affects balance, and both risk and fear of falling in community-dwelling older people, particularly women (Gadelha et al., 2017). In a study, Sterling and colleagues (2001) noted that falls resulted in serious injury more often in older people compared to younger people. Furthermore, the authors (Sterling et al., 2001) identified that same-level falls which resulted in serious injury were found to occur more in older people. In another study, Lindner and colleagues (2015) also reported that out of 195 falls, 41% were injurious with a moderate or severe post-fall injury in 6.7% of patients.

In AD, even though neuropathological changes that occur selectively affect critical areas contributing to pain's medial pathway (particularly the medial nuclei of thalamus, hypothalamus, cingulate and insula), brain regions involved in pain's lateral pathway are relatively well-preserved (Braak & Braak, 1997). Therefore, with typical degeneration of AD, the affective-motivational component of pain (medial pathway) appears to be more involved than the sensory-discriminative dimension (lateral pathway), according to a widely accepted theory (Scherder & Bouma, 1997). Furthermore, memory deficits and reasoning, which usually characterize AD, have the tendency of affecting individual assessment of a painful experience as well as the ability to describe it (Cravello et al., 2019). Indeed, previous studies have reported a higher tolerance for intense pain in individuals with AD relative to controls (Benedetti et al., 1999), and some authors have suggested that the perception of acute pain is relatively preserved in AD and that there may be altered experience of chronic pain (Pickering, Jourdan, & Dubray, 2006).

Clinical, Socioeconomic, and Public Health Implications of Falls

Falls pose a significant health risk to older adults such that as close to 30% of community-dwelling older adults ^{3} 65 years fall annually (Tromp et al., 2001). Falls have been identified as a leading cause of unintentional injury and death in older age (Deandrea et al., 2010; Deandrea et al., 2013) resulting in impaired mobility, disability, fear of falling, loss of confidence, and reduced quality of life (da Costa, Rutjes, Mendy, Freund-Heritage, & Vieira, 2012; Gillespie et al., 2012; Kwan et al., 2013; Yardley & Smith, 2002). Consequently, the result is self-restricted activity levels, which may also lead to reduced physical function and social interactions (Yardley & Smith, 2002). In addition, falls are very costly to health and social care systems (Centre for Disease Control and Prevention, 2013). Falling also exerts pressure on the family and it is considered mainly as an independent predictor of institutionalization (Laird, Studenski, Perera, & Wallace, 2001; Tinetti & Williams, 1997). A prospective study (Buchner & Larson, 1987), which focused on falls and fractures reported that during the follow-up period of the study, 50% of the study participants either fell or were unable to walk, and the fracture rate was three times the age and sex adjusted rate in the general population (Buchner & Larson, 1987). In another study, Wei and colleagues (2016), reported an association between antidepressants and higher fall and fracture risk compared to antipsychotics in the management of elderly individuals with AD and related dementias who experience moderate-to-severe behavioral symptoms. Evidence shows there is a strong correlation between the use of psychopharmacological medication and increased risk of falls or fractures (Oderda, Young, Asche, & Pepper, 2012; Coupland et al., 2011; Woolcott et al., 2009). In fact it is estimated that about 5% of falls lead to a fracture, with another 5% leading to other serious consequences (Stel, Smit, Pluijm, & Lips, 2004). It was also reported that many who fall experience psychological concerns, i.e. fear of falling, which tends to increase their risk of future falls (Stubb, West, Patchay, & Schofield, 2014).

The socioeconomic and public health impact of falls can be a critical issue that can weigh a heavy toll on the society, community, and family (WHO, 2007). Costs associated with falls can be categorized as either direct or indirect costs. Direct costs can include costs for both diagnostic (i.e. diagnostic imaging and laboratory) and therapeutic services (i.e. physiotherapy or rehabilitation), including costs of medications. On the other hand, indirect costs are associated with societal productivity losses of activities in the individual suffering from the fall or caregivers responsible for taking care of the fall victim, resulting in loss of income (WHO, 2007).

NEUROIMAGING

Computed Tomography (CT)

Injuries related to falls i.e. structural anatomical fractures involving the head, hip, pelvis, or lower limbs usually commence with the performance of plain x-ray. X-ray may be followed by advanced imaging modalities i.e. CT and MRI or bone scan if there is persistent pain (Strout & Anderson, 2016), and the need to evaluate bony details and/or tissue injury i.e. laceration. Evidence shows that there is a substantial rise in the number of ED visits related to falls in the elderly as well as the increase in CT use for their clinical evaluation (Brinjikji, Kallmes, & Cloft, 2015; Roudsari, Psoter, Fine, & Jarvik, 2012; Korley, Pham, & Kirsch, 2010). CT of the brain is a mainstay diagnostic imaging tool for head injuries in people who are 65 years or older (Stiell et al., 2001). Head injuries secondary to falls in the elderly can reveal a myriad of findings on CT including intracranial bleeds, bony fractures or incidental findings i.e. pathology. In particular, brain CT scans are mainly conducted after a fall to detect subdural hematomas (Tan & Tan, 2016), and bony injury.

In a study of elderly people (with a mean age of 83.3 years) and participants divided into 2 groups without evidence of neurologic diagnoses, Masdeu et al. (1986) found that 16 of the subjects who were fallers demonstrated a significantly higher degree of white matter hypodensity. Danielson et al. (2019) also investigate 713 patients over the age of 65 with a history of low-energy fall, of which 76.2% (543/713) underwent a head CT scan as part of their evaluation. They found that even though the most common presenting symptom was patient hitting their head, only 0.4% (3) of those who underwent head CT showed acute findings (i.e. infarct and parenchymal bleed) and none of them required acute neurosurgical intervention (Masdeu et al., 1986). This is somewhat similar to a study conducted by Maniar et al. (2015) in which a relatively smaller number of patients underwent brain CT to be evaluated for factors associated with intracerebral pathology in geriatric hip fractures. They also reported acute findings in only 6% of the patients who underwent head CT and none of them also required neurosurgical intervention. These smaller percentages reported by Masdeu et al. (1996) and Maniar et al. (2015) appear to resonate with that of Bennett et al. (2015). In their analysis of 321 patients (mean age of 81.4 years) who had head CT out of 783 patients who presented with fall and traumatic injury, Bennett et al. (2015) noted that only 3.1% (12) had abnormal head CTs with 2.8% (9) showing an acute intracranial injury. None of these patients also required neurosurgical intervention (Bennett et al., 2015). The findings reported in these studies (Masdeu et al., 1996; Maniar et al., 2015; Bennett et al., 2015) somewhat conflicts with that reported by Nagurney and colleagues (1998). Nagurney et al. (1998) reported that 16% (31) had an abnormal head CT scan, and 2% (4) required neurosurgery. The most common lesions found on CT were subdural haematomas and cerebral contusions, which were noted in 33% and 38% of patients respectively (Nagurney et al., 1998). In a recent study, Pages et al (2019) also reported that out of 500 consecutive patients aged 65 and over who underwent head CT for fall 7.6% (38) showed evidence of traumatic lesions on CT, and 53.4% (267) were hospitalized following the scan. Only 0.6% (3) of the patients underwent urgent head surgery (Pages et al., 2019).

The fear of lawsuit has been identified as one of the reasons for over-reliance on CT (Rohacek, Albrecht, Kleim, Zimmermann, & Exadaktylos, 2012). Clinicians appear to be at risk of lawsuits in case they miss out important findings managing a patient with head injury. For instance, Lindor and colleagues (2015) in their review of 60 lawsuits found that in 10 cases, providers were found negligent for failing to apply clinical decision rules, following the management of patients with head injury who would have otherwise been requested to undergo a head CT (Lindor et al., 2015).

Positron Emission Tomography (PET)

PET is a versatile minimally invasive neuroimaging modality with a wide range of applications in both clinical and research areas. The three-dimensional (3D) mapping of radiopharmaceuticals i.e. fluorodeoxyglucose-18 to track the metabolism of glucose, is one of its major hallmarks.

The 12-month prospective cohort PET study conducted by Stark et al. (2013) suggests that falls may be an early sign of AD, in this case older adults with preclinical AD. They found higher levels of PiB retention and CSF biomarker ratios were associated with a faster time to first fall (Stark et al., 2013). Bohnen et al (2009) also investigated the relationship between the severity of age-associated striatal dopaminergic denervation (AASDD) and falls in 77 community-dwelling subjects. Dopamine is a neurotransmitter that exerts widespread effects not only in neuronal tissues but also in non-neuronal tissues where it acts as an autocrine or paracrine agent (Drozak & Bryla, 2005). The authors (Bohnen et al., 2009) found that about 34% (26) participants reported at least one fall, with 6.5% (5) of them reporting ³ 2 falls. A recent review (Martorana & Koch, 2014) noted that different degree of dopamine dysfunction can occur during any phase of AD. Evidence shows that dopaminergic drugs administered to AD patients resulted in beneficial effects on some cognitive domains (Koch et al., 2014). Therefore dopamine may be a predictor for falls in elderly people at risk or with AD, and may serve as target for early intervention.

Magnetic Resonance Imaging (MRI)

MRI provides better advantage than CT as it does not involve the use of ionizing radiation, and provides better contrast resolution of soft tissues, making it a powerful tool for interrogating brain structures. Volumetric measures of the brain structures are often carried out using a technique called "voxel-based morphometry". Voxel-based comparison of these images can then be undertaken between groups or correlations with neuropsychological measures (Holtzer, Epstein, Mahoney, Izzetoglu, & Blumen, 2014).

Structural changes in the brain have been reported in older adults with gait problems (Rosano et al., 2012) and postural instability (Kido et al 2010). Specifically, reduced GM density are associated with gait impairment (Rosano et al., 2012; Rosano et al., 2008; Rosano et al., 2007) and postural instability (Kido et al., 2012). In the study conducted by Kido et al. (2012), they found postural instability to be associated with GM volume loss, and it is related to pathological cognitive decline, such as MCI and AD. Indeed reduced GM volume has not only been found to be related to cognitive decline, but also decreased physical function (Makizako et al., 2013). In their study, Makizako et al. (2013) also studied 42 older adults with MCI and found that fallers demonstrated a significantly increased reduction in the bilateral middle frontal gyrus and superior frontal gyrus (Makizako et al., 2013). The function of the middle frontal gyrus is its involvement in motor output and the direct control of behavior, including planning, spatial guidance, and sensory guidance of movement (Graziano & Gross, 1998). Bae et al. (2019) in their recent study, which also sought to analyze volumetric size of the brain in patients afflicted with osteoporosis found a statistically decreased volume percentage of the brain parenchyma, coupled with an increased volume percentage of the lateral ventricles with increasing age. Additionally, they found that patients with osteoporotic vertebral compression fractures (OVCF) demonstrated a significantly reduced volume percentage of brain parenchyma compared to those without OVCF (Bae et al., 2019). Osteoporosis is well known to contribute to bone fragility and increase risk of injury, fractures of the wrist, spine, and wrist, and their sequelae following falls (National Institute of Arthritis and Musculoskeletal and Skin Diseases, 2018; Guggenbuhl, 2009). Indeed some studies have reportedly demonstrated the incidence of reduced bone mineral density of the hip in patients with AD, and their two times fold susceptibility of hip fracture (Wang et al., 2014; Zhao et al., 2012).

Fluid Attenuated Inversion Recovery (FLAIR)

FLAIR is an MRI technique that employs long inversion times to null the MRI signal from CSF to reveal periventricular lesions or white matter lesions.

WM lesions have been investigated using FLAIR in elderly people. Elderly people with history of falls have also been investigated for evidence of WM lesions, and their relation with incident of falls. In one of such studies, Srikanth et al. (2009) found that WM lesion volume associated independently with any incident fall and multiple incident falls. In another study, Zheng et al. (2012) also reported that those with severe WM lesion burden had an increased risk of falls during a 1-year follow-up. Other studies have also established that greater WM lesion load is associated with falls (Baezner et al., 2008) and poorer balance in older people (Tell, Lefkowitz, Diehr, & Elster, 1998).

Gradient Echo (GRE)

GRE pulse sequences, due to their lack of 180^0 radiofrequency (RF) refocusing pulse that is required for the formation of an RF spin-echo (Bernstein, King, & Zhou, 2018), they are useful for providing susceptibility-weighted (SW) images or T2* weighted images. On T2* weighted image, haemorrhage appears in the form of signal loss (hypointensity). Evidence shows that increased vessel wall thickness may be a predisposing factor in the formation of microbleeds compared to macrobleeds (Greenberg et al., 2009). Cerebral MBs are small, round, or ovoid foci (< 5mm) of signal loss on GRE, and purported to be caused by structural abnormalities of the small vessels (Cheng et al., 2013; Martinez-Ramirez, Greenberg, & Viswanathan, 2014). Even though T2* weighted imaging is sensitive for identifying MBs, there are studies (Tsui, Tsai, Hasso, Greensite, & Nguyen, 2009; Haacke et al., 2007) that have made pronouncements on the relatively higher sensitivity of SW imaging compared to T2* for detection of MBs. Pathological analysis of MBs shows that they represent small regions of hemosiderin deposition adjacent to small arteries (Fazekas et al., 1999). There have been consistent reports associating MBs with vascular risk factors (i.e. age and hypertension), and markers of small vessel pathology (i.e. lacunar infarcts and WM hyperintensities) (Koennecke, 2006). It is however important to note that in the absence of hypertension, MBs can be present (Fisher, French, Ji, & Kim, 2010). The distribution of MBs in deep and infratentorial regions (i.e. thalamus, basal ganglia, and brainstem) are reflective of hypertensive vasculopathy (Vernooij et al., 2008). On the other hand, when MBs are distributed in cortical and subcortical regions, they are considered to reflect hemorrhagic lesions, which have been attributed to cerebral amyloid angiopathy (CAA) (Greenberg et al., 2009; Vernooij et al., 2008). CAA refers to the deposition of amyloid-beta in the media and adventitia of small cerebral arterioles (Greenberg et al., 2009; Vernooij et al., 2008).

Although MBs are a common finding in healthy older individuals (Martinez-Ramirez et al., 2014), their overall prevalence is considered to be much higher in people with AD compared with the non-demented older individuals (Cordonnier et al., 2006; Pettersen et al., 2008). Therefore MBs have clinical importance in cognitive aging. That people with AD have relatively higher MBs than non-demented older people (Cordonnier et al., 2006; Pettersen et al., 2008), and most of them demonstrating CAA at autopsy (Jellinger, 2002) provides evidence that MBs may be associated with incidents of falls in older people. This finding is supported in a recent study (Dörr, Schickel, Lucke-Paulig, Schöntag, & Lobmann, 2019) which reported that CAA-related inflammation was causative not only for neuro-psychiatric symptoms but also worsening of gait with recurrent falls as well as cognitive decline. In older individuals, the presence of MBs, as well as lacunar infarcts, have also been reported to be associated with a slower 25-metre walking speed (Stijntjes et al., 2016).

Diffusion Tensor Imaging (DTI)

DTI is unique in its strength to interrogate WM microstructural integrity, thereby allowing quantification of WM alterations. Impairment of WM leading to neurological disorders can be classified according to the abnormality of myelin (demyelination), axonal injury, or a combination of both (Perry & Anthony, 1999; McGavern, Murray, & Rodrigquez, 1999).

DTI has been widely used to characterize elderly people identified to be at risk or suffering from AD. DTI has also been used to interrogate WM integrity in the genu of corpus callosum of older people with gait problems (Bhadelia et al., 2009; De Laat et al., 2011; Kafri et al., 2012). Using whole-brain tract-based spatial statistics analysis, Wong et al (2017) found significant differences in both MD and AxD values for various WM tracts between fallers and non-fallers. In another study, Koo et al. (2012) found several abnormal WM regions, which include the medial frontal and parietal subcortical pathways, genu and splenium of corpus callosum, posterior cingulate, prefrontal, and orbitofrontal pathways, and longitudinal pathways that connect frontal-parietal-temporal lobes. A recent study conducted by Snir and colleagues (2019) also found that several WM tracts including the corpus callosum, forceps minor, and the left inferior fronto-occipital fasciculus were significantly associated with history of falls, and lower dual-task gait performance. Indeed evidence shows that individuals with MCI have twice the risk of fall relative to age matched cognitively normal older adults (Tinetti et al., 1988). Another study (Gómez-Ansón et al., 2015) also revealed that there was evidence of significant deteriorations in local WM integrity within the superior longitudinal fasciculus and corticospinal tract, and these region were found to be associated with falls. Further studies have also revealed that increases in AxD are not only associated with axonal damage, but unveils potential microstructural changes associated with falls in older adults (Roosendaal et al., 2009; Metwalli et al., 2010).

Functional Magnetic Resonance Imaging (fMRI)

fMRI is a noninvasive advanced MRI technique developed to provide measures of brain activity and connectivity with unparalleled spatial specificity (Soares et al., 2016). Mapping of brain function is most often undertaken using the venous BOLD contrast technique (Ogawa, 2012). This BOLD fMRI primarily uses GRE because of the increased T2* contrast (Boxerman et al., 1995). fMRI has also been used to study functional correlates in older adults with falls.

In a comparative study, which compared functional connectivity (FC) of four brain networks, at rest and during a simple motor tapping task, Hsu et al (2014) revealed that fallers demonstrated more connectivity between DMN and FPN during tapping of the right finger, as well as significantly less functional connectivity between the SMN and FPN during rest, when compared to the non-fallers. Evidence of less FC between SMN and FPN has also been reported by Inman et al. (2012) during rest in survivors of stroke.

SUMMARY AND FUTURE DIRECTION

Prediction and prevention systems are crucial to help reduce the socioeconomic, physical, and psychological impact of falls (Rajagopalan et al., 2017). With elderly individuals at risk or suffering from AD being highly susceptible to falls compared to those with healthy cognitive aging, a multifactorial intervention may be required to stem the tide of falls in this population (Gillespie et al., 2012).

CT may be used to rule out injuries, pathology, or structural changes that may be associated with incidence of falls. PET studies show that dopmamine levels (Bohnen et al., 2009), and deposits of AD-associated plaques (Stark et al., 2013) may also offer some insight regarding the prediction of future falls, hence may be targeted for therapeutic intervention to prevent or reduce falls among elderly people.

MRI findings of structural brain changes i.e. GM volume loss, WM hyperintensities, and macro and microbleeds noted to be prevalent with increasing age, and in people with AD can also be targeted for therapeutic interventions in this population as a measure to prevent falls. Improvement in bone mass among elderly people to prevent or reduce osteopenia and osteoporosis, particularly among women may also suffice to reduce or prevent the risk of falls. WM abnormalities in specific regions of the brain, found to correlate with cognitive function scores (Koo et al., 2012; Snir et al., 2019; Gómez-Ansón et al., 2015) may be targeted for early therapeutic interventions. Alterations in FC between the SMN and FPN may also be targeted for fall prevention (Hsu et al., 2014). Longitudinal studies employing multimodal neuroimaging techniques, large sample sizes with control groups may also be required to help predict incidents of falls in elderly individuals at risk or suffering from AD.

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Chapter 7
Fall Risk and the Use of Exercise as a Fall Prevention Strategy

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ABSTRACT

Increasing life expectancy and the growing number of elderly people have also increased the number of comorbidities common in this population in the same proportion, where the risk of falling is highlighted and has been increasing in a worrying and negative way. However, the practice of physical exercise can improve the prevention and reduction of falls. In this context, this chapter addresses the theme with the objective of identifying how, which, and when physical exercise can contribute in relation to the risk of falling in the elderly. Through analysis of articles and recent reviews, the chapter addresses the influence of strength, power, aerobic, and multicomponent exercises in their various components and possible influences on the risk of falling. There is also a proposal for a specific program for the risk of falling in the elderly, with adjustments in volume and intensity according to the needs of the target audience, based and improved by worldwide guidelines.

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INTRODUCTION

Despite the known benefits of physical activity on health and physical function with aging, the proportion of older adults meeting recommended physical activity remains low, being around 30% or below (Dipietro et al., 2019; Guthold, Stevens, Riley, & Bull, 2018). Therefore, in the last two decades, considerable evidence (including a significative number of guidelines) has emerged regarding the relative benefits of various modes or combinations of physical activity, such as progressive resistance training, multicomponent exercise, dual-task training, tai chi, yoga, dance, and balance for fall-related injury prevention and for specific physical function outcomes (e.g., strength, gait speed, balance, activities of daily living [ADL] function) (Erickson et al., 2019; Europeia, 2008; Jakicic et al., 2019).

Falls are partly a consequence, and to a great part cause of physical inactivity in older adults. Falls are defined as involuntary events that make you lose your balance and hit the body on the ground or another firm surface that stops it (Windle, Hughes, Linck, Russell, & Woods, 2013). Falls are the main cause of fatal and nonfatal injuries among the elderly according to a survey by the Behavioral Risk and Surveillance System, which was analyzed by the US Centers for Disease Control and Prevention (Center of Disease Control and Prevention, 2018). In this survey, in 2014, about 28.7% of older people reported falling at least one time in last year, what resulted in 29.0 million falls and about 7.0 million fall injuries only in United States (Bergen, Stevens, & Burns, 2016).

Moreover, the percentage of older people who fall increases with age, from 26.7% among people aged 65 to 74, to 29.8% among people aged 75 to 84, to 36.5% among older people over 85 years old (Florence et al., 2018). Of the older adults who fall, half have recurrent falls and 50% will fall again in the same year (Rebelatto, Castro, & Chan, 2007). The fall event is, therefore, a risk factor for suffering further falls. According to the Brazilian Ministry of Health, approximately one third of the elderly population suffers multiple falls each year (DATASUS, 2009) and in the USA one in each four elderly falls every year, these falls being the major and most common cause of fatal injuries and hospitalizations (Center of Disease Control and Prevention, 2018).

The severity of the fall injury can advocate the early onset of morbidity and mortality. From the total number analyzed by the US, 2.8 million were treated at emergency units for fall-related injuries and approximately 800.000 of those treated, were subsequently hospitalized, and approximately 27.000 died, with women being more likely to report falls and a fall injury than men (Bergen et al., 2016; Florence et al., 2018). These numbers kept growing, between 2007 to 2016, the falls related occur by 2030, which is pretty death in USA increasing by 30%. Within this scenario around 7 deaths/hour will dramatic and highly costly. And Europe goes in the same way, with the Western region with 8.4 million older adults attended in medical centers due to fall-related injuries in 2017 (Haagsma et al., 2020).

Also it should be emphasized that falls are the most common cause of traumatic brain injury in older adults (Center of Disease Control and Prevention, 2018). That can produce an increment in cognitive impairment and contribute to the acceleration of the loss of functionality and an increase of sedentary behaviors through the emergence of fear-of-falling (Erickson et al., 2019; Freiberger, Häberle, Spirduso, & Rixt Zijlstra, 2012).

Prevention of falls and injuries is not easy due to the combination of intrinsic impairments (e.g., decreased muscle mass; deterioration of nerve, musculoskeletal, vestibular and visual systems; loss of tactile sensitivity to pain; memory loss, depression and anxiety) and extrinsic or environmental hazards (e.g., uneven ground surface, loose carpets, inadequate lighting, high beds, low toilet, inappropriate footwear, etc.) (Silva et al., 2016). Knowledge of preventive factors for falls in the older people might lead to a reduction in this personal and public health problem. In a large number of occasions falls in the elderly lead to fractures of the hip and/or femoral bones, that situation increases the level of dependence and elevates the institutionalization rates with the consequent rise in socioeconomic cost (Teixeira, Oliveira, & Dias, 2006). Furthermore, older adults institutionalized are even at greater risk of falls, concisely they are three times more likely to fall because its higher physical and cognitive impairment, and 39.8% of then being between 80 and 89 years old, showing even more vulnerability (Florence et al., 2018; Hartholt et al., 2012).

The institutionalized elderly usually have singular characteristics, such as sedentary habits, decreased autonomy and, in many cases, family abandonment, which contribute to the increase and prevalence of related to morbidities and comorbidities, especially falls, as it is one of the most relevant (and preventable) health issues in aging, due to the high social and economic cost (Ribeiro, Souza, Atie, Souza, & Schilithz, 2008).

Institutionalized elderly have different needs, requiring attention, support and specialized services, as the vast majority are considered frail, presenting physical and/or mental morbidities, which makes them more prone to health problems, conceptualizing the frailty syndrome (E. J. Kim et al., 2015; Vlaeyen et al., 2015).

The concept of frailty refers to the heterogeneous syndrome that is found in older people, characterized by physical frailty concomitant with cognitive impairment (Fried et al., 2001). Among the features of the syndrome, the loss of functional physical capabilities such as muscle strength (due to possible sarcopenia), resistance (due to possible sedentary behavior), as well unintentional weight loss, can lead to an increased risk of accidents (Cai, Chan, Yan, & Peng, 2014; Bothania Hassan et al., 2016).

AGE-RELATED BIOLOGICAL CHANGES PREDISPOSING TO FALL EVENTS

Before the design of an intervention program to reduce the risk of falling through physical exercise, the health professional has to analyze and understand the changes related to age that increase the risk of falls.

Loss of Muscle Mass

Originally, the loss of muscle mass has been considered as an inherent phenomenon to the aging and determining process in increasing the risk of falls. Since the age of 25 to 30, there is a progressive loss of muscle mass that could reach up to 30% at the age of 80 (Center of Disease Control and Prevention, 2003). However, the ratio of muscle mass loss is not the same between men and women and among the upper and lower members. Older men lose muscle mass in arms at a rate of ~ 0.29 kg/decade and women ~ 0.19 kg/decade, however this loss is greater in the lower limbs, reaching values of ~ 0.63 vs. ~ 0.49 kg/decade for men and women respectively (Janssen, Heymsfield, Wang, & Ross, 2000). In addition, the anatomical cross-sectional area may be overestimated if the noncontractile tissue is not deducted, which usually represent a higher percentage in the elderly (Overend, Cunningham, Paterson, & Lefcoe, 1992). Taking into account all this information, it is expected that the older adults have a reduced amount of contractile tissue that harms functionality and increases the risk of falls. To this reduction in the muscle mass produced during the process of aging and unrelated to the presence of other circumstances (e.g., cancer, accident immobilization) has been called Sarcopenia (Rosenberg, 1989). This denomination marked a before and after research on the decline of muscle mass and its relationship with functionality in older people. However, we now know that functionality, understood as the ability to perform movements required in daily life, and in which we could frame walking or getting up from a chair without falling, depends on other factors in addition to the amount of muscle mass. In this sense, more than four decades ago that dissociation between muscle mass and the force applied in a gesture (Moritani & DeVries, 1979) is reported. In fact, the concept of sarcopenia has evolved, and, in many consensus scientific articles, the deterioration of force, power or functionality have been included within the definition (Cruz-Jentoft et al., 2019). In this sense, in the last decade, the use of the term Dynapenia has been proposed to refer to the deterioration of muscle strength, power and functionality (Manini & Clark, 2012), arguing that this new paradigm can mark the means used for evaluation and the intervention in the improvement of functionality.

Loss of Strength and Power

The rate of decline in muscle strength is greater than muscle mass during the aging process. Results of cross-sectional studies report a difference in maximum isometric force of 30%-50% between young people and older adults (~70 y). Muscle strength reaches its peak between the second and third decades of life, is maintained or slightly reduced between the fourth and fifth decades, and then progressively declines sharply at a rate of ~ 1.0 to ~ 1.5% per year (12%/decade), especially this reduction accelerates from 65 to 70 years (Booth, Harwood, Hood, Masud, & Logan, 2016; Chen et al., 2019). The rate of loss of strength, like the age-related muscle mass loss, is faster in the lower limbs than in the upper limbs (Booth et al., 2016; Chen et al., 2019). In addition, women have less absolute strength throughout the life cycle, which leads them to reach the dependency threshold at an earlier age. This makes strength training in women a priority to prevent dependency and the risk of falling. A deterioration in the ability to exert force and to contract fibers at high velocity has its origin in the atrophy that occurs over the years in muscle fibers, especially in the fast velocity contraction fibers or type-II fibers, the reduced muscle thickness and pinnation angle, slower formation of actin-myosin cross bridges, the deterioration of the recruitment capacity of high-frequency motor units and the reduction in voluntary activation. The reduction in force and velocity that experiments older people leads to a critically affected ability to generate muscle power or the ability to perform movements that require a manifestation of force at a certain speed. Two decades ago, muscle power was believed necessary to improve performance in sports activities, however, during the last ten years it has been known that it is also an essential component in the performance of certain activities of daily life and that is closely linked with improved functionality (Raj, Bird, & Shield, 2010). An adequate level of neuromuscular power will help older people to decelerate their movement to change their spontaneous direction of gait or stop their movement in a situation that poses a certain risk of falling, it will also allow them to rebalance in the face of an external disturbance (e.g., a stone in the road, a boost on the bus, etc.). Indeed, it has been suggested that muscle power is a more discriminating predictor of functional performance in older adults than muscle strength (Baltasar-fernandez et al., 2021). In a study carried out with women in good physical condition in which two age groups were compared (18 to 30 vs. 65 to 74 years), it was reported that the muscular power measured in the unilateral leg press exercise was 61% lower in older women (Macaluso & Vito, 2004). This difference was determined by a 52% reduction in optimal force and a 21% reduction in optimal velocity, resulting in a 22.1% reduction in the ratio between peak power and maximum isometric voluntary contraction (Macaluso & Vito, 2004). The importance of introducing power training in exercise programs that seek functional improvement in older people and the consequent reduction in the risk of falls seems unquestionable. There are an increasing number of studies that have applied high-speed training in older adults (Jaque et al., 2020; Ramirez-campillo, Castillo, De, & Campos-jara, 2018) and have shown that exercise interventions aimed at improving muscle power of the lower extremities are well tolerated, safe and effective even among frail older adults.

Decrease of Force Steadiness

The normalized amplitude (coefficient of variation, CV) of force fluctuations measured when a person attempts to sustain a constant force during submaximal isometric activation or the standard deviation (SD) of anisometric (eccentric, concentric) force activation is called force steadiness (or force variability) (de Luca, LeFever, McCue, & Xenakis, 1982; Enoka et al., 2003; Enoka & Farina, 2021). In general, older individuals are less steady (greater CV during isometric activation or greater SD during anisometric activation) than young individuals when they applied force at levels generally lower than 40% (Enoka & Farina, 2021). Force steadiness has been moderately associated with standing balance (Davis et al., 2020; Kouzaki & Shinohara, 2010) and risk of falls in older individuals (Carville, Perry, Rutherford, Smith, & Newham, 2007). For instance, Carville et al. (2007) have observed that older adults (>70 y) with a history of falls presented 31% lower levels of force steadiness compared to those older adults who did not have a history of falls, moreover this observation was independent of their maximal muscle strength. It has been suggested that the dominant factor influencing the amplitude of the fluctuations in force (<10 Hz) is the variance in the modulation of discharge times within the force bandwidth, which represents only the slow oscillatory variability in motor unit discharge times (Enoka & Farina, 2021). Even though it remains unclear why the variability in the neural drive to muscle during a submaximal isometric or anisometric activation can explain significant amounts of the variance in tests of motor function it has been stated that the CV for force during steady contractions can explain more of the variance in motor performance than can measures of muscle strength (Enoka & Farina, 2021).

Brain and Cognitive Deterioration

The aging process, besides the association with locomotor system, is also strongly associated with changes in cognitive abilities (Seidler et al., 2010). In fact, daily life activities need the combination of executive/cognitive and functional abilities (locomotor system) (Faulkner et al., 2007), with the progressive deterioration of the capacity to perform simultaneous (dual) tasks, also referred as cognitive-motor interference, starts to be a major risk for falls (Wollesen & Voelcker-Rehage, 2014).

A recent study (Wollesen, Wildbredt, Schooten, Lim, & Delbaere, 2020) has shown three important factors of executive function which are of special relevance to daily life activities:

(i) inhibitory control (ability to stay focused, without distraction);
(ii) working memory (ability to hold/manipulate information, priorities, and action plan);
(iii) cognitive flexibility (ability to adjust/change attention, set-shifting, task-switching).

The executive functions need to be trained and improved to prevent fast deterioration, and increased risk of fall (Wollesen et al., 2020). Furthermore, as an additive effect specific higher-order cognitive processes may moderate efficacy of exercise via adherence (Best, Nagamatsu, & Liu-Ambrose, 2014). Adhering to exercise training is a must precondition to take benefits that regularly practice of exercise offers. Therefore, it may be important to assess and consider internal self-regulatory cognitive processes at baseline to determine optimal strategies for promoting adherence to exercise recommendations for preventing falls in non-supervised programs. For example, those with executive dysfunction may require more frequent contact and in-person support versus those without executive dysfunction, and strategies as exergames training could be an more than optimal option to reduce fall risk and to work executive capacities (Gschwind et al., 2015; J. M. Cisneros Herreros & G. Peñalva Moreno, 2010).

PHYSICAL ACTIVITY AND FALL RISK

The above discussed about the decline in functional capacity results in part from neuromuscular changes such as muscle denervation, atrophy, and selective loss of muscle fibers (especially type II fibers) with reduced total muscle mass and decreased muscle strength and power, negatively affecting the balance and functional mobility of the elderly by reducing the effectiveness of postural adjustment and motor control mechanisms (Sherrington et al., 2019), and contributing to this increased risk of falls and fractures. This risk is particularly high in institutionalized elderly, since, among other factors, functional fitness levels are lower than in non-institutionalized elderly, which may partially explain the higher prevalence of falls with femur fracture that has been observed in this segment of population (Bergen et al., 2016; Florence et al., 2018).

Loss of muscle and functionality are only part of the age-related changes in the body (Milte & Crotty, 2014). Causes of physical and cognitive impairment include cardiometabolic disease, chronic kidney disease, insulin resistance, sleep disorders, chronic inflammation and obesity (A. King et al., 2019; Kraus et al., 2019; Salminen, 2020). Some of the predisposing factors underlying sarcopenia (e.g., oxidative stress, inflammation) are also associated and may explain the common etiological factor, which is potentiated by physical inactivity (Jensen, Hasselbalch, Waldemar, & Simonsen, 2015).

As well, the increase in the older population and the high levels of physical inactivity that occur in several countries in this population, predict the increased prevalence and incidence of falls in this population. Thus, physical exercise may play a key role in maintaining balance, functional mobility and consequently preventing falls in the elderly (A. King et al., 2019).

In this context, physical exercise appears as a non-pharmacological tool against consequences related to the risk of falling, as well as syndromes that may contribute to a greater predisposition to falling, or to the risk of falling. During exercise, various substances outside the central nervous system have the ability to communicate with the brain, including various types of cytokines. Some systemic inflammatory cytokines, such as TNF-α and IL-1β, have direct catabolic effects on skeletal muscle and brain functions during and after prolonged exercise (Trappe, Standley, Jemiolo, Carroll, & Trappe, 2013). Observations of the beneficial effects of physical exercise on physical and cognitive performance, particularly in the elderly, were made experimentally by several researchers.

However, regardless of gender, older people's participation in exercise programs promotes increased muscle mass, muscle strength and balance, reducing the risk of falls and consequently fractures (Stokes, 2009). The ACSM, in their 2018 Physical Activity Guidelines (A. King et al., 2019) provides strong evidence that physical activity reduces around 30-40% the risk of fall-related injuries in older people, and this includes severe falls requiring medical care or hospitalization.

Thus, the effectiveness of physical activity/exercise programs that emphasize combinations of moderate-intensity balance, strength, aerobic, gait, and physical function training for risk reduction has significant public health relevance in older age, due to the high prevalence of falls and fall-related injuries and fractures among older adults, as well as the consequent morbidity, disability and reduced quality of life (Erickson et al., 2019; Kraus et al., 2019).

Strength-Power Training and Fall Risk

As a fall has a strong connection with muscle weakness and the loss of muscle mass, the kind of exercise that fights it, is strength training, is one of the most recommended type of physical activity for older populations (Cruz-Jentoft et al., 2010; de Souto Barreto et al., 2016; Bothaina Hassan et al., 2016; A. King et al., 2019).

Studies that associate strength exercises and the possible effects on fall risk and quality of life are scarce, but have been increasing its number in the last 5 years (Chupel et al., 2017; Cuevas-trisan, 2019; A. King et al., 2019). In some of the studies, it was observed that strengthening exercises promoted significative improvements in muscle strength, increasing, or maintaining (or, at least, reducing the speed of loss of) muscle mass, as it plays a key role in maintaining balance and functional mobility, which are important factors for reducing and controlling the risk of falling in the elderly (Blain, Bernard, Boubakri, & Bousquet, 2019; Chodzko-Zajko et al., 2009; Cruz-Jentoft et al., 2010; Dipietro et al., 2019).

Also, the strength training programs were able to improved psychological well-being, stress levels and cognitive functioning (Kearney, Harwood, Gladman, Lincoln, & Masud, 2013; Salzman, 2011) which could help the individuals keep their adherence to exercise programs. Moreover, strength training based on perceived exertion has been shown to be an effective method for improving health-related quality of life in some subscales (vitality, functional capacity, general health, and mental health) as well in reducing depressive symptoms (Cuevas-trisan, 2019; A. King et al., 2019).

In some studies (Baltasar-fernandez et al., 2021; Rodriguez-lopez et al., 2021) were compared the power and strength training in different ways. Using traditional resistance training, focused on strength capacity, and some high-speed resistance training, focusing in the development of power as well. Over the 12-week training period, both groups showed significant improvements, and were effective in improving functional capacity, muscle performance and quality of life in older women, but the high-speed resistance training program induced in a greater way, the improvements in muscle power and functional capacity (Ramirez-campillo et al., 2018), showing another interesting way for interventions.

Briefly, the programs that emphasizes in the use of strength and power training were able to improve muscle strength by 6% to 60% in older people and were effective in reducing the fall rate by 22% to 35% (Cadore, Rodríguez-Mañas, Sinclair, & Izquierdo, 2013).

Balance and Fall Risk

Recent studies have shown that exercise programs with at least 3 hour/duration/week, with some levels of balance challenge, and balance-specific training could reduce around 21% the rate of falls in community-dwelling older people (Chou, Hwang, & Wu, 2012; Hauer et al., 2001). This studies also showed that all exercise programs had a fall prevention effect in community-dwelling people with some level of cognitive impairment and Parkinson's disease. However, among stroke survivors and recently hospitalized elderly, the fall prevention effect, was not found with the same physical exercise program.

In another study (Binder et al., 2002) was compared the frequency of falls in 91 institutionalized frail elderly, divided in three different groups: i) Vitamin D supplementation; ii) low-frequency exercise and

iii) combination of both. The intervention iii) (i.e., combination of both) showed to be the most effective for the reduction of falls among institutionalized frail elderly individuals, showing the importance of the vitamin D supplementation, beyond the importance of physical exercise.

A recent meta-analysis (based on 18 RCT studies) (Huang, Feng, Li, & Lv, 2017) that analyzed the influence and use of Tai Chi, showed some evidence of its beneficial issues, mainly, in improving balance, and therefore reducing fall risk. Another review evaluating outcomes of these kind of interventions revealed that programs targeting at least two of these components (strength, endurance, flexibility, and balance) were able to improve balance capacities between 5% to 80% in older adults, and reduce the rate of falls significantly, with the rate of fall, and fall risk reduction above 55% (Cadore et al., 2013; Casas & Izquierdo, 2012).

Aerobic Exercise and Fall Risk

As the aging process is always associated with a cardiorespiratory capacity decline, the use of aerobic exercise has been recommended to counteract this process (Carrick-Ranson et al., 2020; Valenzuela, Maffiuletti, Joyner, Lucia, & Lepers, 2020). The aerobic/endurance/cardiorespiratory training usually include treadmill walking, step-ups, stair climb, cycling (usually, stationary cycling), and walking, with changes in pace and time duration (Freiberger et al., 2012; H. K. Kim et al., 2012; Zhang et al., 2016).

In a review investigating the effect of exercise interventions (Cadore et al., 2013), the outcomes of aerobic exercise showed improvements in maximum rate of oxygen consumption (VO_{2max}) around 13% in older adults, after 3 months of practicing walking exercise ate 70-75% of maximal heart rate (HR) intensity, with progression starting in 20 minutes to 60 minutes duration. However, older persons with severe functional decline, most of times, are not able to perform this kind of exercise interventions, in a way to recover their cardiorespiratory capacities, or to promote significative changes (Cadore et al., 2012; Izquierdo et al., 2001).

Although, aerobic capacity is a very important characteristic of physical capacity, and should be included in an exercise training routine, there may be a need to strengthen the muscular system, or to use some method for controlling the adequate intensity for cardiorespiratory tolerance, previously the starting of an aerobic training, in order to achieve significant changes and adaptations (Izquierdo et al., 2001).

Some studies (Cadore et al., 2012; Izquierdo et al., 2001) have demonstrated that has a positive association between strength and aerobic capacity, recommending the use of multicomponent interventions (Freiberger et al., 2012; García-Molina et al., 2018; H. K. Kim et al., 2012; Wang et al., 2018; Zhang et al., 2016), which have shown improvement not only in physical capacities, but also in cognitive functions of the participants, including reaction time, gait speed, balance, memory, mood and general well-being (Meurer, Benedetti, & Mazo, 2009). As well in a study by Chupel et al (2017) where aerobic capacity was correlated with cognitive performance and positive effects were noted in the trained group.

Multicomponent Exercise and Fall Risk

The “multicomponent” term refers to physical exercise programs which are composed by more than an only one mode of physical activity, being a mix of some of most common types such as strength training, aerobic exercise and stretching training, for example.

A review (Cadore et al., 2013) on the use of this kind of exercise training, concluded that multiple-component group exercise programs reduced the rate of falls and risk of falling, in both individually or group prescribed, home-based or physically present exercise programs in a very significant way.

In the same way, the American College of Sports Medicine (ACSM) 2018 Guidelines report convincing evidence related to the greater benefits of multicomponent exercise when compared to a single-mode of exercise alone (strength, aerobic, balance, etc.), in the prevention/reduction of fall-related injuries, and fall risk, by improvements in physical function in older adults. It has become the most recommended type of exercise program (A. King et al., 2019) with a rate of fall prevention around 31% in frail older adults (Cadore et al., 2013).

Moreover, multicomponent exercise programs, as well as the multi-task activities (that which combine cognitive and physical task together) have shown to be an important and better option to daily live routine, being a positive alternative to the single, structure and regular exercise programs.

Dual-Task and Fall Risk

Dual-task activities refers to the combination of some cognitive task with some physical/locomotor activity (e.g., walking while counting backwards) (Wollesen & Voelcker-Rehage, 2014).

A recent meta-analyses has shown general dual-task activities improved significativly the level of global cognition and executive functions as well, in many and different types of exercise, its intensity, and the intervention settings, with some heterogenity, but all being positivi in some ways (Wollesen et al., 2020). Therefore, the review suggest that the studies where long interventions was choosen, had more benefits and improvents in general cognition

Also, the domains of cognitive function that are influenced by this kind of training are vast and significant, going of inhibitory control to attention and mental shifting skills (Faulkner et al., 2007; Wollesen & Voelcker-Rehage, 2014). In this way, the use and promotion of new technologies may be a helpful tool to complement some kind of home-based and/or not supervised program for older adults, as they can, in some level, independently perform interesting and more diverse training sessions (Wollesen et al., 2020).

RECOMMENDATIONS, PREVENTION AND MANAGEMENT STRATEGIES

Adding to the above discussed benefits, physical exercise exceed fall prevention and the reduction of fall risk, being beneficial to general health and well-being and able to reduce the risk of disease onset, also managing chronic conditions such as arthritis, diabetes, heart and respiratory conditions, which are very common and related to aging process (Mendes, Sousa, & Barata, 2011).

Taking into account, the general recommendation from the ACSM (Jakicic et al., 2019), the European Union (European Union, 2014), the World Health Organization (Bull et al., 2020) and The National Program for Health and Physical Activity from Portugal (Direcao Geral de Saude, 2017) on physical activity to prevent fall converges in many point, highlighting that older adults should perform a varied multicomponent exercise at moderate to high intensity, that should include:

i) Around 30 minutes/day of moderate intensity aerobic exercise, 3 to 5 days a week; or do vigorously intense aerobic exercise, for 20 minutes/day, 3 to 5 days a week.
ii) Around 8 to 10 strength training exercises, with 10 to 20 repetitions, 2 to 3 times per week.

iii) Include balance exercises in the physical activity plan, as they can prevent fall in both, high risk groups and the general population.

These general recommendations of physical exercise to older adult population include the incorporation of physical activities focusing on maintaining and/or increasing/improving physical capabilities, such as muscle mass, flexibility, balance, endurance, and gait speed (A. King et al., 2019).

Some studies (Albornos-Muñoz et al., 2018; García-Molina et al., 2018; Hamed, Bohm, Mersmann, & Arampatzis, 2018; Pimentel & Scheicher, 2009; Sosnoff et al., 2015) also highlight the importance of effectively challenge balance with specific exercises that are conducted whilst standing, and participants should be encouraged, among other things, to:

i) stand with their feet closer together or on one leg;
ii) minimize the use of their hands to assist balance;
iii) practice controlled movements of the body's center of mass/gravity.

However, the prescription of the exercise and its difficulty must be guided taking account the individual's capacities and limitation, and the safety conditions. When balance, or any other physical capacity is mastered in a safe, stable and positive manner without any other support, it should be progressed to increase challenge and continue the progression rate (A. King et al., 2019; Kraus et al., 2019).

Specific ways to increase intensity of balance training for example, should taking to account the progressively difficulty of postures in different bases of body support, such as semi-tandem, tandem, and one leg stands, as well the movements which perturb the body's gravity center, like circle turns, stepping over obstacles and tandem walk, and activities with reduced sensory output (eyes closed, walking or at least stand in unstable surfaces). Specific strength training exercises should also be included to improve balance, such as hip abduction and heel and toe stands (de Souto Barreto et al., 2016).

In addition to that, high doses of exercise (more than 50 hours – 2 session of 1 hour/ week, for 6 months) have been shown to even have bigger effects on fall prevention. It is almost mandatory that exercise needs to be ongoing to have a lasting effect on fall rates. Therefore programs should offer ongoing exercise, or encourage people to undertake ongoing exercise at the end of a short-term formal program as recommended by the ACSM (A. King et al., 2019).

A study including 54 randomized controlled trials (Sherrington et al., 2011) indicates that the better options of exercise programs for preventing falls is those containing these three characteristics:

i) Exercises specific to challenge balance;
ii) High volume of exercise;
iii) Low volume of walking program.

These three characteristics combined resulted in a rate of falls reduction by 38%. On the other hand, the exercise programs that have included walking resulted in a rate of fall reduction by 21%. According to the authors, this "apparently" lower effect around walking programs, may be related to one or more of these indicators:

i) Elevated exposure to threats, contributing to increase fall risk with walking;

ii) The walking activity taking time away from exercises more indicated (balance training and/or strength training) and/or;

iii) Confounding results (as the walking programs were more frequently prescribed to high-risk populations-institutionalized elderly, the beneficial effects of exercise in this population are less marked, and progress slower, even a reduction in the speed of capacities degradation can be understood as an improvement).

However, while walking appears not to be an effective strategy for fall prevention, there are other benefits in walking for aged people (Kraus et al., 2019; Mendes et al., 2011). In general, it was suggest that walking training may be add into a fall prevention program as long it does not take the place of balance training for example, and people at higher risk should not do brisk walking programs due to the increased risk with this activity (Grue, Kirkevold, Mowinchel, & Ranhoff, 2009; Kraus et al., 2019; Rapp, Becker, Cameron, König, & Büchele, 2012; Wu & Lu, 2017).

Additionally, the use of dual task programs should also be encouraged, with different kinds of combination, such as memory task and gait training or balance exercise, balance/walking exercises and hand-eye coordination, tandem walk with cognitive tasks, counting backward when weightlifting, and balance itself can be considered a coordination task, since it involves ongoing postural adjustments in different moments and conditions (standing, sitting, walking to a new base of support, or seat) (Wang et al., 2018).

Also, research aimed at studying if older adults were able to learn a specific movement ("tuck-and-roll") which could reduce impact during a fall, when the participants were trained and performed, in a standardized way, sideway falls (Moon, Bishnoi, Sun, Shin, & Sosnoff, 2019). The results showed significant decrease in the hip impact force, showing preliminary evidence that this kind of training has potential effect in reducing the severity of an unpredictably fall in older adults, and could be included in specific programs.

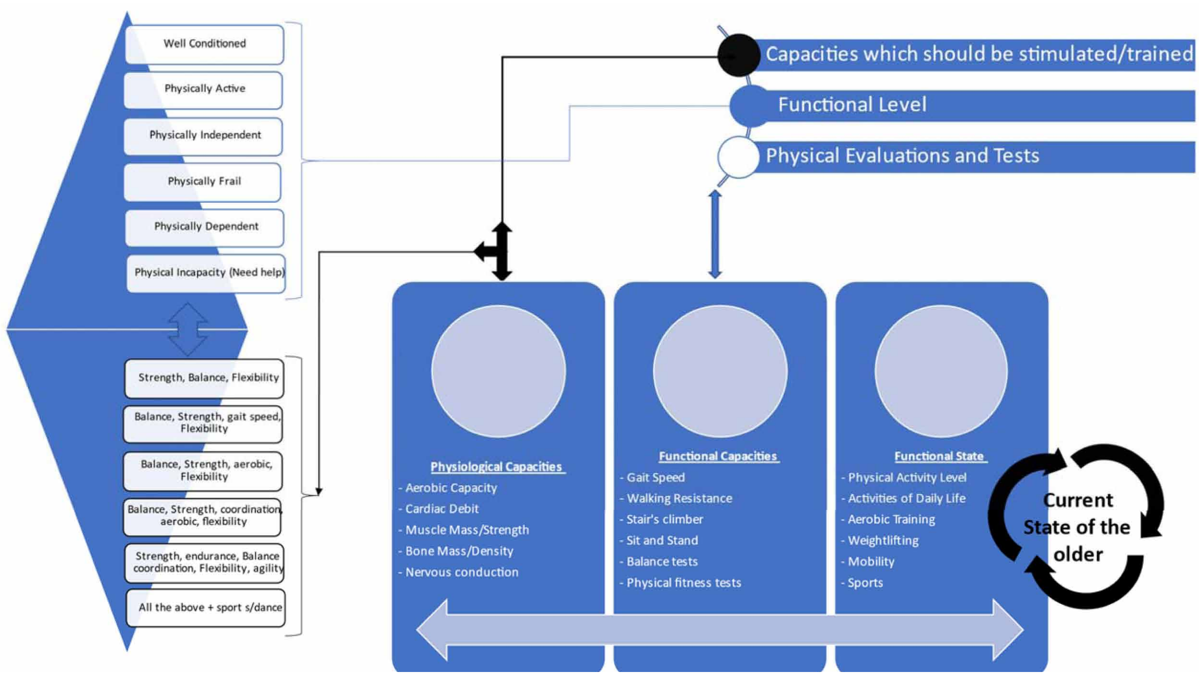
The exercise program also must include and respect the gradual approach to increase and increment the physical activity (types and time duration) over time (de Vries et al., 2012; Jakicic et al., 2019; A. King et al., 2019). Muscle strength training and weightlifting exercises are very important for older adults due to their specific role in preventing loss of muscle and bone mass overtime (de Vries et al., 2012; Jakicic et al., 2019; A. King et al., 2019). A significative number of studies (Chan et al., 2015; Ferreira, Ferreira, & Escobar, 2012; García-Molina et al., 2018; Padoin, Gonçalves, Comaru, & Silva, 2010; Pimentel & Scheicher, 2009; Ramalho et al., 2018; Sherrington et al., 2019) showed that exercise has important and consistent effects in reducing fall risk in older adult populations, mainly when prescribed at the very correct progression rate and intensity (Chou et al., 2012).

Besides some emphasis on the importance of balance and its training, the strength training is also gaining space/importance since strength capacities declines strongly after the age of 35-40 years (Blain et al., 2019; Cruz-Jentoft et al., 2010; Gielen et al., 2012), and impaired lower limb strength has been identified as an important fall risk factor (Menezes & Bachion, 2008; Ramalho et al., 2018). So, physical activities focusing on strengthening the lower limb muscle groups (Gillespie et al., 2012; Ramalho et al., 2018), muscles of the ankles, and feet (Spink et al., 2011) have been observed in successful fall prevention programs (Dipietro et al., 2019).

Moreover, the older adults who has some medical issues where therapeutic exercise should be performed in a specific manner to treat the condition, should engage in activities in a very specific way to prevent and reduce some of the risk involved, and the risk of developing any other diseases (Kraus et al., 2019).

In summary, exercise programs which focus on balance and strength activities, providing continuous exercise, are showing to be effective in preventing falls. Exercises targeting the muscles of ankles and feet are considered important components of a successful fall prevention program (Spink et al., 2011). Also, the exercise programs design should meet the needs (Graph 1) and abilities of the targeted population to provide exercises which are safe, motivational, and challenging.

Figure 1. Elderly Needs



The "functional state" is defined as the current state of the first evaluating moment, in summary, what he/she is capable in terms of training capability. This "functional state" is dependent on the "functional capacities", which is the capacity of to do/to perform daily life activities. This "capacities" being determined by their "physiological capacities", that is, the physiological capacity of nervous system transmission to muscle fibers, cardiac debit, muscle strength and proprioception.

Therefore, the "physiological capacity" determines the "functional capacity" that determines the "functional state", which is, the current state of the older person, so with correct physical evaluations and tests, addressing the correct functional level, we should be capable to recommend the most adequate kind of exercises to achieve the expected adaptation in the "physiological capacities", to improve de "functional capacities" and level-up the "functional state", keeping the circle working as good as possible.

In addition, some other activities such as aerobic classes, dancing, and specific sports have not been used in studies about fall prevention and its context, possible due to their difficulty, however as they are activities in which coordination, balance, and body control are required, they may be beneficial in maintaining balance and physical fitness status, but only for older people who are more able and active (at the top of the pyramids in Table 1), or middle age groups. For older people with poor physical status and postural control, these activities can be more dangerous, and increase fall risk (Gillespie et al., 2012; Tinetti, 2003).

CONSIDERATION FOR CLINICAL GROUPS

Most guidelines (de Souto Barreto et al., 2016; European Union, 2014; A. King et al., 2019) declare that is safe to (almost) all individuals (even sedentary ones) to start a moderate-intensity exercise program, and they have some assessment screening to know and clarify about any specific medical conditions and recommendations for older adults. However, they also state that if any older person wants to start a moderate physical exercise, and is apparently healthy, with no special condition to address, medical screening is not necessary, but is still recommended, and if the older one wants to start a vigorous physical exercise program, medical screening is strongly recommended.

On the other hand, older persons with some known disease (cardiac, pulmonary or metabolic) or any other factors which increase or influence the risk of adverse effects should undergo medical screening prior the beginning of any exercise programs. In addition, immediate cessation of physical exercise and a fast medical review is strongly recommended if they have any symptom or experience dizziness, chest pain, difficulty of breath (Dipietro et al., 2019). Taking that to account, the intensity of exercise should also be progressive with time, but in a much more tailored way, identifying individual tolerances, difficulties and preferences (Chodzko-Zajko et al., 2009; de Souto Barreto et al., 2016).

When prescribing exercise to people aged over 85 years, with or without any chronic disease, like functional limitation, Parkinson and previous stroke, for example, it is very important to be aware that they are at a substantially increased risk of falls (Erickson et al., 2019; A. King et al., 2019; Kraus et al., 2019). Meanwhile, the evidence about the potential to prevent falls using well-design exercise program even in high-risk populations is well established, taking only extra attention to safety, ensuring that exercise is well supervised by well-trained professionals (Albornos-Muñoz et al., 2018; Barnett, Smith, Lord, Williams, & Baumand, 2003).

However, further studies are still necessary to better explain the most correct approach to prevent falls in older persons in some of these special conditions, since the scientific evidence about this is limited (Dipietro et al., 2019; Hill et al., 2011; Pimentel & Scheicher, 2009). In the same way, exercise programs designed for cognitively impaired populations, and its relation to fall and fall risk outcomes are scarce. However, it is expected that these populations will benefit from carefully, specifically prescribed and well monitored exercise programs.

For older persons with other kinds of medical conditions, some extra precautions may be required to ensure safe and effective exercise participation. Elderly with asthma and/or hearth disease may need some medication (Kraus et al., 2019), the diabetics may require the use of additional carbohydrate before or even during exercise (Foscolou et al., 2019; Hsu et al., 2011), and all of this can have a direct or indirect effect on exercise execution.

Additionally, some guidelines (Bull et al., 2020; Dipietro et al., 2019; Jakicic et al., 2019) recommend extra attention, and the possibility of an extended period for a cool down activity, after physical exercise, to reduce the possibility syncope, hypotension, or even arrhythmias during the post-exercise period. The hydration status is also a concern since dehydration is more likely to occur in older persons (and some of them take diuretics to hypertension control, for example), so intake of mainly water is highly recommended, before, during and after exercise (Picetti et al., 2017; Scherer, Maroto-Sánchez, Palacios, & González-Gross, 2016).

PRACTICAL PROPOSAL AND TIPS

The programs should all be supervised by an exercise expert, since some studies have shown that older people who exercise without a professional supervision, have the same benefits as the ones who do not exercise (Steele et al., 2017). The program proposed below of structured exercises performed with a chair to help and ensure the safety of the participants, consists of a progressively increased intensity employing elastic bands in 7 to 10 exercises per session (Table 1). Intensity progression was fixed according to the OMNI table for bands progression (Colado et al., 2018).

These exercises and its progression (and periodization) were adjusted to the recommendations from the guidelines mentioned above. The intensity of the proposed program was indirectly calculated using the Karvonen's formula to predict target heart rate (HR), with HR_{max} being calculated using a speciðc formula for older populations (Target Heart Rate = (HR_{max}−resting HR) x %Intensity) + resting HR (Tanaka et al., 2001). During the exercise programs, to assess the internal load, cardiac frequency could be monitored with heart rate monitors and the rate of perceived exertion (RPE) with the Borg scale (Borg, 1982) for example.

The exercise program proposed here consisted of 3 to 4 session/week, with 7 to 10 exercise plus some level of aerobic and stretching exercising, of 2-3 sets of 10-20 repetitions, starting using only the body weight (just doing the movements) first, and goes on with a light intensity band during the adaptation period and progressed to 2-3 sets of 10-20 repetitions with a higher intensity elastic band for 2-3 weeks and increasing to 2-3 sets of 10-20 repetitions for another 2-3 weeks. Keeping this same system of progression for the following weeks, with the increase happening every 2-3 weeks, or, to the point that the supervisor believes it should happen. Finally, when the elastic band reach the green or blue colour (using Thera-band® colour-weight system), meaning they have been exercising for at least for 2 months, some extra exercises for balance (e.g. taking more time in the stand position than seated at the chair, stand in one foot, walking in a straight line, etc.), some free weights and shin guards could be added in, preferable in a circuit format, which will allow a more intense and diversified range of exercises. Some gym exercises, and specific classes like yoga or tai-chi, to increase the variety of exercises could also be added.

The exercise program dynamics consisted of performing muscle groups alternated, with the approximate cadence of 2 seconds concentric phase and 3 seconds' eccentric phase, and the frequency of 2-3 times week, in alternated days, to allow appropriate recovery. Also, the use of music can be helpful to help then to warm-up, do exercises, and cooldown in a better way (Ziv & Lidor, 2011).

The program could start using the simple sequence of doing some warm-up exercise for 5min, and exercise 1, 2, 4, 6, 7, 8 and 9, without the elastic band, using only the body weight, with 2 sets of 10-15 repetitions, with 30 seconds resting interval, for a week or two (3-6 training session), and in the following week, the same, with the first elastic band (yellow). The following increment could be to include exercise 3, during 1-2 weeks with the yellow band, and going on to the red one. In the next step, exercise 10 could be addressed, and in this 1st week, start with the yellow band, just to adapt, and go on to the red for another 2 weeks. In the following steps, using all 10 exercises proposed, starting with the red elastic band, 2 sets of 10-15 repetitions, being increased in the following week to 3 sets of 20 repetitions.

Table 1. Protocol of Multicomponent Exercise Program

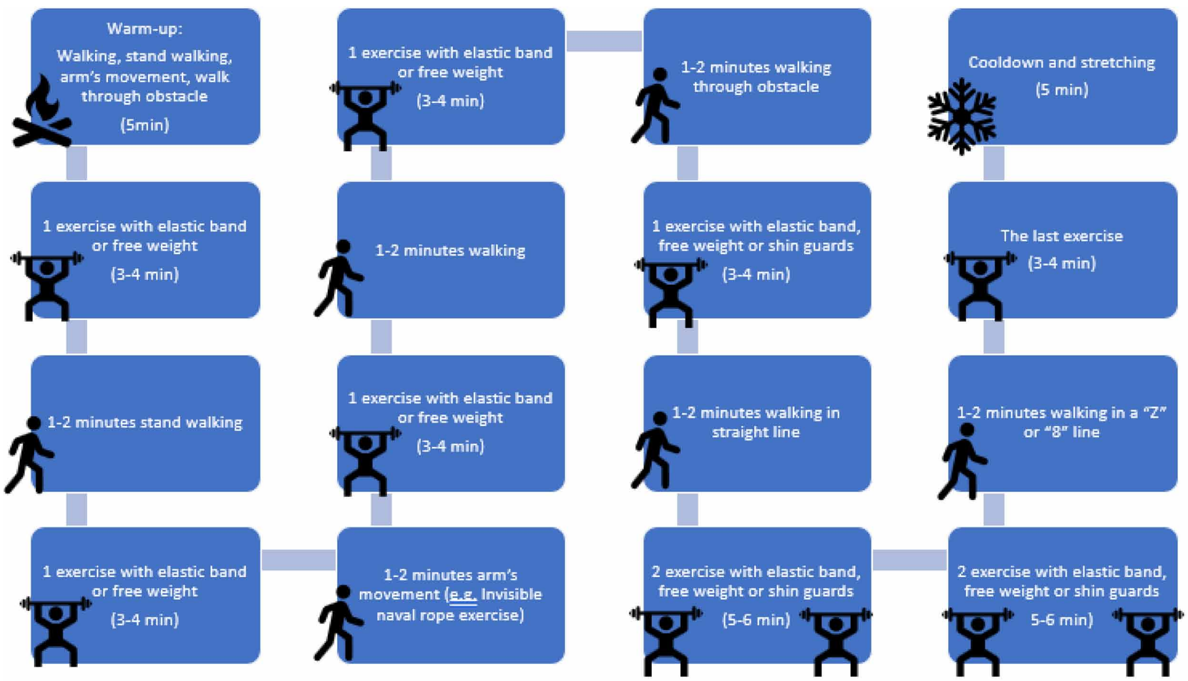
Warm-up 5-10 minutes PSE 4-6 Stand walking/Walking/Arm's movements					
Exercises (7-10)	**Sets**	**Repetitions**	**Cadence**	**Interval**	**PSE**
1. Front squat (with a chair for beginners)	2-3	10-20	1:2	30 seconds	4 to 7
2. Chair Bench over row (with flexion)	2-3	10-20	1:2	30 seconds	4 to 7
3. Chair unilateral hip flexion	2-3	10-20	1:2	30 seconds	4 to 7
4. Chest Press (stand and/or chair)	2-3	10-20	1:2	30 seconds	4 to 7
5. Bench over row unilateral (Stand)	2-3	10-20	1:2	30 seconds	4 to 7
6. Chair (or stand) frontal total raiser	2-3	10-20	1:2	30 seconds	4 to 7
7. Chair (or Stand) reverse fly	2-3	10-20	1:2	30 seconds	4 to 7
8. Shoulder Press/twist arm front position	2-3	10-20	1:2	30 seconds	4 to 7
9. Chair (or Stand) Biceps arm curl	2-3	10-20	1:2	30 seconds	4 to 7
10. Chair (or Stand) Overhead triceps extension	2-3	10-20	1:2	30 seconds	4 to 7
Cooling down 5-10 minutes PSE 1-3 Upper and Lower body's stretching (seated and/or standing)					

Table 2. Progression and Intensity of Elastic Bands (by color and weeks)

Week	Exercises	Elastic band/weighs/shin guards	Sets/Repetition
1 2	1, 2, 4, 6, 7, 8, 9 1, 2, 4, 6, 7, 8, 9	Body weight Body weight	2x 10-15 2x15-20
3 4 5	1, 2, 4, 6, 7, 8, 9 1, 2, 3, 4, 6, 7, 8, 9 1, 2, 3, 4, 6, 7, 8, 9	Yellow Yellow Yellow/Red	2x10-15 2x10-20 3x15-20
6 7 8 9	1, 2, 3, 4, 6, 7, 8, 9, 10 1, 2, 3, 4, 6, 7, 8, 9, 10 1, 2, 3, 4, 6, 7, 8, 9, 10 1, 2, 3, 4, 6, 7, 8, 9, 10	Yellow Red Red Red	2x10-15 2x10-15 2x10-20 3x15-20
10 11 12	All 10 All 10 All 10	Red Green Green	2x10-15 2x10-20 3x15-20
13 14 15	All 10 in a Circuit format All 10 in a Circuit format All 10 in a Circuit format	Red Green Green	2x10-20 3x10-15 3x15-20
16 17 18	All 10 + Circuit format + Free weight All 10 + Circuit format + Free weight All 10 + Circuit format + Free weight	Green Green + free weight (exercises 1, 5, 8) Green + free weight (exercises 1, 5, 8)	2x10-20 3x10-15 3x15-20
19 20 21	All 10 + Circuit format + Free weight All 10 + Circuit format + Free weight All 10 + Circuit format + Free weight	Green + free weight (exercises 1, 5, 6, 8, 10) Blue + free weight (exercises 1, 5, 6, 8, 10) Blue + free weight (exercises 1, 5, 6, 8, 10)	2x10-20 3x10-15 3x15-20
22 23 24	All above + Shin guards All above + Shin guards All above + Shin guards	Blue + free weight (ex. 1, 5, 8) + shin guards (ex. 3) Blue + free weight (ex. 1, 5, 6, 8, 10) +shin guards (ex. 3) Blue + free weight (ex. 1, 5, 6, 8, 10) +shin guards (ex. 3)	2x10-20 3x10-15 3x15-20

This system (Table 2) can go on for a long period of time, with some and different levels of increment in one of the three exercise categories (quantity and difficulty, color/intensity of elastic band, and the number of sets and repetition) each 1 to 2 weeks, and a general "level up" at each 3 to 4 weeks, which shows progression in an easy and safety way, which could (should) be adapted to the personal needs of the "participants" according to the examination of the professional in charge, who will be the one deciding the best way to progress during exercise sessions, as well in the circuit training example proposed (Figure 1).

Figure 2. Example of a Circuit Training



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FINAL CONSIDERATIONS

Since de first guidelines were published, significant scientific evidence has emerged and showed, in some details, the benefits of a variety of types of exercise (aerobic, strengthening, balance) and its combinations and/or composed activities (Tai Chi, Yoga, multicomponent exercise, HIIT, Dance, dual-task training) in physical functions (gait, balance, ADL, muscular strength, muscle mass) and fall-related injuries (Dipietro et al., 2019; Jakicic et al., 2019).

In spite of the benefits of physical exercise on health and physical function throughout life and during aging being well known, the proportion of older adults meeting the recommended levels of physical activity remains very low, being not above 27% in USA (Dipietro et al., 2019), 36% in Brazil (DATASUS, 2009) and 30% in Europe (WHO, 2018). Also, low levels of physical exercise usually walk side-by-side with chronic diseases, which have a big impact in physical function decline. Some evidence shows that a sedentary lifestyle is one of the strongest indicators of disability in older population, which will also increase fall risk and for consequentely mortality (Dipietro et al., 2019; Erickson et al., 2019; Jakicic et al., 2019)

In the opposite way, a more active lifestyle with regular physical activity/exercise, meeting the minimum recommendation of aerobic, strength training, and/or multicomponent exercise seems to have a very strong relationship with improved physical capacities and health in the elderly, as well in those suffering of some chronic disease, so, these kinds of activities may improve, or at least delay the processes of decreased mobility, frailty status, fall risk, and consequently the loss of independence during the aging process (Dipietro et al., 2019).

However, evidence on long-term exercise, aided by nutrition, is still scarce in this population. Supplementation of branched chain amino acids has been studied and used as an alternative to try to combat / alleviate the process of musculoskeletal degradation and may be an important agent in the control of falls in the elderly (Mitchell et al., 2012).

Thus, the role of adequate physical exercise programs in targeting these events must be highlighted, and fall prevention programs must be established with priority, including not only exercise programs (effective single prevention strategy), but also environmental modifications and multifactorial interventions(M. King et al., 2002).

In this perspective, appropriate interventions by health professionals are important in order to provide better conditions for a good quality of life and to prevent the increase of disabilities, which are the earliest causes of institutionalization, and one of the causes for an increased risk of fall, showing the need and importance of multifactorial interventions, which will be more effective than any single intervention (Cuevas-trisan, 2019).

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Chapter 8
Fall Prevention in Education and Training of Healthcare Students, Professionals, and Non-Professionals

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ABSTRACT

Falls are a significant and increasing threat to wellbeing and health of older adults in Finland. Education is a key factor to prevent falls. National recommendations have been published to guide the health care professionals' work in falls prevention. In addition, interprofessional collaboration between different organizations have been done to prevent falls. This collaboration has produced evidence-based falls risk assessment tools, falls prevention programs, and materials advising older adults to prevent falls. Healthcare and educational organizations use these methods and materials to educate professionals and students in the risk assessment and prevention of falls among older adults. Finland is a good example how healthcare professionals from different settings and universities have worked together to increase the knowledge about falls and skills to prevent falls. Good collaboration can prevent falls nationally.

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INTRODUCTION

Falls are a growing health challenge for older adults worldwide. Life expectancy is increasing globally (United Nations, Department of Economic and Social Affairs, Population Division, 2015). In rapidly aging Finland, the number and incidence of severe fall-related injuries and deaths has increased during the last four decades, only the incidence of hip fractures has shown declining trend (Korhonen, 2014). Among the oldest old, especially among older women, there is an increasing need of long-term care because of fall-related injuries (Ryynänen, Kivelä, Honkanen, Laippala & Soini, 1991; Halonen, Raitanen, Jämsen, Enroth & Jylhä, 2019).

Falls and falls prevention have a long research tradition in Finland. The first studies were about fall-related hip fractures from the beginning of 20th century (Faltin, 1924) continuing with intervention studies (Edgren et al 2019). Despite the increasing knowledge about falls, there are shortcomings in implementation and integration of falls prevention into clinical practice and care of older adults. However, in the recent years some major efforts have been done in Finland in spreading the evidence-based knowledge to enhance effective falls prevention.

In education, falls prevention is an important topic for several reasons. Falls are prevalent and a major public health concern (World Health Organization, 2007). At individual level, falls cause distress, fear, harm and disability (World Health Organization, 2007; Panel on Prevention of Falls in Older Persons, American Geriatrics Society and British Geriatrics Society, 2011; Vieira, Palmer, & Chaves, 2016). Furthermore, consequences of falls demand health care resources and cause direct and indirect costs to the society (Florence, Bergen, Atherly, Burns, Stevens, & Drake, 2018).

This chapter focuses on fall prevention aimed at older adults. The authors describe the development of falls prevention work and education in Finland. The chapter determine the role of educational, health care, research, administrative and non-profit organizations (NGOs) in falls prevention work. The authors present the work done in Finland to make falls prevention more consistent and systematic across the organizations and among the social and health care students and professionals.

Background

Research about falls in older adults has a long history in Finland. Academic theses and articles focusing on epidemiology and treatment of fall-related hip fractures were first published (Faltin, 1924; Solonen 1955; Nieminen, 1974; Kannus, Niemi, Parkkari & Sievänen, 2018), followed by epidemiology (Kurkipää, Vaalasti, & Peltokallio, 1959; Lönnroos et al., 2006), prognosis (Kivilaakso, 1956; Nieminen, 1974) and costs (Heikel & Österman, 1962; Nurmi, Narinen, Lüthje & Tanninen, 2003) of hip fractures. Studies on epidemiology and risk factors of falls have been conducted since the 1980s (Ryynänen, 1993; Luukinen, 1995).

Since the international evidence-based recommendations on falls prevention have been published (Guideline for the prevention of falls in older persons, 2001; Panel on Prevention of Falls in Older Persons, American Geriatrics Society and British Geriatrics Society in 2011), they have become widely recognized and utilized in the Finnish health care and education. The Finnish Association of Physiotherapists published an evidence-based physiotherapy recommendation on the prevention of falls and fall-related injuries first in 2011 and updated version in 2017 (The Finnish Association of Physiotherapists, 2017).

As a national level project, the systematic implementation of falls prevention has started in Finland. The knowledge on falls prevention strategies is increasing. Regional falls prevention networks have been established (The Regional Fall Prevention Network, n.d.), and programs for implementing falls prevention practices have been built and evaluated (Good Ageing in Lahti region; Ikihyvä, n.d.). This development has taken place during the past couple of decades. At the moment, the leadership and management play a key role in the long-term implementation of falls prevention practices. In addition, tools and practices on how to measure gains and effectiveness of falls prevention at population level are under development. In the field of education, the contents of fall prevention studies are clear.

A challenge is how to make teaching and learning attractive. For certain, health care professionals such as physicians, registered nurses, practical nurses, physiotherapist, occupational therapists and social workers, should be involved in falls prevention during their undergraduate studies. To reinforce learning and assure that practical learning periods confirm the importance of falls prevention, it is utmost important for all health care students to see, that falls prevention is a living and important issue at hospitals and health care centers, and in residential aged care facilities.

INCREASING THE EVIDENCE-BASED KNOWLEDGE ON FALLS PREVENTION

Guidelines and Fall Risk Assessment Tools for Health Care Professionals

To increase evidence-based knowledge and practices of falls prevention, Finnish Institute for Health and Welfare (THL) published Finnish national guideline on assessment and prevention of falls in 2006 (Mänty et al. 2006). The extended and updated version of the Guideline was published in 2012. (Pajala, 2012). The aim of the guideline was to unify practices and tools used in falls prevention work nationally. The guideline was targeted to professionals and students working with older adults. This guideline included the model to implement evidence-based falls prevention, called IKINÄ-model. The model is based on international guidelines (Panel on Prevention of Falls in Older Persons, American Geriatrics Society and British Geriatrics Society, 2011) and research evidence. It is enriched with practical instructions and tools for implementing falls prevention among community dwelling older adults as well as in residential aged care and hospital settings. Included are the tools to assess fall risk as well as several measures for further evaluating specific fall risk factors, such as physical performance and mobility, cognition, fear of falling, nutrition, medication use and depression. These tools are introduced in Table 1. Selection criteria in including these tools to guideline was their validity and usability in falls prevention work.

In Finland, TOIMIA Functioning Measures Database is the repository of the national and those international measures that have been translated in Finnish (TOIMIA, n.d.). Database provides also description and evaluation of the psychometric properties of each measure. Most of the measures presented in the falls prevention guideline have sound validity and reliability, and they can be found from the TOIMIA Database.

The UKK Institute for Health Promotion Research has developed and a validated self-rated fall risk assessment tool called KaatumisSeula (Karinkanta et al. 2019). This screening tool is intended primarily for non-professionals, such as exercise leaders, volunteers and NGO workers, who meet older adults elsewhere than in health care organizations. However, the screening tool is also in use among those health professionals who prefer self-assessment in their target group.

Table 1. Recommended tools for fall risk assessment and falls prevention in Finland

Assessment	Tools and tests	Available
Fall risk screening		
	FROP-Com Screen (Falls Risk for Older People)	http://urn.fi/URN:NBN:fi-fe201205085108
	FRAT, (Fall Risk Assessment Scale)	http://urn.fi/URN:NBN:fi-fe201205085108
	Comprehensive Fall Risk Assessment	http://urn.fi/URN:NBN:fi-fe201205085108
	KaatumisSeula self-rated fall risk assessment tool	www.kaatumisseula.fi, pdf-versions (digital version coming in Spring 2020)
Physical performance		
Balance & muscle strength	SPPB (Short Physical Performance Battery)	http://urn.fi/URN:NBN:fi-fe201205085108
Mobility & balance	TUG (Timed “Up and Go” Test)	http://urn.fi/URN:NBN:fi-fe201205085108
Balance	BBS (Berg Balance Scale)	https://www.terveysportti.fi/dtk/tmi/tmm00154
Self-rated balance	ABC (The Activities-Specific Balance Confidence Scale)	http://urn.fi/URN:NBN:fi-fe201205085108
Cognition and mood		
Cognition	MMSE (Mini Mental State Examination)	http://urn.fi/URN:NBN:fi-fe201205085108
Depression	GDS-15 (Geriatric Depression Scale)	http://urn.fi/URN:NBN:fi-fe201205085108
Fear of falling	FES-I-FIN (Falls Efficacy Scale International Finnish Version)	www.ukkinstituutti.fi/ammattilaisille/testaaminen/kaatumispelkokysely
Nutrition		
	MNA (Mini Nutritional Assessment)	http://urn.fi/URN:NBN:fi-fe201205085108
	NRS-2002	http://urn.fi/URN:NBN:fi-fe201205085108
Alcohol consumption		
	AUDIT-C (Alcohol Use Disorders Identification Test)	http://urn.fi/URN:NBN:fi-fe201205085108
Environmental hazards		
	Environmental checklist for fall prevention	http://urn.fi/URN:NBN:fi-fe201205085108

Clinical Practice Tools for Falls Prevention

Good guiding materials help health care professionals to implement falls prevention. Guidebook for Implementation of falls prevention of older adults published by THL includes a set of tools, which are useful when starting implementation and evaluating the process. These are for example registering the falls, determination of fall incidence, staff knowledge level about falls prevention in the beginning of the process and how to monitor progress throughout the process. Along with Guidebook of Falls Prevention THL produced fact-sheets for different health professional groups to aid their work to implement falls prevention. These include separate fact-sheets for medical doctors, registered nurses, leaders and managers. In addition, fact-sheets for clients and their families are available.

The UKK Institute has published the following materials for falls prevention: Exercise Guide, Checklist of Risk Factors for Falls which You Can Influence, and Ten Ways to Prevent Falls. These materials can be used independently or alongside with KaatumisSeula Self-rated Fall Risk Assessment. Materials are freely available in Finnish, Swedish and English (The UKK Institute for Health Promotion Research n.d.). The Regional Fall Prevention Network (RFPNetwork) has also published a guide Stay Up! Information about fall prevention for you and your loved ones. This guide is intended for clients and is also useful for professionals and students. (The Regional Fall Prevention Network, n.d.) All of the above tools are introduced in Table 2.

Table 2. Recommended tools for implementation of falls prevention in Finland

Target groups	Tools	Available
Professionals and health care students		
	Guidebook for Implementation of falls prevention	http://urn.fi/URN:NBN:fi-fe201205085108
	Falls Prevention fact-sheets	https://thl.fi/web/hyvinvoinnin-ja-terveyden-edistamisen-johtaminen/turvallisuuden-edistaminen/tapaturmien-ehkaisy/ikaantyneiden-tapaturmat/kaatumisten-ehkaisy/kaatumisvaaran-arviointi_
Older adults		
	Safety years for older adults -guide	https://www.kotitapaturma.fi/en/
	Safe times with memory disabilities – a guide for families	https://www.muistiturku.fi/media/filer_public/20/cf/20cf9e4e-7b85-46be-9449-a6b3031ce160/turvallisia_vuosia_muistiperheille.pdf
	Exercise Guide, Checklist of Risk Factors for Falls and Ten Ways to Prevent Falls materials	www.kaatumisseula.fi
	Stay Up –guide	www.psshp.fi/rfpnetwork_

EDUCATION IN FALLS PREVENTION IN FINLAND

Health Care Professionals' Undergraduate Education

In education of health care students, falls are an excellent topic to teach the concept of comprehensive geriatric assessment (Pilotto & Finbarr, 2018) and interprofessional teamwork. In Finland, falls prevention ought to be a core content in the health care students' curricula. Right timing is also important. For example, in the curriculum of registered nurses', the last third of the studies showed to be optimal for the falls prevention education. In this study phase, the students are able to integrate theory and practical skills and manage multifactorial and multidimensional health risks such as falls in older adults. (Äijö 2019.)

As a learning content falls prevention is broad. First, it is important for health care students to notice the impact of falls at individual, health care organization and societal levels. The second step is how to identify older adults at risk of falling. Health care students must learn to ask about falls. All older adults who are under the care of health care professional should be asked about falls at least once a year (Panel on Prevention of Falls in Older Persons, American Geriatrics Society and British Geriatrics Society, 2011). Those who report single fall should have gait and balance evaluation, for example with Timed Up and go Test. Those demonstrating difficulty or unsteadiness require further assessment. All high-risk groups such as older adults who present for medical attention because of a fall, report recurrent falls, or have gait and / or balance problems should be directed to comprehensive assessment. Third, knowing the screening tools, such as FRAT and FROP-Com, and learn to use them is part of the fall prevention studies. Screening tools are also a method to guide students to understand intrinsic and extrinsic risk factors of falls (Vieira, Palmer, & Chaves, 2016).

Forth, it is essential for students to see in practice how comprehensive fall risk assessment is done, and after that how the care and rehabilitation plan is developed and implemented. The multiprofessional falls clinics are best places to learn these skills. Unfortunately, these kinds of clinics are still few in Finland. Assessing older adults' risk of falls in different environments such as outdoors, at home, in residential care facilities and hospitals, should be an advanced step in falls prevention studies.

Fifth, the students need to know evidence-based falls risk prevention methods. It is utmost important for students to see these methods and programs in action during their clinical practices in health care. Last but not least, students need to know their own role and responsibility as health care professionals and as members of the interprofessional falls prevention teams. Ethical issues are always present when students or health care professionals are working with older adults at increased risk of falling. The major concern is if a professional or student does not understand or ignores the risks of falling and consequences of falls.

All health care students have to learn how to identify persons at increased risk of falling, and what are the steps following the identification. For example, physiotherapy and nurse students need to recognize when the patient needs assistive devises or when it is important to do environmental assessment to reduce the risk of falls. Respectively, medical students need to be able to evaluate the role of patient's health status, chronic conditions and medication with regard to risk of falls. Nearly all patients' at increased risk of falls benefit from physical exercise to prevent future falls.

Evidence based knowledge form the solid basis for teaching and learning falls prevention. In addition to presenting sound theory, active and new teaching methods should be applied. Modern learning environments such as simulation and skills labs promote students integrative learning by serving experiences how to combine theoretical knowledge, practical skills and interdisciplinary team working. Interactive skills such as how to interview, counsel and advise older adults are important in falls prevention, as are also the skills how to use different falls prevention assessment tools. There should be opportunities to practice these skills at vocational education institutions, universities and in clinical practice (Äijö, 2019).

Health Care Professionals' Continuing Education

In Finland, specialized medical care hospitals are responsible to organize training courses for the staff in their region. Because of that obligation, Kuopio University Hospital (KUH) and RFPNetwork has organized several courses, videos, and information days in fall prevention. For example, KUH together with Kuopio´s education organizations have made a video "Why Lempi falled". An educational version of this video will be made during spring 2020. It can be used as an education material for both professionals and students. This will support consistent falls prevention practices, procedures and guidelines.

KUH is piloting evidence-based Fall T.I.P.S. –model (Dykes, et al., 2017; Dykes, et al., 2019) to prevent falls in acute care hospital. The pilot started in December 2019 and will be implemented to all inpatient wards before the end of 2020. The pilot contains education for professionals and collaboration with educational organizations and students. In continuing education, national web-based courses and materials have been used to increase the knowledge and skills of health care professionals (The Finnish Medical Society Duodecim n.d.). In addition, KUH has developed game-based education, using the escape room idea, to learn serious topics in a fun way (Niiranen 2019).

The UKK Institute offers knowledge and education for health care professionals nationally. A web-based education program concerning different aspects of falls prevention has started recently. Web-based education allows equal participation from all regions of the country and is available without time limitation. Education is free of charge, but registration is needed since the course is offered as a part of falls prevention implementation project. This project, funded by the Finnish ministry of social affairs and health, also enables to further development of kaatumisseula.fi website. In the future, targeted information is available for health professionals, NGOs and older adults and their relatives. Based on large research and development, the UKK Institute has a long history of educating health professionals in falls prevention among older adults.

The Finnish Medical Society Duodecim (n.d.) produced on-line training package for falls prevention in 2015. This package is available through Oppiportti learning portal. Duodecim provides also many other on-line learning modules which are useful in recognizing and treating risk factors of falls. The National Current Care Guidelines produced by Duodecim cover important issues related to falls prevention, for example, physical activity and exercise training for adults in sickness and in health, hip fracture, osteoporosis and hypertension.

FALLS PREVENTION IMPLEMENTATION EXAMPLES FROM FINLAND

IKINÄ Model

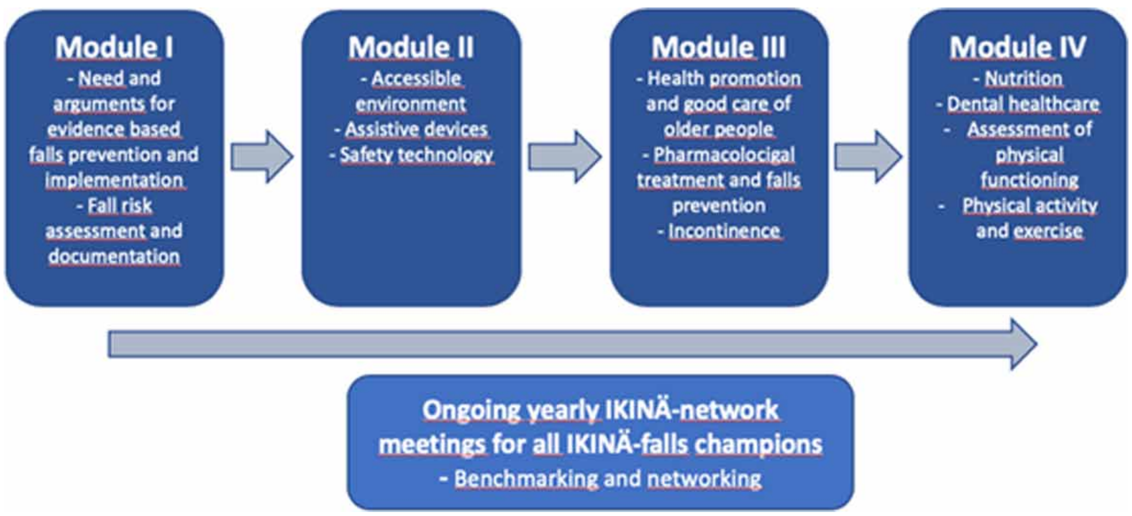
Widespread and systematic falls prevention remains insufficient despite extensive knowledge on the issue. In 2014, the Joint Authority for Päijät-Häme Social and Health Care in Finland made the decision to begin the project to enhance implementation of falls prevention. Reduction of falls and fall injuries was set into one of the organizations strategic goals. Implementation project targeted over 7000 social and healthcare professionals.

The IKINÄ-model, based on AGS/BGS Clinical Practice Guideline, was chosen as a framework for the implementation and developing local falls prevention practices. The emphasis was on organized and systematic multi-professional fall risk assessment, risk-assessment-based planning and execution of necessary interventions. Implementation initiates always with analysis of falls, practices of recording the falls and skills and competence of the health care staff.

Since 2014, one or two staff members of each nursing home units, home care and acute/rehabilitation wards (altogether 300 staff members) have undergone training of falls prevention and implementation champions. The basic training program consist of four modules, which include evidence-based knowledge on risk and prevention of falls together with practical tools for local implementation (Figure 1). In addition, each fall champion attends yearly one-day further training event. Each staff member at the care unit is entitled to take web-based course of falls prevention, provided by The Finnish Medical Society Duodecim (n.d.). Furthermore, the head of each unit have taken part of the training program and they are liable for deployment of implementation in co-operation with the staff. Practices and scales for systematic fall risk factor assessment using FRAT and Resident Assessment Instrument (RAI) have been put into operation.

Up until the autumn 2019, systematic fall risk assessment has become a fixed procedure at the region. Documentation of falls, risk factors, patient safety incident reporting and preventive work has improved. Physical activity and exercise are included in standard everyday program in care units. Beyond major improvements in falls prevention practices, the most important achievements of implementation so far are the ideas of ongoing process, continuous improvement and falls prevention being a permanent part of daily work of social and healthcare staff.

Figure 1. Falls champion training program in Päijät-Häme region in Finland



KaatumisSeula® Model

The UKK Institute has implemented falls prevention work from the perspectives of research and evidence-based operational models and practices. Actors have been educated and tools developed to support falls prevention work. In addition to social and health care professionals, other actors such as physical education instructors and NGO actors have been involved in falls prevention work.

Volunteers and NGOs meet a large number of older adults in their activities – also those who are not visiting healthcare regularly. Therefore, resources of the NGOs should be utilized in falls prevention. The main goal of KaatumisSeula® project (2014-2016) was to create local operational models for fall risk screening and implementing evidence-based preventive measures. The models were based on co-operation between health care sector and NGOs, and local circumstances and resources were taken into consideration. The main action ideas were to offer risk screening largely and to put in action individually tailored preventive measures based on the screening.

Especially NGOs implemented the use of self-rated fall risk screening tool developed in the project (KaatumisSeula Fall Risk Assessment, see Table 2). Based on preliminary risk screening, people at high risk of falls were referred to comprehensive assessment conducted by educated health care professionals.

As the result of comprehensive assessment, tailored preventive measures were defined and implemeted. This approach is based on the multifactorial Chaos Falls Clinic Study (Palvanen, et al., 2014).

NGOs played a central role in not only screening but also informing about fall prevention measures and offering accessible balance and strength training for those with low risk. Exercise, especially balance and strength training, has been found to be the most effective single intervention in fall prevention, and therefore is the most important preventive measure in terms of primary prevention.

As a result of the project NGOs were found to be very active and keen in their role. Targeted educational material and self-rated fall risk screening tool produced in the project made it possible for NGOs to start fall risk screening and informing of preventive measures as part of their normal activities, such as in social meetings and events. At the moment, the UKK Institute is implementing both KaatumisSeula® and IKINÄ (developed by THL) models nationally to enhance multifaceted use of evidence-based fall prevention practices.

The Regional Fall Prevention Network

Kuopio University Hospital constantly develops methods to better meet the needs of patients and population. Care and rehabilitation are developed in co-operation with the clients considering the quality and safety aspects and clients' self-care and agency. The Regional Fall Prevention Network (RFPNetwork) established in 2012 is part of this development project. It is an open, interprofessional group with the aim of promoting falls prevention and fall-related accidents in the Kuopio University Hospital District by supporting the implementation of evidence-based and consistent falls prevention practices. The main objective is that the number of accidental falls and fall-related injuries will not increase in the area but rather turns to decline. (Tervo-Heikkinen, Äijö & Holopainen 2016; The Regional Fall Prevention Network n.d.) RFPNetwork member organizations represent different kinds of hospitals, health centers, nursing homes, homecare or educational organizations, altogether 15 organizations and groups of organizations in the area. The network has also nonprofessional members. (Figure 2.)

Network supports evidence-based falls prevention work and education by searching and producing consistent practices and guidelines. For example, the Stay Up! -guide (The Regional Fall Prevention Network, n.d., Figure 3) was developed to support the counseling or older adults. Another example is a pocket card list of fall risk increasing drugs compiled by pharmacists members of the network. The list helps health care professionals to identify medication-related fall risks and, if necessary, request a complete medication review for their clients.

CONCLUSION

Much has been done at regional and organizational levels to prevent falls among older adults in Finland. However, national level co-ordination is crucial to ensure that evidence-based practices are in use all over the country and development work will continue utilizing the results of newest and most relevant research. In addition, good leadership in practical level is needed to support and follow the results of falls prevention work. Falls prevention champions could play a key role in ensuring quality and continuity of falls prevention work in practice.

Figure 2. The RFPNetwork covers the entire area of the Kuopio University Hospital District i.e. nearly 20% of the Finnish population (The Base map @ Maanmittauslaitos, 2020)

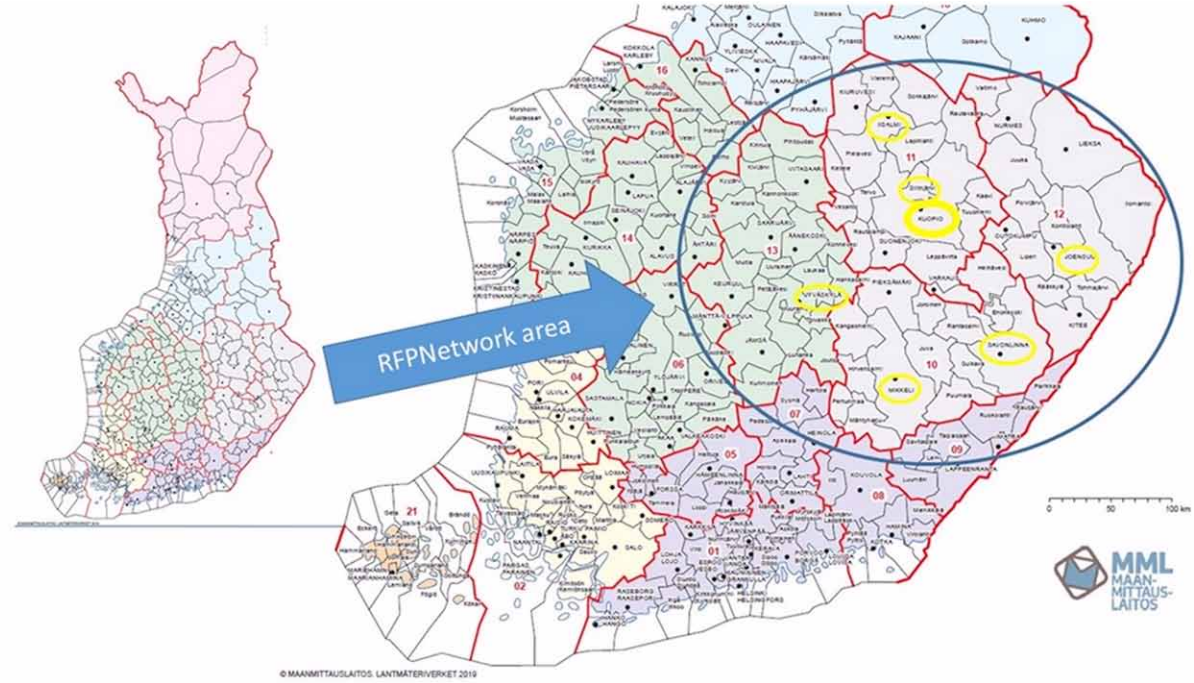
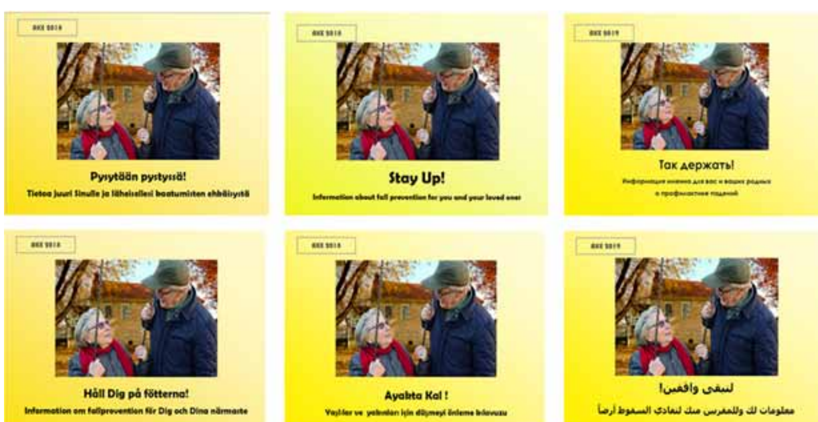


Figure 3. The Stay Up - Information is available in Finnish, Swedish, English, Russian, Turkish and Arabic



Future projects are for instance the national 'Terveyskylä' House for Falls Prevention webpage and the UKK institute's (n.d.) webpage for falls prevention. A national goal and policy implementation program on prevention of home and leisure time accidents promotes the central goals of falls prevention and easy access to core information. Instructions and recommendations in falls prevention should be up-to-date and in line with the new research evidence. Technology, for example in-house and wearable sensors, may provide new options and possibilities for falls prevention work among older adults. This methods should be part of the educational contents as well.

A well-functioning co-operation and interaction between educational and different health and social care organizations is of vital importance in falls prevention education. Network-based and work life oriented co-operation promotes the education of skilled future professionals.

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Chapter 9
Fall Prevention Education:
Good Examples From Higher Education

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ABSTRACT

Current demographic development requires appropriate care (informal/formal) for falls prevention in the growing older population across different settings as well as in the community. The development of new knowledge and research must be echoed in education and training of healthcare staff and also in the society. There is an urgent need to develop an interdisciplinary and interprofessional Master of Gerontology ("Master of Active and Healthy Aging"), which brings together research and practice. The innovative character of the program should be highlighted by the holistic perspective, incorporating courses in medical, nursing, rehabilitation, social, behavioral, psychological, economic, physiological, and management service aspects related to aging. A strong focus should be on active aging as well as the empowerment of self-care and (care) independency leading to falls prevention. In fall prevention work, new educational structures to teach and develop the workways across the Europe is needed.

INTRODUCTION

Ageing is a human phenomenon that is occurring globally. In Europe, 13% of the population is aged 65 or more but in 2030, it is expected to be almost doubled to 24% (European Stakeholders Alliance for Active Ageing through Falls Prevention, 2015). This means that the average life expectancy is increasing - largely attributed to the development of medical and technological advances - but so are the challenges in geriatric care such as medical aspects of care, rehabilitation, nursing, psychology, sociology, pharmacy,

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social aspects, amongst others. According to epidemiological data, about 28-35% of people aged 65 or more fall each year and over 70 years of age, this increases to 32-42% (WHO, 2007). This indicates that falls in older people must be addressed by health care professionals both in acute and chronic care setting.

Falls are considered as alarming adverse event due their consequences such as lacerations, bruises, loss of function, hip and/or skulls fractures or even death. In addition, WHO (2018) classified falls as the second highest cause of accidental injuries in older persons, and highlighted that programs to avoid falls and research in underlying causes of falls should be prioritized. Falls are adverse events that affect not only older people physically but also psychologically and socially. Consequently, falls and falls-related injuries are common problems of Public Health as they are associated with high morbidity and mortality in older persons. Besides these aspects, falls and fall-related injuries increase costs in residential homes, nursing homes, public health services, hospitals and to old people that fall at home but have no health insurance. Therefore, it is relevant to contribute for patient safety by preventing falls in old people. Aspects related to causes of falls and how to prevent them should be taught at universities and higher education institutes. How exactly such education should be provided to the students could be particularly challenging to the teachers of such programs.

Most of the falls are preventable. Therefore, health care professionals such as medical doctors, nurses and physiotherapists can play important roles towards the prevention of falls. Their knowledge and skills to evaluate a patient´s overall health status and the risk of falls is vital and highlights the relevance of working as a team to prevent falls. This can potentially constitute a challenge to many educators, who are often used to work individually. For proper training of health professionals working in geriatrics, universities and universities of applied sciences must come together and develop joint aging related curricula. Inter-professional teachers should educate students as a team when teaching aspects such as falls and how to prevent them. As falls are multifactorial in etiology, the knowhow from different professions is needed. In addition, the health care professional´s skills to advise patients to decrease their falls risk are important. In many cases we need different kind of interventions involving different expertises of health care professionals. Unsurprisingly, what constitutes optimal fall prevention intervention and how to organize multi-professionals to work together, is a challenge. Similarly, another challenging point is teaching falls prevention to health care students in an effective way thus enabling them to educate old persons properly, implement accurate measures to prevent falls and to develop research in this field.

This chapter describes education, in a broad sense, related to falls, falls-related injuries and risk of falls, with particular focus on falls prevention as developed within the European Innovative Partnership Active and Healthy Aging (EIP- AHA), as related to mitigation, recovery, care, and prevention of further falls (that is, in situations after falls, not just in situations leading to injuries). This includes the development of an innovative, dynamic and sustainable geriatric care system for AHA via capacity building using senior/patient-centered, multidisciplinary and inter-professional educational programs aimed at patients, patient caregivers (both formal and informal), health and social workers, administrators, entrepreneurs and other key stakeholders. The chapter will provide insights into some typical national education programs from some European countries, and provide some comparisons between these programs and, finally discuss the need of harmonization in geriatric care education across Europe. The chapter reflects ongoing work and collaboration between partners within EIP on AHA, especially in the field of education, teaching and learning. In addition, this chapter discusses falls prevention as a part of curricular related to patient’s safety. Evidence-based knowledge and interventions should be included in the list of topics that are taught in such curricula. Finally, this chapter describes the main teaching topics and teaching methods across Finland, Austria and some other EU countries.

Background

A fall is defined as "*inadvertently coming to rest on the ground, floor or other lower level, excluding intentional change in position to rest in furniture, wall or other objects*" (WHO 2007, p.2). The etiology of falls is multifactorial and could be attributed to the following types of causes: *intrinsic* (due mainly to medical conditions) and *extrinsic* (largely arising due to environmental factors) Intrinsic factors, are related to physical and psychological state of the person, (e.g. lack of vision and/or hearing, reaction time, musculoskeletal disorders, vestibular, proprioceptive and musculoskeletal disorders, gait, prolonged sedentary state, among others); to diseases (e.g. cardiovascular, neurologic, osteoarticular, genitourinary, among others) and to drugs (e.g. those that lead to diminishing of motor functions, dizziness, hypotension, weakness, confusion and bed confinement). Extrinsic factors are related mainly to environmental situations (e.g. inadequate lighting, presence of obstacles, slippery surfaces, absence of handrails, among others) (Saraiva, 2008). In addition, Montero-Odasso (2018) highlights the importance of cognitive impairments such as lack of attention that compromises postural and gait stability and executive functions such as impairment of attention, inhibitory control, work memory and cognitive flexibility thus leading to falls. All these aspects must also take into consideration that older adults with falls show decreases in mobility and become more bed confined due to further functional impairment associated with bedrest *per se* and fear of further falls. This vicious cycle is associated with high risk of falls, increased morbidity and mortality.

Current demographic development in Europe requires appropriate informal and formal care for falls prevention in the growing older population across different settings as well as in the community. The development of new knowledge and research must be echoed in education and training of health care students and professionals in the society (Lowenstein, 2005). Falls are considered a multifactorial problem and therefore multi-professionals must be involved and working as a team in order to prevent falls by contributing to patient safety. Aspects such as interprofessional education (IPE) become particularly important. Interprofessional education in health content can be defined as follows: *"Interprofessional education occurs when two or more professions learn about, from and with each other to enable effective collaboration and improve health outcomes."* (Zwarenstein, Atkins, Barr, Hammick, Koppel, & Reeves, 1999; WHO 2010). In addition, Buring, Bhushan, Broeseker, Conway, Duncan-Hewitt, Hansen & Westberg (2009) define it as follows:

Interprofessional education involves educators and learners from 2 or more health professions and their foundational disciplines who jointly create and foster a collaborative learning environment. The goal of these efforts is to develop knowledge, skills and attitudes that result in interprofessional team behaviors and competence. Ideally, interprofessional education is incorporated throughout the entire curriculum in a vertically and horizontally integrated fashion.

Interprofessional education is not a new idea. The need for IPE has been identified since the 1987 in the United Kingdom (Center for Advancement of Interprofessional Education (CAIPE), 2008) and later spread globally to different countries and different educational fields such as medicine, nursing and rehabilitation (Sander, Schmidt, Rehkämper, Lögters, Zilkens, & Schneider, 2016; Riskiyanaa, Claramitab & Rahayub, 2018), psychology (Ward, Zagoloff, Rieck, & Robiner, 2018), dentistry (Coleman, Finn, & Nattress, 2018) and pharmacy (Buring et al. 2009). Additionally, different kind of network groups have also been established (e.g. European Interprofessional Education Network, Helme 2009).

Recently published meta-analysis shows that the IPE program has a positive impact - and effectiveness of educational intervention - in various disciplines of healthcare. However, more research is needed to identify the effects of IPE program on students' clinical competence (Guraya, & Barr, 2018). There is also a need to develop an interdisciplinary and interprofessional educational program around the world and different professional areas (Riskiyanaa, Claramitab & Rahayub, 2018; Topperzer, Hoffmann, Roug, Larsen, Lausen, Schmiegelow & Sørensen, 2019) and for tackling the issue of falls and falls-related injuries, especially in older persons.

From an educational perspective, it is important to educate geriatric health care students to know how to carry out work related to falls prevention. The global curriculum, courses and contents related to falls prevention should be included in interprofessional pedagogical development work. When the falls prevention knowledge is in the curriculum and the teachers discuss it in a context with the students during the courses, the students learn to do falls prevention work and student learn to work interprofessionally and will get experiences what it means to be a one member of interprofessional team.

One example of such a courses is Master of Gerontology („Master of Active and Healthy Aging"). As teamwork is particularly important in older persons care, the Master program should emphasize IPE and learning (Banks, & Janke, 1998). This is important as, currently, there is a lack of targeted educational structure concerning the falls prevention across Europe comparable to those in the United States and Canada.

ACTION ON INTERPROFESSIONAL EDUCATION AND COLLABORATION IN FALLS PREVENTION

Interprofessional Education (IPE)

To accomplish proper education related to falls and falls prevention, health care professionals should come together and discuss the best way to teach students, caregivers and older persons. Firstly, health care professional students should engage in IPE program, which requires that "*….two or more professions learn about, from and with each other to enable effective collaboration and improve health outcomes*" (World Health Organization (2010, p. 13). This form of education is different from the traditional one, where health care programs are more strict and rigid and the disciplines are administered in close modules leading to memorization -rather than understanding - of the content. On the other hand, IPE programs are more flexible and engage encouragement of students from different professions (Sullivan, Charrette, Massey, et al. 2018) as well as allow collaboration with other and with different expertise. McKenzie, Lasater, Delander, Neal, Morgove, and Eckstrom (2017, p. 232) referred that scientific papers concerning IPE "*have linked positive outcomes in health care to evidence-based (EB) interprofessional (IP) collaborative practice*". Such collaborative practices are the most promising forms of activities for solving different problems in clinical practice as they involve the interactions of several professions to achieve patient –centered care, and contribute towards patient safety.

In Portugal, for example, it is currently challenging to get inter-professional students to learn about falls from different professions and perspectives. However, incorporating IPE in educational curricula in the future, could lead to improvements in falls prevention in older persons. It has to be initiated at schools in an inter-professional curriculum, where physiotherapists, physicians, nurses, pharmacists and others could come together and develop a falls-based curriculum for students from different educational and professional backgrounds. In order, to engage different students' in theory, evidence-based lectures or workshops could be a good approach followed by problem solving based on problem based learning (PBL) methodology. PBL is an active pedagogic methodology used for students to interact with each other and it helps in development of critical, analytical and reflective thinking competences; all these are aspects needed for students from different care professionals (Abreu, & Loureiro, 2007). After training, for example, in simulation classes, students are more prepared to go engage in practice and teach older persons about falls prevention, usually under a teacher's supervision. Once the older people get the falls prevention knowledge, they can engage in educating other seniors. Peer education is highly profitable as older persons can share their falls knowledge, values related to geriatric health and active and healthy aging behaviors with each other (Vernon, 2010).

We outline here a typical example of a Master ("Active and Healthy Aging") that can be used to promote falls education for all potential stakeholders involved in falls prevention initiatives.

Master of Active and Healthy Aging

The development of a distinctive Master of Gerontology should encompass inter-disciplinary, interprofessional research based/ research-oriented education. It should have a flexible and modular structure to fulfil the needs of a heterogeneous student group as well as to upgrade the level of knowledge related to prevention and management of falls of different professionals. A further aim of the Master program is to bring together research and practice.

The innovative character of the program should be highlighted by the holistic perspective, incorporating courses in medical, nursing, rehabilitation, social, behavioral, psychological, economic, physiological, management service aspects related to aging. A strong focus should be on active aging as well as the empowerment of self-care and (care) independency leading to falls prevention. It could also focus on the link between universities and communities and other institutions for older persons; to achieve this it is important to understand the knowledge and competencies of each other's professions. The program must be flexible in its nature and should be potentially changeable based on feedback and evaluation - as well as the needs - of the participants of the Master program.

An important aspect to consider in the education of gerontology and geriatrics it the need to build a knowledge base. This fundamental base, should incorporate a systematic literature review, including for example, the Cochrane Handbook for Systematic Reviews of Interventions, focused on community-dwelling persons aged 65 years or older with frailty or pre-frailty. The following aspects should be included:

- Diagnostic criteria, methods of identification, and prevalence of falls
- Predictors and/or prognostic factors (modifiable risks) of falls
- Patient profiles, treatment and rehabilitation pathway of falls
- Burden of the condition on patients and the role of caregivers in fall prevention

The creation of a Master could be performed as a co-operative group activity of experts in the medical field as well as experienced and qualified educators in the field of higher education and social gerontology. Detailed components as proposed by Billings and Halstead (2005) could be followed when designing the master program.

Pedagogical Development Work in Falls Prevention

To develop a new master degree programme based on the IPE idea, pedagogical aspect need to develop too. Health care students and professionals need more education, new knowledge and skills to tackle aspects related to falls among older adults. To support health care professionals work, many countries have clinical practice guidelines for fall risk screening, assessment and management included in standardized fall prevention tools (Panels on Prevention of Falls in Older Persons, 2011; Falls in Older People: Assessing Risk and Prevention, 2013; Boushon et al., 2012). Multifaceted and tailored strategies have been shown to be successful ways to improve health care professionals´ competence in fall prevention, which, in turn, have been shown to lead to decreases in older adults' risk of falls (Breimaier, Halfens, & Lohrmann, 2015; Goodwin, Abbott, Whear, Bethel, Ukoumunne, Thompson-Coon, & Stein, 2014; Stubbs, Brefka, & Denkinger, 2015). In addition, falls prevention is one significant part of patient safety and effective care work with older adults at the workplace (Reeves, 2016). Based on the development work from the work field, in health care education, students could learn evidence-based practices in fall prevention. During the studies, students need to gain theoretical and practical understanding of what falls prevention is. Theoretically, the students need to understand fall related intrinsic and extrinsic risk factors (Dionyssiotis, 2012; Guidelines for the Prevention of Falls in Older Persons 2001). In addition, the teaching perspective could be broader using the World Health Organization's (2007) risk factors model in which are included four risk factors groups; behavioral, environmental, biological and socioeconomic. It is important that students learn about the availability of screening tools and how these tools are used in working life at the local, national and global level. After the theoretical understanding, students need to strengthen their learning in practical aspects. Interactive learning methods such as simulation-based learning, support student's practical skills learning. It helps students to integrate theoretical knowledge with the practical skills. For example, how to carry out fall risk assessment using screening tools, how to evaluate the results and how to use the results for guidance. In addition, interactive learning methods are key features of IPE (Reeves, 2016).

Excellent learning places for learning falls prevention are clinical practice rounds/ postings. This is an important place for the students where their learning experience from the higher education meet the practices from the clinical practice perspective. In different work places such as in hospitals or in home care, different methods and working procedures to prevent falls exist. Therefore, it is highly important that local health care professionals and teachers collaborate together to support the falls prevention work together with older adults but also students. When students complement learning experiences from the university with those that are learned during the clinical practice, excellent competence towards falls prevention can be achieved.

In their higher educational studies, geriatric health care students are supposed to develop from novice to experts in the field and learn extensively how to prevent falls among older adults. In Savonia University, the department of Applied Sciences has developed a teaching model which integrates theoretical and practical learning aspects (Äijö 2019). This teaching model includes three phases. Firstly, theoretical contents related to falls prevention are taught in lessons using interactive learning methods such as group discussions and seminars. Secondly, students participate in full-scale simulation at the university simulation center. Thirdly, students carry out their clinical practice in different types of work places. During the clinical training, one learning outcome for the students is to carry out work related to falls prevention. The health care students learning experiences from the falls prevention teaching model has been promising. As repeatedly stated in this chapter, education of falls prevention in older persons requires a balanced coherence between theoretical and practical skills.

Aspects Related to Dissemination: An Overlooked Component of Aging Care

Included in the development of the translational patient-centered Gerontology Master Program („Master of Active and Healthy Aging“)- an inter-professional program for senior citizens, social and health carers – should be an important component related to dissemination. Aspects such as the need to develop good practice guidelines, training and outreach programs of personnel involved in aging care should be emphasized. Dissemination of good practices in aging care, including falls prevention, should be carried out at regional, national and EU levels, including via an information and communication technology (ICT) platform. Aspects such as educational and information tools for citizens and formal and informal caregivers should be incorporated in the curriculum.

Other important aspects to be included in the educational program of falls include:

1. *Development and dissemination of good practice guidelines* for health care workers, policy makers and partners regarding application of tools developed from ontology for improved fall prevention.
2. Development of best practice (evidence-based) guidelines as aid for health care professionals and partners requires *using state of the art research by formulating recommendations for practice* and as means to external control by translating the recommendations to performance indicators. The scope and purpose of the guidelines and the target groups should be clearly described in the course. For instance, the development of the guidelines could be followed in a structured and coordinated 8-step wise procedure (Grol, Wensing, Eccles, & Davis, 2013). The development group includes representatives from all relevant professional groups (medical, nursing, rehabilitation, etc.) represented in aging care as well as representatives of the target groups (patients', relatives, caregivers). To develop such fall prevention guidelines, multidisciplinary expertise involving biostatistics, economics or medical knowledge has to be complemented with knowledge from patient representatives and other target group members as well as experts in group dynamics. Additionally, to ensure the acceptance of these guidelines across different stakeholders, the needs/ knowledge of possible users must be taken into account e.g. clarity of language, easy to use and practical as well as characteristics of innovation such as advantages of the guideline recommendations, adaptability etc. Finally, effective dissemination and implementation strategies related to the various groups has to be selected e.g. audit & feed-back. When developing all these aspects in the curriculum, identification of commonality in municipal and regional policies for falls risk reduction in community living should be emphasized.
3. *Development of evidence-based cost effectiveness analysis of intervention strategies and follow up and social support programs for policy makers*. The preventive guidelines must embrace the implementation process structure that enables intermediaries like health and social care providers, and public health authorities, to provide access to solutions for citizens and families. These guidelines can provide the foundation for business investment and inputs to insurance strategies, while identifying benefits and risks of prevention strategies.
4. *Development and administration of interdisciplinary education and training* for health care personnel, caring relatives and voluntary helpers must be carried out in cooperation with relief organizations. Training of caring relatives and voluntary helpers should be targeted by their needs

and wishes, which must be supported in two dimensions. These can be labelled in the so-called "tangible and intangible dimensions". The first one will be represented with detailed information/ training regarding different services, goods, equipment, basic information e.g. changes in health status, aging and training related to basic care of the frail elderly. The co-dependent and essential intangible dimension deals with the relationship qualities between the informal (relatives, volunteers) and formal carers (nurses, medical doctors). Therefore, an important focus area is how family members can express their positive and negative experiences (which they have had while caring for older persons) with dedicated health professionals and how they can receive adequate support while they are providing care (Stoltz, Willman, & Giggi, 2006). In addition, support and promote local civil group and family involvement by designing outreach programs for falls prevention for relatives and laypersons as target group for information. These programs are aimed at teaching family members and laypersons involved in older persons care how to promote healthy lifestyle in older people including compliance and adherence to healthy lifestyle programs, increasing health self-awareness and management, promoting self-empowering behavior to support their commitment to positive lifestyle changes thereby leading to falls prevention. Furthermore, it will give information about necessary assisted devices to the relatives as well as guide them regarding specific home modifications that are required for older persons.

When developing such programs an important aspect is creation of art and media-based information and campaigns to promote an active life-style in older people including compliance and adherence to intervention programs, increasing health self-awareness and management, promoting self-empowering behavior to support the commitment to positive lifestyle changes and information about helpful assisted devices. These include telecommunication, cinema and literature.

CONCLUSION

This chapter summarizes the need of- and the development of- a translational patient-centered Gerontology Master Program ("Master of Active and Healthy Aging")- an inter-professional program for senior citizens, social and health carers. This program should also have an important component related to interdisciplinary education and dissemination, amongst other aspects related to aging care. The creation of a Master should be performed as a co-operative group activity of experts in the medical field as well as experienced and qualified educators in the field of higher education and social gerontology. The program should be flexible in its nature and can be changed based on feedback and evaluation as well as oriented to the needs of the participants of the Master program.

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Chapter 10
Health and Fall Risk Monitoring Within Common Assessments

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ABSTRACT

This chapter presents an exploratory review on the evaluation, assessment, and monitoring in health and fall risk by common and the most used assessment tools. The main discussion of this chapter of evaluation in health and fall risk is divided into six categories—global health assessment, specific physical (and fitness) assessment, cognitive and psychological assessment, pharmacological assessment, fall risk specific assessment, and some complementary assessment—which show information and how to access. Whereas health evaluative experiences and practices are essential to drive a better and specific intervention, revealing its importance and necessity was also highlighted.

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DEMOGRAPHICS OF HEALTH AND FALL RISKS IN THE ELDERLY

In the last years an increased attention towards falls prevention and management has been not surprising since falling has been recognized worldwide as a major health risk for older people. The number of falls is increasing each year and is the leading cause of injury (fatal and nonfatal) in older adults in Europe and in USA. Approximately 30% of people over 65 years old, and 50% of those over 80, fall at least once a year, and approximately 33% of these are repeated fallers (Bergen, Stevens, & Burns, 2016; Cuevas-trisan, 2019)

One-third of falls requires medical attention, including serious fractures (2-10%), being also the leading cause of hospitalization, and resulting in about 36.000 deaths per year in Europe (EUPHA, 2009). In the USA, the situation is similar, with 28.7% of older adults reporting falling at least one time in the past 12 months, which amounts to 29 million falls a year (Center of Disease Control and Prevention, 2018). The severity of injuries can vary, but 2.8 million of them were treated in hospital and 25% of these individuals were hospitalized subsequently, resulting in approximately 27.000 deaths (Bergen et al., 2016; Cuevas-trisan, 2019). Also, it is known that older people who lie for an hour or more unattended after falling, are less likely, than those who get up or are helped up to make a good recovery. More than 50% of those who remain on the floor for over an hour will die within 6 months, even though not directly injured by the fall (Blain, Bernard, Boubakri, & Bousquet, 2019).

Populations who report poor health have significantly higher fall-related injuries than the ones who report excellent health. Women are more likely to report falling and fall injuries, and this can be explained by the reduced muscle strength that is found when compared to men, with sex and age being two factors associated with reduced muscle mass (Cuevas-trisan, 2019; Nevitt, Cummings, & Hudes, 1991; Rapp, Becker, Cameron, König, & Büchele, 2012). Also, the percentage of caucasian older adults who report falls is greater than that among black persons, however, only a few studies on racial and ethnic differences had been published, and these differences could also be related to health behavior and/or culture (Bergen et al., 2016; Nicklett & Taylor, 2014)

In USA, the approximate costs related to falls among older people were estimated at 31.3 billion dollars annually in 2016 (EUPHA, 2009), and when applying this number to the expected at risk of falling older population, who is deemed to increase 55% by 2030, this cost could reach around 50 billion dollars annually in order to support the predicted 48,8 million falls and the 11,9 million fall injuries, with this increase in cost being similar worldwide (Hartholt et al., 2012). And what is more alarming about this data, is that does not include persons in long-term care facilities who are at higher risk for falls (Rapp et al., 2012; Vlaeyen et al., 2015), so these numbers could be even greater.

The ageing process itself contributes to falls because of the association with several psychological and physiological changes, the decline of gait and balance, the increase in sedentarism, use of medication and the presence of several chronic conditions, all are risk factors for falls.

However, the good news is that falls in older adults are preventable, and health care professionals can play an important role in it, by discussing about falls prevention with the elderly, providing good and clear information, as well as promoting appropriate interventions (Gillespie et al., 2012). Some studies showed that correct interventions were able of reducing the incidence of falls in more than 20%, which is very significant.

Some guidelines, as those from the American and British Geriatrics Societies, and NICE recommend an approach that includes activities like talking about falls, assessing and reviewing medications, balance, and the level of vitamin D, for example (AGS/BGS Clinical Practice Guideline, 2011; National

Institute for Health and Care Excellence, 2013). A three step guide was also developed to address the patient in an initial visit: 1) ask patients if they have fallen in the past year, feel unsteady, and/or worry about falling; 2) review medications and stop, switch, or reduce the dosage of drugs that are linked to fall risk; and 3) recommend daily vitamin D supplementation (to improved bone, muscle, and nerve health).

Briefly, many factors, such as physical (musculoskeletal and nerve condition, strength/weakness, gait, balance, sarcopenia), psychological (depression, self-esteem, self-confidence), pharmacological (medication), physiological (diabetes, uremia, vitamin deficiency, hypotension, irregular heart rate), health history (diseases), pain and vision impairment are involved in the cause of falls. The very fear of falling can play a crucial role because the greater the fear, the greater self-restricted activities (reduction in social interactions and physical activities), and the greater the risk of falls. However, to address it correctly, and avoid falls and their possible consequences (serious injury, loss of independence, and even death)(Rapp et al., 2012; Salzman, 2011), the health care professionals are essential, and play an important role by screening and monitoring older adults at risk.

Basically, opportunities to make fall prevention a routine part of clinical practice and reduce the barriers to providing services that can prevent falls among older adults, should be created. As mentioned above, fall risk is a multicomponent problem and therefore a multifactorial assessment is need in order to be effective.

1. GLOBAL HEALTH ASSESSMENT

Definition and Characterization

The Global Health Assessment includes an individual's physical, mental, and social health. The measures are generic and global, rather than disease-specific, and often use an "In General" item context as it is intended to globally reflect the subjects' perception of their own health. It should include the patient history, some physical, nutritional, pharmacological, psychological and social assessments (Cuevas-trisan, 2019; King et al., 2019).

1.1. Patient History

Patient history is a set of documents and reports about his health status at different stages of life. It gathers historical information on current, past, family-affecting illnesses and health care provided, physical evaluation, testing and treatments. Gathering information about illness, habits, appointments, tests and treatments, this anamnesis is one of the foundations for providing effective care. For signaling risk factors, this document is also used as a support in preventing pathologies and health conditions. These and other aspects reveal the need for different health professionals to deepen their knowledge of the patient's history. This history should include specific questions about falls and its risk factors (Almeida, Abreu, & Mendes, 2013; Oliveira et al., 2015).

1.2. Initial Assessment of Fall Risk

The STEADI (Stop Elderly Accidents, Death & Injuries) proposes 3 must ask questions to include in a routine part of the exam: 1) Have you fallen in the past year? 2) Do you feel unsteady when standing or walking? 3) Do you worry about falling? If the answers to any of these questions is "yes", the persons are considered at increased risk of falling, and further assessment is recommended (Bergen et al., 2016)

If possible, family members should participate in some of the initial screening to give additional important information that the individual may have dismiss or downplayed. Questions about the environment and its hazards should also be included, like rugs, high clutter areas, electrical cords, steps, poor lighting, stairways, slippery surfaces, etc. The initial assessment should always include a specific screening of the ability to perform basic activities of daily living (Cuevas-trisan, 2019).

1.3. Common Subjective Assessments

WHOQOL-100: The WHOQOL (World Health Organization Quality of Life) instrument assesses quality of life in a variety of situations and population groups. The WHOQOL-100 has 100 questions to assess important aspects of quality of life, which is defined by the organization as an individual's perception of their position in life in the relation to their culture and value systems and in relation to their goals, expectations, standards and concerns. It is a broad ranging concept affected in a complex way by the person's physical health, psychological state, personal beliefs, social relationships and their relationship to salient features of their environment. The questions about quality of life were drafted on the basis of statements made by patients with a range of diseases, health professionals, and by healthy people as well, in a vast variety of countries and cultures (WHO, 2012).

WHOQOL-Bref: WHOQOL-BREF is an abbreviated generic Quality of Life Scale which were developed through the World Health Organization. It is an abbreviated version of WHOQOL-100, and it is composed by 26 questions (WHO, 2012).

Charlson comorbity index: The CCI is a predicting mortality index which classifies/weights comorbid conditions and has been widely utilized by health researchers to measure burden of disease. It has an index based on 17 comorbid conditions that has been shown to predict mortality (1 to 10 years) (Charlson, Szatrowski, Peterson, & Gold, 1994). A recent study aimed to update the index with 12 new comorbidities showed adequate discrimination in predicting and classifying comorbidities and included data from six countries (Quan et al., 2011).

The Vulnerable elders-13 Survey (VES-13): is a 13-item function-based tool designed to screen older patients at risk for health deterioration, with a higher overall score indicating greater vulnerability and decreased function (Arora et al., 2007; Min et al., 2009).

EuroQol (EQ-5D): It is a health-related quality of life measuring instrument that allows to generate an index of an individual general health state. Based on a classification system, it describes health in five dimensions: mobility, personal care, usual activities, pain/malaise, and anxiety/depression. Each dimension has three levels of severity corresponding to the following: level 1 – no problems; Level 2- some problems; and Level 3- extreme problems, experienced, lived or felt by the individual (EuroQol Group, 1990).

SF-36: It is a 36-Item Short Form Health Survey, a set of generic and easily administered quality-of-life questionnaire. It is a patient self-reporting and are widely utilized for routine monitoring and assessment of care outcomes in adult patients (Ware & Sherbourne, 1992).

2. SPECIFIC PHYSICAL (AND FITNESS) ASSESSMENT

Definition and Characterization

The most common cause of falls and increased fall risk, frequently leading to injury and disability, are gait and balance disorders (Salzman, 2011). Balance is defined as an even distribution of weight enabling someone or something to remain upright and steady, gait refers to locomotion and human locomotion/gait is defined as bipedal, biphasic forward propulsion of the center of gravity. Gait and balance are composed by interaction of physiological and cognitive elements, that should allow a precise and fast response to perturbation (fall risk), avoiding any risk at the very moment (i.e., reaction time). Gait and balance disorders are usually complex and multifactorial, and include among others, – medical conditions, pain, fear of falling and cognitive disorders, and it requires a very comprehensive and extensive assessment to determine the factors involved in order to make possible target interventions. The prevalence of gait and balance disorders increases with age and is higher in institutionalized elderly (Cuevas-trisan, 2019; Salzman, 2011).

Common Assessments

8-foot-up-and-go-test: It measures power, speed, agility and dynamic balance. The test involves getting out of a chair, walking 8 feet towards and around a cone, and returning to the chair in the shortest time possible (Rikli & Jones, 2013b).

Timed-up-and-go test: Almost the same as the test above. It starts in a seated position, stands up upon command, walks 3 meters, turns around, walks back to the chair and sits down. The time stops when the person is seated. The use of an assistive device is allowed, but it must be documented (Podsiadlo & Richardson, 1991).

Short physical performance battery: This battery includes balance, gait and chair stand tests, with possible scores range between 0 to 12 points (4 maximum points for each test), and where 0 to 3 points means incapable, 4 to 6 points indicates poor performance, 7 to 9 points moderate performance and 10 to 12 good performance (Guralnik et al., 1994).

Balance test: i) Side-by-Side Stand: The participant is instructed to remain still with parallel feet for 10 seconds without moving the feet with a score between 0 and 1; ii) Semi-Tandem Stand: With the heel of one foot placed next to the hallux of the other foot, needing to reach the pre-set time of 10 seconds. Thus, 1 point if it is done, if not, 0 points; iii) Tandem Stand: to stand with one foot in front of the other for 10 seconds.

Gait and speed test: This walking speed test has two variations, one that includes walking a 3-meter course and registering the time taken to do it, and another one, that uses a 4-meter course. The participants can do two attempts and the shortest time is the one written down.

Chair stand test: Participants are instructed to cross their arms across the chest and get up from the chair and sit down for 5 consecutive times as quickly as possible but remaining standing at the end of the 5th round. The total time is registered.

Sarcopenia Assessment: Sarcopenia is defined as a generalized and progressive loss of skeletal muscle mass and strength, and is a risk factor for physical disability, poor quality of life, and even death. Its diagnostic criteria can differ depending on different studies, however, all of them include a body composition evaluation (DEXA. Bioimpedance, skin folds, hydrostatic weight) and strength and/

or physical tests (lower and upper body strength, 1Maximum Repetition, walking test, TUG, etc.). With a prevalence of around 1/3 in those older than 60 years of age and still increasing as the percentage of the very old continues to grow (Cruz-Jentoft et al., 2010) it runs along frailty, being one of the frailty criteria that in its initial phase can still be reversed. The fight against sarcopenia in older adults can potentially stop or at least slow down the progressive risk of falls, disability and physical dependency (Delmonico et al., 2007).

Frailty Assessment: The identification of the frailty phenotype is made by assessing five dimensions: 1) Changes in body composition - self-reported loss of four pounds or more of body mass in the last year; 2) Exhaustion and / or low stress resistance (verified through the Fatigue Impact Scale); 3) Physical activity level (quantification of daily and weekly expenditure (five days) through accelerometers or the use of the IPAQ); 4) Slow walking (time taken to travel a distance of 4.6 m at comfortable speed, adjusted for height and gender); 5.) Weakness / Muscle strength (hand-held dynamometer grip test, adjusted for gender and body mass index (BMI)) (Bieniek, Wilczyński, & Szewieczek, 2016; Fried et al., 2001; Macklai, Spagnoli, Junod, & Santos-eggimann, 2013).

Katz Index - The Katz index of independence in activities of daily living (ADL) is an instrument to assess functional status as a measurement of the older person's ability to independently perform daily life activities. The Katz index assess the adequacy of people's performance in six specific functions (bathing, dressing, toileting, transferring, continence, and feeding). There are yes/no questions for independence in each of these six categories. A maximum score (5 to 6) indicates full function, a score of 3 to 4 indicates moderate impairment, and 2 or less indicates severe functional impairment (Buurman, Van Munster, Korevaar, De Haan, & De Rooij, 2011; Katz, Downs, Cash, & Grotz, 1970)

The Lawton-Brody instrumental activities of daily life: is an 8-item tool designed to evaluate functioning, where a higher summary score represents greater levels of Independence (Chong, 1995; Lawton & Brody, 1969)

Strength Assessment: The Center of Disease Control and Prevention of United States recommends using TUG, the 30-s chair stand, and the 4-stage balance test to identify people with gait/strength/balance disturbances (Department of Health and Human Services, 2015). Also, there are specific tests for upper and lower body strength, namely:

Lower Body Strength Test: "30second's chair-and-stand-test" (CST): which consists of calculating the total number of times the subject can sit and get up from the chair, with arms crossed at chest height, completed in 30 seconds (Rikli & Jones, 2013b).

Upper Body Strength Test: hand-held dynamometer grip test: It is designed to replicate the grip strength, using a dynamometer which measures grip strength in kilograms and/or pounds. The test requires to squeeze the dynamometer with maximal effort (as hard as possible). Keep squeezing for at 3 to 5 seconds. It should be done 2 to 3 attempts, recording the best one (Macklai et al., 2013), 2013). "30 seconds Arm-curl test" (ACT) that measures the total number of arm curls executed in the 30-s.

Senior functional battery - The Senior Fitness Test battery includes the following tests: 1) lower body strength test, determined with the "*30 second's chair-and-stand test*" (CST); 2) the upper-body strength test, determined with the "*30 seconds Arm-curl test*" (ACT); 3) aerobic test, determined with the "2-minute step test"(2ST); 4) lower- body flexibility, with the "*chair sit-and-reach test*" (CSR) and; 5) upper-body flexibility, determined with the "*back scratch test (BST)*". For the above mentioned each test, there is cut-off values adjusted for sex and age, which is analyzed as continuous variables (Rikli & Jones, 2013a).

Complementary Information:

"*2-minute step test"* (2ST) that measures the number of full steps completed in 2 min, raising each knee to a point midway between the patella (kneecap) and iliac crest (top hip bone). Score is the number of times the right knee reaches the required height

"*chair sit-and-reach test"* (CSR) measures the maximum reach as forward as possible toward or past the toes.

"*back scratch test (BST)"* that measures the distance of overlap or between the tips of the middle fingers of the back

3. COGNITIVE & PSYCHOLOGICAL ASSESSMENT

Definition and Characterization

Cognitive functions influence almost every factor related to falls (gait, balance, strength, depression, quality of life, activities of daily living, etc), and besides the diagnosis, a cognitive impairment is always a risk factor (Kearney, Harwood, Gladman, Lincoln, & Masud, 2013). Some studies showed that an increase in cognitive impairment increased the prevalence of falls in older adults when compared with their cognitively intact peers (Booth, Harwood, Hood, Masud, & Logan, 2016). The population diagnosed with mild cognitive impairment (MCI) is at a higher risk for a significant number of comorbidities, including functional decline, and consequently, falls, which in turn will also contribute to cognitive and functional decline through hospitalization, lower confidence, deconditioning from injuries and reduced activity level, starting a cyclic problem.

In this scenario, cognitive assessment is a very strong tool to anticipate the risk, and try to minimize, or even stop its development at an early stage. However, there is no clear guidance on how to respond to these individuals needs because recommendations are not clear and documented yet (National Institute for Health and Care Excellence, 2013).

In the same situation, psychological disorders, can contribute to increase sedentarism, once the elderly are more susceptible to depression. And psychological assessment can help understanding, also intervene in problems such as loneliness, isolation, dementia and depression. As well, can help in the design and implementation of health management and monitoring systems to prevent and treat pain and diseases (OPP, 2015).

Common Assessments

<u>Mini mental state examination (MMSE)</u>- The mini mental state examination (MMSE) was designed to assess five areas of cognition: orientation, immediate recall, attention and calculation, delayed recall and language. The maximum possible score is 30 points. Scores below 24 points are considered abnormal and used for dementia and MCI screening (de Melo & Barbosa, 2015). It usually classifies participants by cognitive profile as a category variable, following the criteria: (a) severe cognitive impairment (01 to 09 points), (b) moderate cognitive impairment (10 to 18 points); (c) Mild Cognitive Impairment (19 to 24 points); (d) normal cognitive profile (25 to 30 points). The MSSE also showed to be sensitive to the effects of exercise in an older population (Folstein, Folstein, & McHugh, 1975).

Hopkins verbal fluency test - The Hopkins verbal learning task (HVLT) is one of the most commonly used memory tests in older adults. It is used to assess verbal episodic memory, including immediate memory (Folstein et al., 1975). It is a 4-min test, easy to administer, to score, and is well tolerate even by significantly impaired individuals. This test requires recall of a series of 12 words (nouns) from 3 semantic categories (precious stones, animals, and human dwellings) over 3 learning trials (De Jager, Hogervorst, Combrinck, & Budge, 2003). Scores between 15.5 and 24.5 on this test indicate a risk of dementia or MCI (Dellagi et al., 2019; Rieu, Bachoud-Lévi, Laurent, Jurion, & Dalla Barba, 2006).

Montreal cognitive assessment (MoCA) - The MoCA is a cognitive screening test designed to assist Health Professionals in the detection of mild cognitive impairment (MCI). This tool was designed to assess short term memory, visuospatial abilities, executive functions, attention, concentration and working memory, language, and orientation to time and place. MoCa has a 0 to 30 possible points scale, and has the ability to assess several cognitive domains, that have and has been proved to be a useful tool for screening many illnesses, such as: Alzheimer's, Parkinson's and Huntington's disease, Stroke, Fronto-temporal dementia, Brain metastasis, Sleep behavior disorder, multiple sclerosis, head trauma, depression, schizophrenia, heart failure, substance abuse, etc (Charbonneau, Whitehead, & Collin, 2005).

Rosenberg Self Esteem Scale – It is a 10-item scale which measures global self-worth by measuring feelings (positives and negatives). All items are answered using a 4-point Likert scale which range from "strongly agree" to "strongly disagree". To the items 1, 2, 4, 6, and 7, a reverse value of scores is done. The global self-esteem is represented by the sum of all scores and gives results between 10 and 40 points, where higher values represent higher levels of global self-esteem (Rosenberg, 1965).

Perceived Stress Scale - The perceived stress scale (PSS) is a 14-item scale that assesses the perception of stressful experiences by asking the participant to rate the frequency of feelings and thoughts related to events and situations that occurred over the previous month. 7 out of the 14 items of PSS-14 are negative and the remaining 7 are positive, representing perceived helplessness and self-efficacy, respectively (Trigo, Canudo, Branco, & Silva, 2019). For items 4, 5, 6, 7, 9, 10, and 13, a reversal of the scores is done. Final scores vary from 14 to 70 points. A higher score indicates greater stress (Remor Bitencourt, 2006).

Falls Efficacy Scale - The falls efficacy scale (FES) contains questions about the possibility of falling during the performance of 10 daily activities (Tinetti, Richman, & Powell, 1990). The trust that the elders have to perform the activities without falling is represented on a 10 points scale ranging from "No confidence" (1 point) to "Completely confident" (10 points). The score of the FES is the sum of the scores obtained in each of the 10 items. The minimum score possible is 10 and the maximum is 100 (Morgan, Friscia, Whitney, Furman, & Sparto, 2013).

Hospital Anxiety and Depression Scale (hads) – It is a 14-item questionnaire designed to assess anxiety and depression, 7 of the items relate to anxiety and 7 relate to depression. Items are rated on a 4-point severity scale. The HADS produces 2 scales, one for anxiety and one for depression. Scores of greater than or equal to 11 on either scale indicate a definitive case (Snaith & Zigmond, 1983)

Geriatric Depression Scale (GDS)- It is a "yes" or "no" questionnaire. Simple enough to ensure that the scale can be used in cognitively impaired individuals, for whom a more complex set of answers may be confusing or lead to inaccurate recording of responses. A point is assigned to each answer and its cumulative score is ranked on a scoring grid. The scoring grid sets the results as 0-9 as "normal", 10-19 as "mildly depressed", and 20-30 as "severely depressed" (Yesavage et al., 1982).

Geriatric Depression Scale (GDS) short version- GDS-15, consisting of 15 direct questions with yes or no answers, considers that with 5 or more points, we are in the presence of mild depressive symptoms and above 11 in the presence of severe depressive symptoms (Yesavage et al., 1982).

Bradburn Scale of Psychological Well-Being: assesses happiness, where a higher score indicates greater psychological well-being (MCDOWELL & PRAUGHT, 1982; Mechanic & Bradburn, 1970).

Satisfaction with life: The satisfaction with life scale (SWLS) is a short five-item instrument designed to measure global cognitive judgments of satisfaction with one's life. The scale requires around 2 min to be completed by the participants. It uses a seven-point Likert scale, which indicates the participant's level of agreement with each item by choosing the appropriate number on the line regarding that item. Results range between 1 and 35 points, with higher values representing higher levels of life's satisfaction (Parker, Strath, & Swartz, 2008).

4. PHARMACOLOGICAL ASSESSMENT

Definition and Characterization

Some specific classes of medication, especially those affecting central nervous systems (benzodiazepines, diuretics, vasodilators, opioids, muscle relaxants, beta blockers, tricyclic antidepressants, sleeps aids, and other drugs which cause sedation and delirium), and the use of 4 or more medication need to be observed with caution because of the side effects that these could have, altering elderly's reaction time, memory, brain perfusion, gait, balance, and influencing the risk of fall (Leipzig, Cumming, & Tinetti, 1999).

Its al so recognized that using many medications can generate some iatrogenic problems (from side effects of drugs interactions). Antiplatelet agents and anticoagulants, for example, are common medication in the elderly because of associated cardiovascular ailments, which add another layer of complexity, potentially making falls catastrophic (Cuevas-trisan, 2019). Some common side effects include hypotension and dizziness, all associated with falls. In a study, tapering and discontinuation of psychotropic medications (benzodiazepines, neuroleptic agents, antidepressants) over a 14-week period was associated with a reduction around 39% in the rate of falling (Campbell, Robertson, Gardner, Norton, & Buchner, 1999)

The control and managing medication side effects with other medications, was a common response in clinical setting, but rarely justified and, a new concept is taking place, the concept of medication reconciliation, which is the reviewing process of all medication prescribed by all physicians, and after a review, the professionals should always consider replace or discontinuing some original medication before adding another to treat undesirable side effects (Musich, Wang, Ruiz, Hawkins, & Wicker, 2017). The concept of medication reconciliation has become standard of practice, and successful components of these interventions include review and reduction (in possible) of medications (Cuevas-trisan, 2019; Musich et al., 2017).

5. FALL RISK SPECIFIC ASSESSMENT

Definition and Characterization

Health Professionals are often unaware of the many existing scales specifically for identifying fall risk and are uncertain about how to select an appropriate one. Nowadays there are more than 30 fall risk assessments were some focus on institutionalized, and others are more functional assessment scales. The majority of the scales were developed for elderly populations, characteristics assessed are quite similar across them, and sensitivity can varied from 38% to 100% (Perell et al., 2001). Therefore, a substantial number of fall risk assessment tools are readily available and assess similar patient characteristics. Although their diagnostic accuracy and overall usefulness showed wide variability, there are several scales that can be used with confidence as part of an effective fall prevention program.

FRAT - Fall Risk Assessment Tool: It is a 4-item falls-risk screening tool for sub-acute and residential care. It has three sections: i) falls risk status; ii) – risk factor checklist; iii) action plan. These 3 parts are a complete falls risk assessment tool. However, section 1 can be used as a falls risk screen (Stapleton et al., 2009), which also includes the Abreviated Mental Test Score (Hodkinson, 1972).

Posturography Plataform PhysioSensing – Fall Risk Test - This fall risk test allows the identification of potential fall candidates. The protocol assesses static balance under four conditions, each lasting 40 seconds: 1. comfortable posture with eyes open; 2. Comfortable posture with eyes closed; 3. Narrow posture with eyes open; 4. Narrow posture with eyes closed (Bigelow KE and Berme N. 2011) (Pajala, S. et al. 2008). After performing all protocol conditions, the value of the oscillation speed index for each of the conditions appears.

The Hendrich II Fall Risk Model: It determines the risk of falling based on sex, mental and emotional status, (possible) symptoms of dizziness, and by the categories of medications taking that could increase risk. This tool screens for fall risk and is integral in a post-fall assessment for the secondary prevention of falls (Hendrich, Bender, & Nyhuis, 2003).

6. COMPLEMENTARY ASSESSMENT

Environmental Assessment (and modifications) -An effective prevent falls program should include some environmental assessment, and some modification if necessary. However, the experience of the professional who is performing the assessment and proposing some recommendations are a very important factor, so this professional should be well trained and prepared. The common recommendation includes removal of rugs, the use of non slip bath mats, lightning at night, safer footwear, and to add stair rails. (Tinetti, 2003). Although nonspecific advice about this changes in home hazards are directly targeted, an assessment and a follow up by a an occupational therapist is the most recommended, and these changes was associated with a 20% reduction in fall risk (Gillespie et al., 2012; Sherrington et al., 2017). Some scientific evidence supports the idea of environmental modification being beneficial in individuals in risk, mainly in those with history of falls. And the public environmental should be adapted as well. The NICE guidelines (National Institute for Health and Care Excellence, 2013) recommend modifications such as "age-friendly" transportation to help older people in daily life, and these kind of modification and the implementation of a fall prevention program can reduce fall, and fall-related injury by 20 to 40% in community dwelling people, and are cost effective.

Visual Assessment - Visual impairment is recognized to be an important risk factor, but it is not well studied. Vision impairments increase as we age, and sometimes it is overlooked because the process of decreasing vision is often slow and may even be unnoticeable (Cuevas-trisan, 2019). A glaucoma for example, is associated with fear of falling, which contributes to a decrease in mobility (Zhang, Shuai, & Li, 2015). Therefore, improving vision can have some advantages. A review also showed that a cataract surgery can reduce the rate of falls(Gillespie et al., 2012). However, it should be made with extra attention because some studies showed that these kind of interventions could increase the rate of falls because with an improved vision leads to a behavior changes, and increase the elderly's exposure to fall risk situation (Grue, Kirkevold, Mowinchel, & Ranhoff, 2009). Also, a combinations of intervention can be more effective than a visual intervention alone, so a combined interventions (eg, exercise and vision) is more effective in preventing falls in older people (Zhang et al., 2015).

Hypotension, Cardiac Pacing, rhythm and frequency – A health evaluation is only complete when obtaining vital signs, and when it is assessed appropriately, postural hypotension is identified in almost 1/3 of older people, besides some of elderly do not report dizziness, or some other symptoms related. Elderly usually have some cardiovascular issue, such as arrhythmias which can lead to falls, also a special attention should be taken around orthostatic hypotension and hearing problems, which can lead to syncope. A review article showed that people with carotid sinus hypersensitivity who had pacemakers had the rate of falls reduced (Gillespie et al., 2012). Therefore, a use of pacemaker must be considered when falls are associated with condition that make changes in heart rate and blood pressure (Booth et al., 2016).

Pain: Persistent pain, reduced mobility and function, and reduced general quality of life are some common experiences associated with musculoskeletal conditions in the ageing process. However, musculoskeletal pain usually limited the people's ability to make lifestyle changes to be more active. A strong relationship exists between painful musculoskeletal conditions and a reduced capacity to engage in physical activity, and it can result and/or generate frailty, functional decline, independence loss, and increased fall risk. In a group of community-dwelling adults (^{3}88 years), joint pain was reported as the most common contributor to gait problems (Bloem et al., 1992), showing the importance of pain in the fall risk. However, pain still being a very hard to assess, control, and reduce, being necessary a multi professional approach.

Posture – Posture, mainly the body's center of gravity, related to changes in neck limited extension, shift significantly in older people, contributing to postural imbalance, and limited field of vision, collaborating to increase the risk of fall. Therefore, the postural evaluation, e correction e strengthening can reduce the risk and incidence of falls in older people (Cuevas-trisan, 2019).

Proprioception – Neurologic exams to detect or identify deficits such as weakness and possible sensory problems, mainly in proprioception should be included whenever possible because it is capable to show some specifically and treatable problems which can cause balance impairments. One sensitive marker of abnormal proprioception is the decrease in vibration sense, as well the worse balance problems with closed eyes (Tinetti, 2003). The evaluator should always include tone and coordination assessments to have a better conclusion.

Osteoporosis (Risk) – The prevalence of osteoporosis is higher in those who fall, and it is very common is elderly, and worst in those with sarcopenia (Gillespie et al., 2012). The STEADI and NICE guidelines recommend giving calcium and vitamin D supplements to all, besides their risk of fall, but taking extra attention, and performing some exams to evaluate bones and muscles to determine more specific recommendation and proceeding to a more specific treatment (Jang et al., 2016; Kearney et al., 2013)

7. FINAL CONSIDERATIONS

Falls and their associated injuries are we could see are common in the elderly and usually result from multiple factors interactions, and many of them may be modifiable or, at least, more adequate. In this scenario, the knowledge of the existent tools to assess the different levels and factors associate with fall risk is mandatory and can play a critical role in reducing fall risk factors among the older population.

Additionally, most guidelines recommend at least an annual general screening with an objective to identify people at increased risk, targeting to understand the risk and trying to manage/modify the fall risk factors identified. Also, understand the perspective of the older adults, and their involvement (or not) in some prevention activities can be critical to have success.

Falls Prevention Educational Programs as The NICE guidelines (National Institute for Health and Care Excellence, 2013) also recommend to talk about falls, and increase the knowledge of older people to enhance their “fall awareness”. In the same way, the STEADI (Bergen et al., 2016) and ProFound group (ProFound, 2015) developed and disseminate best practices in fall prevention, producing even documents to influence policy, and trying to reach all sectors – NGOs, commercial sector, and the general public as well. However, these educational programs alone showed to not been able to decrease the rate of falls in older adults significantly.

Therefore, as fall risk is multidimensional, and has multiple cause, an equal multiple intervention, with a multidisciplinary staff, and multiple screening tool is needed to address it in the best way.

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KEY TERMS AND DEFINITIONS

Cognitive Assessment: A specific kind of evaluation focusing on a general or specific component of cognition.

Environmental Assessment: The kind of tool designed to evaluate information from de environment in some specific, or general component.

Fall Risk Assessment: A group of specific tools used to verify the risk of fall in specific population and/or groups.

Health Assessment: A group of tools used scientifically to assess health parameters.

Pharmacological Assessment: A kind tool to access pharmacological information from an specific person or group.

Physical Assessment: A specific kind of evaluation focusing on physical and/or fitness level in a general or specific component.

Psychological Assessment: A group of tools designed to specifically assess psychological background.

Chapter 11
Patient Safety:
The Patient's Perspective From Public Sector Health Institutions in the Algarve Region, Portugal

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ABSTRACT

The purpose of this chapter is to give a perspective of patient safety culture by users of public health units through a qualitative analysis of open questions asked. The sample consists of 241 patients from the health region of Algarve. The open questions were the object of content analysis in thematic and categorical form, followed by lexical treatment using the Iramuteq software. From the patients' point of view, the evolution of patient safety is the result of an understanding of the meaning of the highlighted terms (safety, health, meaning), as well as of the intervention and improvement in these categories. It is known with these associations that for the patient, patient safety involves the existence of professionals for each individual (personal) and the existence of a receptive and empathic nature on the part of the professionals (human), as well as the need to demystify care for the understanding of patients (technician/knowledge) and the provision of care completely focused on the patient (attention).

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INTRODUCTION

The provision of healthcare is liable to include events with serious consequences for patients, professionals, institutions, and society in general. These are reflected in the quality of life of patients, loss of confidence in healthcare organizations and professionals, dissatisfaction and demoralization of the professionals involved, the increase of social and economic costs, cases of dispute and in reducing the possibility of reaching the expected results (NPSA, 2004). The concern with the issue of Patient Safety (PS) by various governments of different latitudes and international organizations is growing due to the high number of incidents reported by citizens, without the equivalent notice by the health professionals involved.

The negative impact resulting from healthcare incidents is a reality for the affected patient, but it must be seen as a problem to be solved by all the actors involved. The need for a paradigm shift in the health professional-patient relationship has been reinforced by the increase in the available information that the patient has about his health condition (Busch, Saxena, & Wu, 2020). In the past, he placed all confidence in health professionals without judging the consequences of his intervention in the provision of healthcare. From the moment that the patient accesses the information not only about the disease but, and above all about the possibilities of available treatments and the respective results expected from them, his ability to "confront" professionals about possible incidents resulting from the provision of care is much higher than what happened in the past, which is not always welcomed on the part of professionals (Etchegaray, Ottosen, Dancsak, & Thomas, 2017).

This should not be the major reason that moves us to contribute to a paradigm shift concerning patient safety, but rather the overriding interest in the preservation of human life, thus guaranteeing the fundamental principles that the constitutions of civilized countries safeguard regardless of economic issues. The costs associated with healthcare incidents cannot be neglected not only for the patient but for the entire health care system. The use of Accreditation Systems by health institutions is a current and growing practice, however, it is necessary to carry out processes involving all stakeholders (patients, health professionals, the community, and politicians).

The patient as the central figure must play an active role, by facilitating communication channels in health care institutions with professionals at different levels of the organization. The complementary role of this information with the one provided by health professionals would enable the establishment of an ecologically balanced patient safety system.

In the quality of health care, patient safety has been highlighted in recent years, due to the need for patients and family members to feel safe and confident about health care, as well as professionals who want to provide safe, effective, and efficient care (Fragata, 2011). The WHO also recommends that the change in behaviours and attitudes comes from the culture of security established within the organization. This is the result of individual and group values, attitudes, perceptions, skills and behavioural patterns that determine the commitment to safety. To identify areas for improvement and introduce changes in the behaviour of professionals, it is necessary to assess and monitor the organization's safety culture for continuous improvement (WHO, 2009).

Although in recent decades, health policy in Portugal has evolved significantly, it requires an assessment of the effectiveness and status of the implementation of its strategies. The small number of studies in this area in Portugal and especially in the Algarve Region (RAlg) associated with an integrated and global perspective of safety, was the determining assumption for carrying out this work. The subject of patient safety, which is currently relevant, is an unavoidable and priority issue in the management of health organizations and the provision of healthcare. That said, this chapter intends to give a perspective on the culture of patient safety by users of the RAlg public health units through a qualitative analysis regarding open questions asked to users/patients.

It is important to mention that this is part of a broader study that had as its general objectives: To know the determining factors of favourable environments for the practice of patient safety in public sector health organizations in the Algarve Region - Portugal from the perspective of the Patient and Health Professionals; Contribute to the improvement of the intervention model in hospital health organizations and health centres, namely in terms of active measures in the dimensions of patient safety (policies and programs, incident notification systems, patient involvement, education and training and others). The study in question had as starting point the considerations already identified, and the absence of information and empirical studies on the subject, especially the one related to the safety culture of users, with these assumptions it was outlined with a descriptive approach, supported in a theoretical-methodological orientation of multidimensional and prospective analysis of patient safety in the organizational system of hospitals and health centres of RAlg-Pt. From the methodological point of view, guidelines for studies of organizational diagnosis were used. Health sciences theories and concepts on patient safety, such as clinical governance and risk management in health services, were also convened. In a second phase, the study consisted of the design and construction of the questionnaire, and validation for health professionals and another for users/patients, subsequently applied in all public health organizations in the Algarve on patient safety for the patient, for illustration the situation and the state of development of the subject of patient safety (Ribeiro, 2018).

METHODOLOGY

As already mentioned in this chapter, it is intended to make known part of the results of the broader study, which consisted in development and validation of measurement instruments that would allow a "Multidimensional approach to patient safety in public sector health institutions in the region of Algarve-Portugal", for this purpose versions were developed for patients and health professionals (Ribeiro, 2018). It was a quantitative study, located in the cross-sectional descriptive-correlational category (Fortin, 2003) and qualitative since content analysis procedures were carried out according to the categorical thematic technique, plus the lexical analysis of the corpus using the Iramuteq software. This is the part of the study that we will present in this chapter.

Authorization was requested to and granted by the administration of the Centro Hospitalar do Algarve and the Regional Health Administration of the Algarve, following a favourable opinion from the Ethics Committee. All procedures respected the ethical principles established by the Declaration of Helsinki (1964), following the last revision of 2008. Before the delivery of each questionnaire, users filled out a free and informed consent form, it was read and understood by each participant, and any doubt was promptly clarified.

The study population consists of users of public health institutions in the Algarve region, Centro Hospitalar Universitário do Algarve (Faro, Portimão and Lagos units) and Regional Health Administration (ARS) of the Algarve, I.P.

The study's sample comprises two hundred and forty-one patients who agreed to participate in the study. It was obtained in a proportional stratified random way by source relative to the hospital environment and health centres. Sixty-five per cent (65.1%) of the questionnaires were from hospital users and thirty-four per cent (34.9%) of health centres. The patients included in the sample have an overall average age of about 51.19 years, with users of health centres having an average age of 45.76 years and hospital users an average of 54.06 years. As for gender, 70.1% of respondents are women, 71.3% separately in the hospital and 67.97% in health centres, since the average age is high, it was observed that 23.7% have the first schooling cycle. Only 16.1% of all patients have a higher education, of which 20.3% belong to health centres and 14% belong to the hospital. Study participants are resident in Portugal, 44% are employed and 26.6% are retired.

The measurement instrument used in this study was the questionnaire "Multidimensional approach to patient safety in public sector health institutions in the Algarve-Portugal region" version for patients. The questionnaire used is the result of a process of elaboration and validation based on the theoretical frameworks of WHO for Patient Safety and other authors who dedicated themselves to the development of instruments for the evaluation of user/patient safety (WHO, 2007; Agency for Healthcare Research And Quality 2008; Ministry of Health Policy and Research, 2010). A pre-test was carried out on an intentional sample of methodological experts, on patients, to assess the facial validity and content of the questions. The questionnaire "is a measurement instrument that translates the objectives of a study with measurable variables. It helps to organize, normalize and control the data, in such a way that the information sought can be collected in a rigorous manner", while still allowing good control of the biases (Fortin, 2003).

The questionnaire is self-administered, and consists of parts A and B. Part A has 8 questions, in which questions 1 (Perception in relation to the management and organization of the health unit), 2 (Experience during the stay in the unit) and 5 (Experience in relation to the adverse event that you reported), are presented in the form of a Likert Scale from 1 to 10, where 1 means "disagree" and 10 "totally agree", 9 for P1, 11 for P2 and 6 for P5, respectively. Questions 4 and 5 are only answered by users who answered yes to question 3, which has a dichotomous answer (yes or no). Otherwise, it will go directly to question 6. Question 4 is composed of 6 sub-questions of dichotomous answer (yes or no). Question 6 concerns the feeling of security they have regarding the health care provided in their health unit on a scale of 1 to 7, in which they are very insecure (1) and very safe (7). Questions 7 and 8 are open-ended questions that will be studied in this chapter. Part B of the questionnaire consists of the sociodemographic characterization that contains: gender, age, marital status, geographic area of residence, whether you live in Portugal or abroad, educational level and professional status (Annex 1).

In this study, the face, content, and construct validity were performed (Polit & Beck, 2006; Kimberlin & Winterstein, 2008; Hertzog, 2008; Muhlenbock & Kokkinakis, 2009).

The data was collected from November 2016 to July 2017. A previous meeting was scheduled with those responsible for the services in the area of patient safety. In this meeting, the days and hours of data collection from users/patients were planned. The morning shift was selected for the administration of the questionnaires in the health centres and the CHUA E.P.E. The questionnaires were distributed on paper and by hand. Respondents completed the questionnaire using a self-administered technique (Streiner & Norman, 2015). It took about 20 minutes to be completed by respondents depending on the respondents' literacy level. The questionnaire was distributed to respondents and collected after completion.

For the analysis of qualitative data regarding the open questions of the questionnaires ("P7. In your opinion, what does patient/patient/user safety mean in a health unit?" and "P8. Do you want to give any suggestions at the individual level that contribute to the improvement of the safety of the patient/patient/user in the health unit?") content analysis procedures were carried out according to the categorical thematic technique, plus the lexical analysis of the corpus with computer support from Iramuteq.

Iramuteq is an open-source computer application that allowed the identification of the relevance of the lexicons of each thematic area of the corpus, thus complementing, on the one hand, the clarifications of meaning expressed in the quantitative results referring to the factor profiles extracted in the exploratory and confirmatory, and, on the other hand, allowed to disclose the main groupings of suggestions to be taken into account in a process of improving patient safety conditions in a health unit.

The following are the main features of the Iramuteq software:

- Iramuteq: R interface for all Multidimensional Analyzes by Textes and by Questionnaires
- free software (open source): developed in R (http://www.r-project.org) and the Python language (http://www.python.org), and is licensed in the form of open-source GNU GPL (v2)
- authorship: Pierre Ratinaud of Laboratoire d'Études et de Recherches Appliquées en Sciences Sociales, Toulouse-France
- access: download of the application for installation and tutorial in Portuguese are available on the internet at http://www.iramuteq.org/

For the lexicometric procedure of the corpus through Iramuteq, the procedures suggested by Camargo & Justo (2013) were taken:

- organization of the corpus in a * .txt file with variables and modalities.
- treatment of the corpus:
    a. a.The. construction of the dictionary of text segments;
    b. b. preparation of significant text units in Initial Context Units (UCI) and Elementary Context Units (UCE);
    c. initial extraction of the Zipf law diagram
        i. according to Zipf's law, formulated by George Kingsley Zipf, it is possible to predict that in a given text corpus the frequency of occurrence f (n) of a word is somehow linked to its order n in the order of frequencies as follows: f (n) = k / n, where k is a constant.
    d. creation of the stemming table (automatic motto creation process);
    e. calculation of classic textual statistics, through word frequencies, with graphic representation in word cloud;
    f. similitude analysis (association) between words, with a graphic representation of co-occurrences between words;
    g. descending hierarchical classification (CHD) of groupings of text segments, according to the calculation of distance matrices according to Reinert's method:
        i. Reinert's method: procedure for grouping or creating classes in an approximate way to ALCESTE (Analyze Lexicale par Contexte d'un Ensemble de Segment de Texte), or "Lexical Contextual Analysis of a Set of Text Segments";
        ii. Description and chi-square measurements ($\chi 2$) of the text segment classes;
        iii. Projection of classes in factorial plans.
    h. extraction of the specificities of the most significant text segments.

It should also be added that for the purposes of organizing and codifying the themes of the corpus, the following has been adapted:

- Theme 1: Perception of the meaning of patient/patient/user safety (P7. In your opinion, what does patient/user safety mean in a health unit?) - SIGSEG (P7: Theme 1: Patients/users)
- Theme 2: Suggestions for improving the safety conditions of the patient/user (P8. Do you want to give any suggestions at the individual level that contribute to improving the safety of the patient/ patient/user in the health unit?) - SUGMEL (P8: Theme 2: Patients/users)

Labels (variables and modalities):

id: identifier of the respondent to the questionnaire (respondent)
ent: respondent (- patient / patient / user)
sex: sex (1- male; 2- female)
idd: age
getar: age group (1- less than or equal to 30 years; 2- 31 to 40 years; 3- 41 to 50 years; 4- 51 or more years)
marital: marital status (1- single; 2- married or de facto union; 3- divorced / separated; 4- widowed)
educa: educational level (1- without schooling; 2- 1st Cycle (4th class); 3- 2nd cycle (6th class); 4- 3rd cycle (9th year); 5- Complementary Secondary Education; 6- Technical-Professional Course ; 7- Bachelor / High School; 8- Degree; 9- Postgraduate, Master or PhD)
Org Type: 1- hospital; 2- health center

Finally, the following references are added to interpret the outputs extracted through Iramuteq:

Interpretation of the theme info file (stat):
Resume
Nombre de textes (number of initial texts: UCI - initial context unit): n1
Name d'occurrences (number of occurrences): n2
Nombre de formes (UCE - elementary context unit): n3
Nombre d'hapax: n4 (a% of occurrences - b% of forms)
Moyenne d'occurrences par texte (average occurrences per text): n5
Interpretation of the profiles file extracted in the Reinert method:
n. (number of order of words in the table);
eff. st (number of text segments that contain the word in the class);
eff. total (number of text segments in the corpus that contains, at least once, the word cited);
percentage (percentage of occurrence of the word in the text segments in that class, in relation to its occurrence in the corpus);
chi2 or $\chi 2$ ($\chi 2$ of association of the word with the class);
Type (grammatical class in which the word was identified in the shape dictionary);
Form (identifies the word)
p (level of significance of the association of the word with the class).

Additionally, as this study was conducted in Portuguese it is important to note some aspects regarding the translation for the English version of this chapter. A language is not limited to a lexicon and the respective definitions, it also includes its context, and therefore when translating some terms from the analysis a direct translation was not appropriate. Per that, a subjective process was undertaken to select a synonym more adequate to the original term's meaning in context, when necessary. Furthermore, the original terminology is provided with its translation in order for readers to be able to interpret the figures, as they are on their original untranslated version.

RESULTS

Perception of Patients/Users About the Meaning of Patient/User Safety - SIGSEG (P7)

In the analysis of the open questions, it was identified that for patients the meaning of patient safety is related to the words' *safety*, *health*, *meaning*, *unit*, *professional*, *patient*, *doctor*, *patient*, *and tend to ("atender")*, as described in table 1 through the frequency of use and as can be seen in figure 1 by highlighting and formatting them in the word cloud. As mentioned in the previous paragraph, from the patients' point of view, patient safety is the result of an understanding of the meanings of the highlighted terms, as well as the effect on it as a result of the action in these categories.

Table 1. Perception of patients /users about the meaning of patient safety: Main lexical frequencies (active forms)

Formas Ativas	Active formes	nº.	Formas Ativas	Active formes	nº.
segurança	safety	27	Rápido	Fast	3
saúde	health	26	Resposta	Reply	3
significar	to mean	21	Relação	Relationship	3
utente	user	18	Relacionar	To relate	3
unidade	unit	18	Recorrer	To resort	3
profissional	professional	18	Querer	To want	3
paciente	patient	18	Precisar	Need	3
médico	doctor	18	Pedir	Ask	3
doente	patient	18	Nível	Level	3
atender	tend to/care for	16	Melhor	Better	3
tratamento	treatment	12	Importante	Important	3
sentir	to feel	11	Hospitalar	Hospital	3
atendimento	tend to/care for	11	Falta	Lack	3
seguro	safe	10	Exame	Exam	3
opinião	opinion	10	Erro	Mistake	3
confiança	trust	9	Educação	Politeness	3
situação	situation	8	Doença	Disease	3
dever	duty	8	Disponibilidade	Availability	3
cuidado	care	8	Diretamente	Directly	3
técnico	technician	7	Conhecimento	Knowledge	3
prestar	provide	6	Ajudar	Help	3

continues on following page

Table 1. Continued

Formas Ativas	Active formes	nº.	Formas Ativas	Active formes	nº.
diagnóstico	diagnosis	6	Vigiar	Watch	2
atenção	Warning	6	Transmitir	To transmit	2
adequado	adequate	6	Tranquilidade	Tranquillity	2
tratado	treated	5	Simpatia	Sympathy	2
pessoal	staff	5	Sector	Sector	2
físico	physical	5	Sentar	To sit	2
dúvida	doubt	5	Risco	Risk	2
correto	right	5	Responsável	Responsible	2
clínico	clinical	5	Recusar	Refuse	2
tratar	treat	4	Recurso	Resource	2
sair	get out	4	Queixa	Complaint	2
qualidade	quality	4	Público	Public	2
possível	possible	4	Psicológico	Psychological	2
maior	larger	4	Problema	Problem	2
humano	human	4	Privado	Private	2
forma	form	4	Privacidade	Privacy	2
esperar	wait	4	Prescrição	Prescription	2
entrar	get in	4	Preocupação	Concern	2
dar	to give	4	Necessário	Required	2
confiar	trust	4	Medicar	Medicate	2
caso	case	4	Linguagem	Language	2
analisar	analyze	4	Informar	Inform	2
urgência	urgency	3	Hora	Hour	2
serviço	service	3	Historial	History	2

Source: Corpus da P7; output Iramuteq formes_actives.csv

We can see in figure 2, that the relevant terms present in the word cloud and the frequency table are all interconnected, namely the evident link between *safety*, *health* and the *unit* with *patient*, *professional*, *doctor*, *to tend* and *to mean*. Associated with these more relevant terms, we have co-occurrences that are particularly highlighted, evidencing the existence of aspects of patient safety with their particular characteristics from the point of view of users.

Starting with the *security* aspect, we can see that there is an association with the words *always*, *opinion, feeling, duty* and *wanting*. It is demonstrated by the associations that patients highlight the constancy and obligation of the patient's safety (*always/duty*), the need for its search and visible application (*wanting/feeling*), and the importance of the perception of it by professionals and patients for its effectiveness (*opinion*).

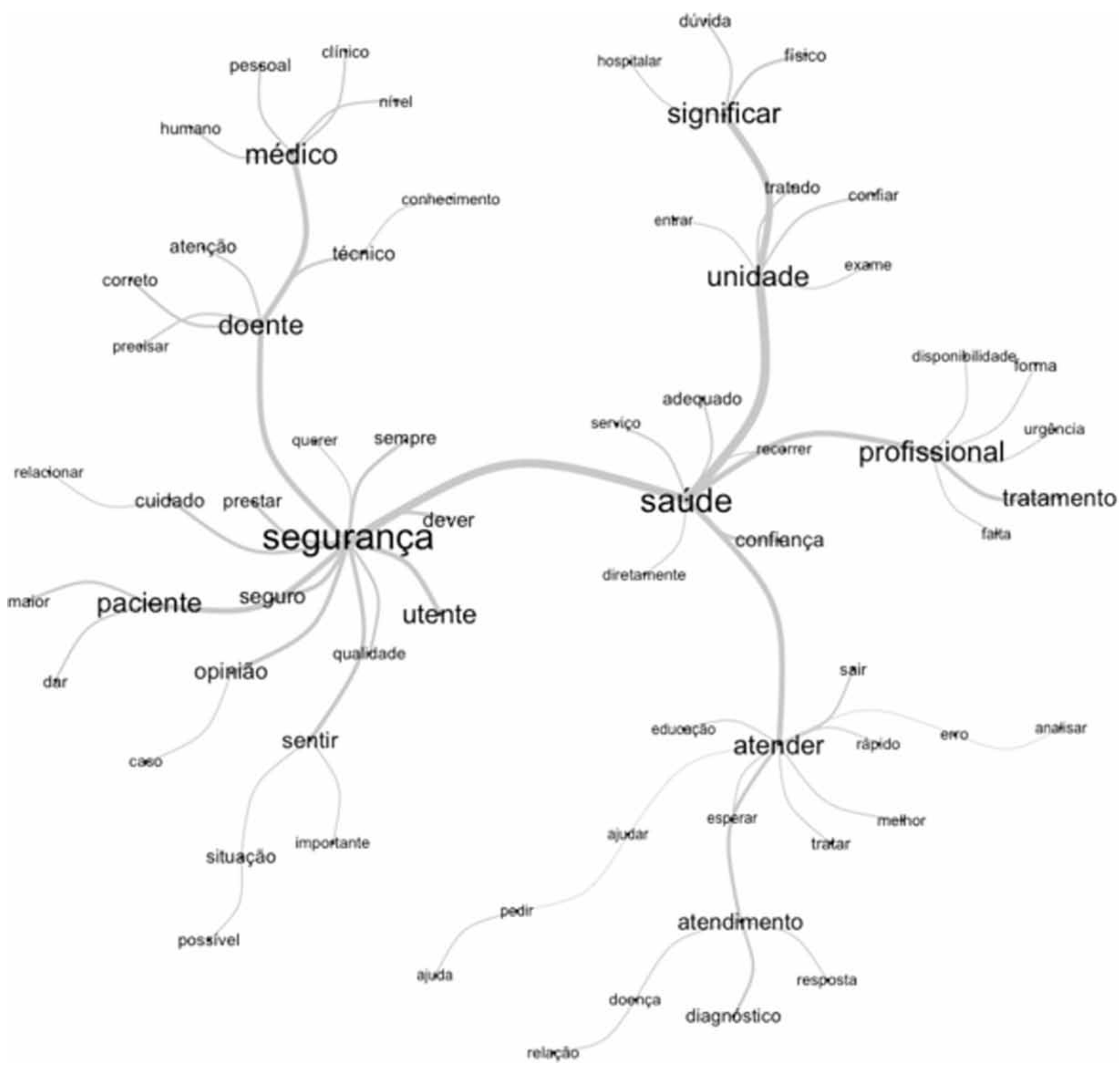
Figure 1. Perception of patients/users about the meaning of patient safety: Word Cloud
Source: Corpus da P7; output Iramuteq nuage_1.png

A *medical* aspect and a *patient* aspect are mentioned, which are associated with *human* and *personal*, respectively, *attention*, *technician,* and *knowledge*. These associations highlight that for the patient, patient safety involves the existence of professionals for each individual *(personal*) and the existence of a receptive and empathic nature on the part of the professionals (*human*), as well as the need to demystify care for the understanding of patients (*technician/knowledge*) and the provision of care completely focused on the patient (*attention).* The mention of the provision of *attention* is made by mentioning the aspect described in the previous paragraph and with the words "*atender" and "atendimento*" (both expressing the concept of tending to/care for someone), the first connected with *politeness*, *fast*, *better*, *error* and *analysis*, and the second associated with *response*, *diagnosis, disease* and *relationship*. The first set suggests that it is crucial for patients to have cordial service (*politeness*), efficient working hours (*fast*), improving service and performance evolution through the identification of failures (*better/error/analyse*). The second set, on the other hand, suggests the need for specialization in the clinical care provided (*diagnosis/relationship/disease/response*).

In the *health* aspect, the words *trust*, *directly*, *appropriate*, *resort* and *service* are used by patients, indicating that the patients' perception defines the existence of easily accessible care (*service/resort/directly*) and the existence of relevant services for the patient's safety, emerging from the belief in the value and effectiveness of the care provided (*trust/adequate*).

In the *unit* aspect, there is an association with the words *treated*, *examination* and *trust*, and also with the word *meaning* that associates itself with *physical*, *hospital* and *doubt*. This type of composition identifies that users define their safety as being informed in order to understand their care (*hospital/ doubt/physical/trust*) and that it also depends on the resources and procedures in the care (*treatment/ examination*).

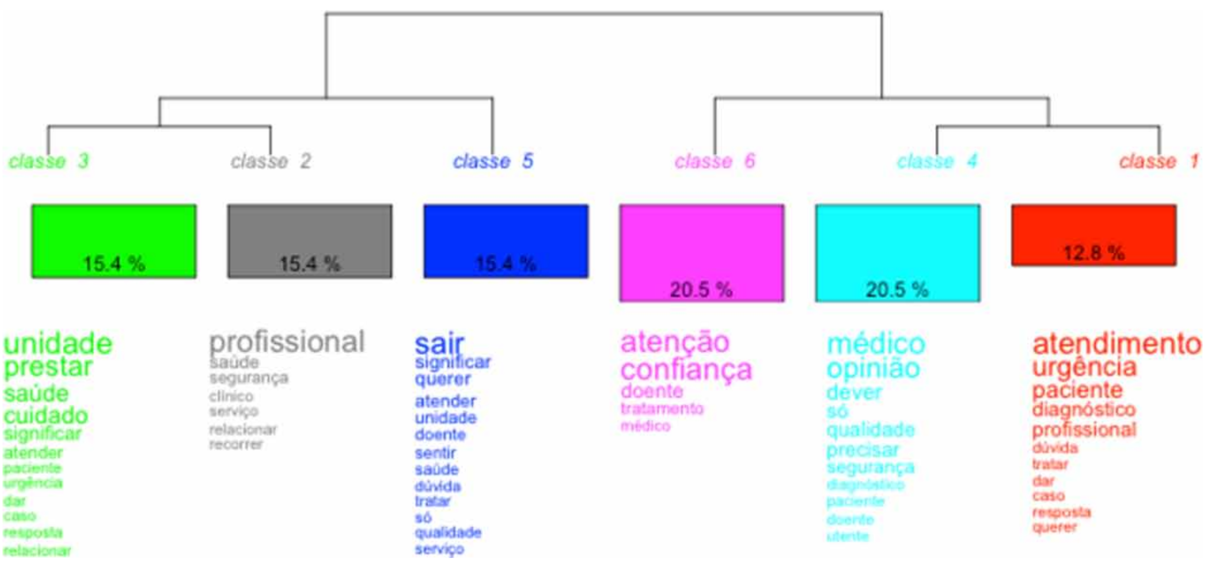
Figure 2. Perception of patients/users about the meaning of patient safety: Similitude (co-occurrences).
Source: Corpus da P7; output Iramuteq arbre maximum - graph_simi_1.png



Perception of Patients/Users about the Meaning of Patient Safety: Classes of Lexical Groupings

The dendrogram of the lexical group classes was performed regarding the users' perception of patient safety as seen in figure 3. Taking into account the co-occurrences already verified, it was possible to identify 6 groups of word classes organized according to the descending hierarchical classification technique. Regarding patients/users, classes 4 and 6 stand out and in which the words *doctor* and *opinion* are highlighted in class 4, and in class 6 we have the words *attention* and *confidence*. Then we have classes 2, 3 and 5 in which the words *professional*, *health* and *safety* stand out, in 2, the words *unit*, *providing* and *health*, in 3 and the words *leave*, *mean* and *want*, in 5.

Figure 3. Perception of patients/users about the meaning of patient safety: Dendrogram of Classes of lexical clusters.
Source: Corpus da P7; output Iramuteq dendrogramme_1.png



Clusters 4 and 6 are composed of 8 relevant words in a total of 39 and which correspond to 41% of the weight of the mass of information, in turn, Cluster 2 is composed of 6 words in a total of 39 and corresponds to 15. The set of these 3 lexical groupings (4, 6, 2) represent 69% of the weight of the mass of information (Table 2).

In figure 4 we can see the factorial projection of the lexical group classes, the perception of patients / professional patients about patient safety in which class 4 is located in the 2nd quadrant and class 6 in the 3rd quadrant.

It is possible to find in the projections two factors, factor 1 and factor 2, which represent 53.7% of the importance of the aggregation of words (Table 3).

Theme 2: Suggestions from Patients/Users to Improve the Safety Conditions of the Patient/User - SUG-MEL (P8)

Table 2. Perception of patients/users about the meaning of patient safety: Characteristics of the Class profile of lexical groupings.

	eff.s.t.	eff.total	%
Cluster 4	8	39	20.51
Cluster 6	8	39	20.51
Cluster 2	6	39	15.38
Cluster 3	6	39	15.38
Cluster 5	6	39	15.38
Cluster 1	5	39	12.82

Source: Corpus da P7; output Iramuteq profiles.csv

Figure 4. Perception of patients/users about the meaning of patient safety: Factor projection of the classes of lexical clusters
Source: Corpus da P7; output Iramuteq AFC2DL.png

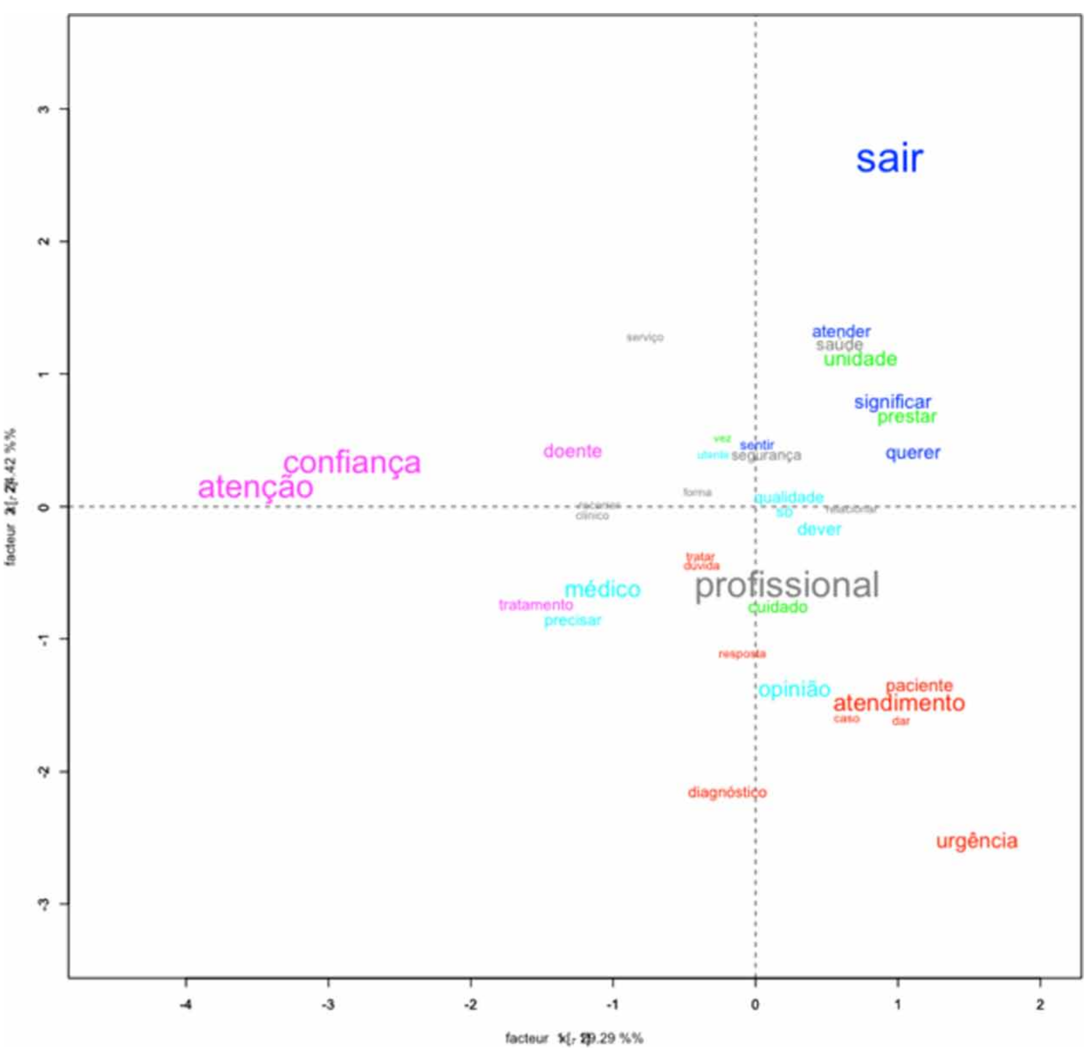


Table 3. Perception of patients/users about the meaning of patient safety: Factorial weight of the classes of lexical groupings

	Valeurs propres	Pourcentages	Pourcentage cumules
Facteur 1	0.320061164	**29.28601134**	29.28601134
Facteur 2	0.266880491	**24.41991082**	53.70592215
Facteur 3	0.214388048	19.6167842	73.32270636
Facteur 4	0.183587423	16.79848715	90.1211935
Facteur 5	0.107963569	9.878806495	100

Source: Corpus da P7; output Iramuteq afc_facteur.csv

In the analysis of the open questions, it was identified that for patients the improvement of the patient's safety conditions is related to the words *user*, *professional*, *wait*, *duty*, *hospital* as described in table 113 through the frequency of its use and how it is possible to observe in figure 13 by highlighting and formatting them in the word cloud.

As mentioned in the previous paragraph, from the point of view of patients the evolution of patient safety is the result of an understanding of the meanings of the highlighted terms, as well as of the intervention and improvement in these categories.

Table 4. Suggestions from patients/users to improve patient safety conditions: Main lexical frequencies (active forms)

Forma Ativa	Active Formes	nº.	Forma Ativa	Active Formes	nº.
Utente	User	16	Mesmo	Same	2
Profissional	Professional	15	Melhor	Better	2
Esperar	Wait	10	Mau	Bad	2
Paciente	Patient	9	Maior	Larger	2
Médico	Doctor	7	Horário	Schedule	2
Doente	Patient	7	Ficar	Stay	2
Dever	Duty	7	Familiar	Familiar/Relative	2
Saúde	Health	6	Faltar	Miss	2
Hospital	Hospital	6	Falta	Lack	2
Forma	Form	6	Falar	Speak	2
Tratamento	Treatment	5	Existir	Exist	2
Atendimento	tend to/care for	5	Doença	Disease	2
Pessoal	Staff	4	Distância	Distance	2
Pensar	Think	4	Dificuldade	Difficulty	2
Exame	Exam	4	Devido	Due	2
Diminuir	Decrease	4	Dar	To give	2
Consulta	Appointment	4	Continuar	Continue	2
Atender	tend to/care for	4	Condição	Condition	2

continues on following page

Table 4. Continued

Forma Ativa	Active Formes	nº.	Forma Ativa	Active Formes	nº.
Unidade	Unit	3	Comunicação	Communication	2
Técnico	Technician	3	Colocação	Placing	2
Sugestão	Suggestion	3	Caso	Case	2
Serviço	Service	3	Atenção	Heads up	2
Seguro	Safe	3	Aprender	Learn	2
Segurança	Safety	3	Apoio	Support	2
Pouco	Little	3	Alguma	Some	2
Material	Material	3	Ainda	Yet	2
Importante	Important	3	Adequado	Adequate	2
Formação	Training	3	Acontecer	Happen	2
Exemplo	Example	3	Acompanhamento	Follow-up	2
especialidade	speciality	3	Ajuda	Help	1
Vir	To go/come	2	Área	Area	1
Triste	Sad	2	Zeloso	Zealous	1
Situação	Situation	2	Vontade	Will	1
Simpatia	Sympathy	2	Voltar	Come back	1
sentir	to feel	2	Vigilância	Surveillance	1
sempre	always	2	Ver	To see	1
sangue	blood	2	Vazão	Handle (able to)	1
relativo	relative	2	Urgência	Emergency	1
questão	question	2	Urgente	Urgent	1
querer	to want	2	Turno	Shift	1
opinião	opinion	2	Tratar	Care	1
número	number	2	Transporte	Transport	1
necessário	required	2	Transfusão	Transfusion	1
necessidade	need/necessity	2	Transcender	Transcend	1
muita	many	2	Total	Total	1

Source: Corpus da P8; output Iramuteq formes_actives.csv

We can see in figure 6, that the relevant terms present in the word cloud and the frequency table are all interconnected, namely, the evident connection between *user*, *professional*, *waiting*, *duty* and *hospital*. Associated with these more relevant terms, we have co-occurrences that are particularly noteworthy, evidencing the existence of strands that require improvement with their particular characteristics from the users' point of view.

Starting with the *professional* aspect, we have an association with the terms *examination*, *consultation*, *treatment*, and *training*. With the aforementioned associations, patients identify that improving patient safety depends on the preparation of professionals (*training*) and the form of application of care (*treatment/examination/consultation*). Then, the association of the word *user* with the words *speciality*

Figure 5. Suggestions from patients/users to improve patient safety conditions: Word Cloud
Source: Corpus da P8; output Iramuteq nuage_1.png

and *unit* is observed, suggesting that for users the improvement is dependent on the availability of care (*unit*) and specific care (*speciality*).

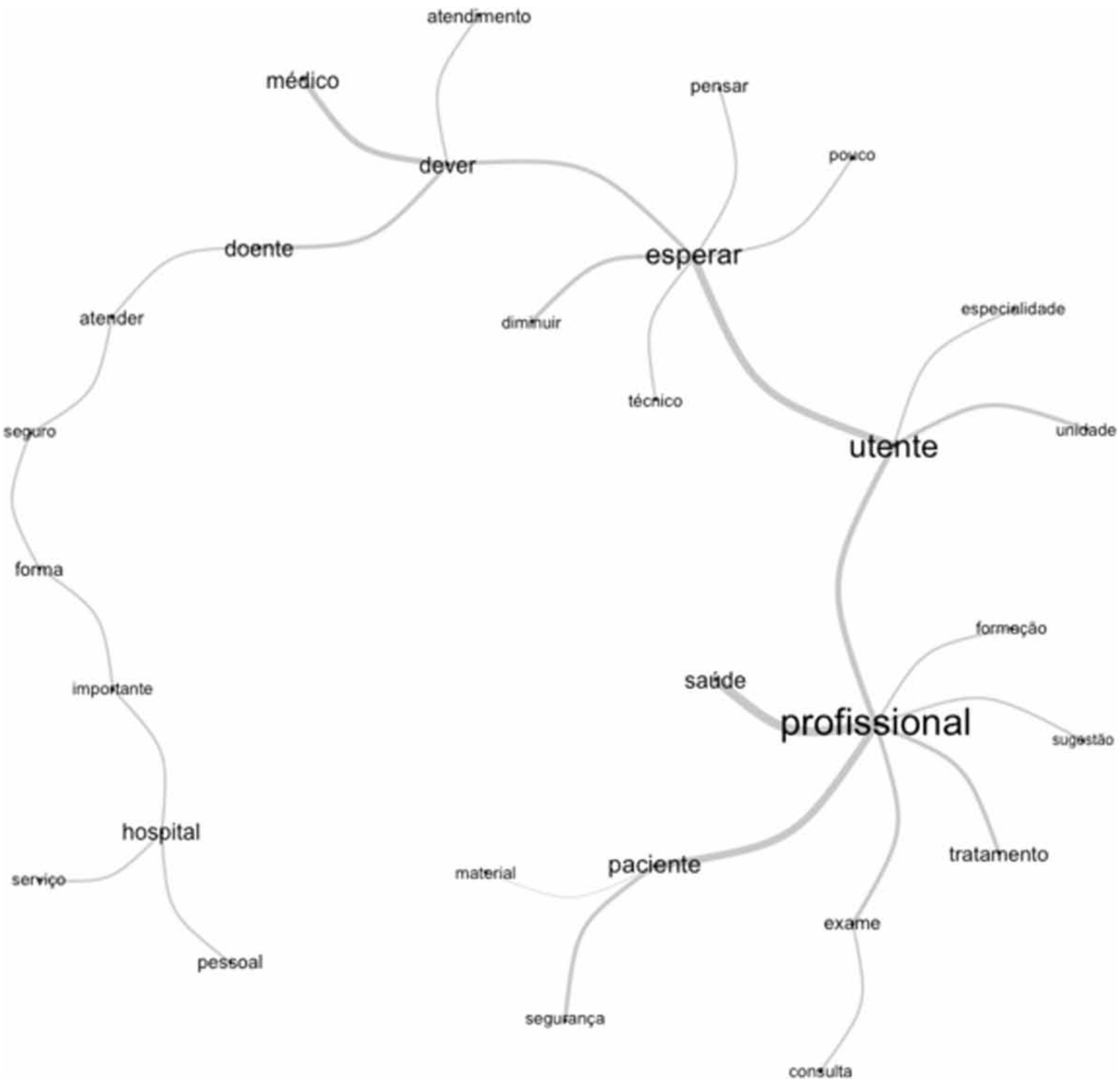
It also denotes the interconnection of the word to wait with the words *little*, *diminish* and *think*. Evidencing that the users consider crucial to the evolution of the security conditions the increase of the efficiency and resources of the health system (*decrease/little*) and the consideration in the use of these (*think*).

There is a branch of the scheme that has a strand directly associated with the word *hospital* where it co-occurs with the words *important*, *service* and *personnel*, connections that echo the need for human resources (*personnel*) and the valuation and emphasis on health units (*service/important*) as important factors in improving patient safety conditions.

Suggestions of patients/users for the improvement of patient safety conditions: Classes of lexical clusters

Cluster 1 is composed of 5 words in a total of 8 and corresponds to 62.5% of the weight of the mass of information, in turn, Cluster 2 is composed of 3 words in a total of 8 and corresponds to 37.5% of the weight of the mass of information (table 5).

Figure 6. Suggestions from patients/users to improve patient safety conditions: Similitude (co-occurrences)
Source: Corpus da P8; output Iramuteq arbre maximum - graph_simi_1.png



DISCUSSION

Our investigation goes beyond the conservative approach that is performed to PS, for the first time it was intended to close the cycle of actors, by "listening" to the main interested party for whom the health system was created, the Patient. Similar to what is done for Professionals, recognizing at once that their constructs on PS are of a different matrix. The professionals' knowledge is based on their academic training with the permanent changes resulting from the evolutionary process of the health context and their continuous training. On the other hand, a Patient's starting point is the naive conception that is built on the assumption of complete surrender to a team of health professionals who are present to serve him, a transfer of autonomy that he is generally willing to accept.

Figure 7. Suggestions of patients/users for the improvement of patient safety conditions: Dendrogram of Classes of lexical groups.
Source: Corpus da P8; output Iramuteq dendro1.png

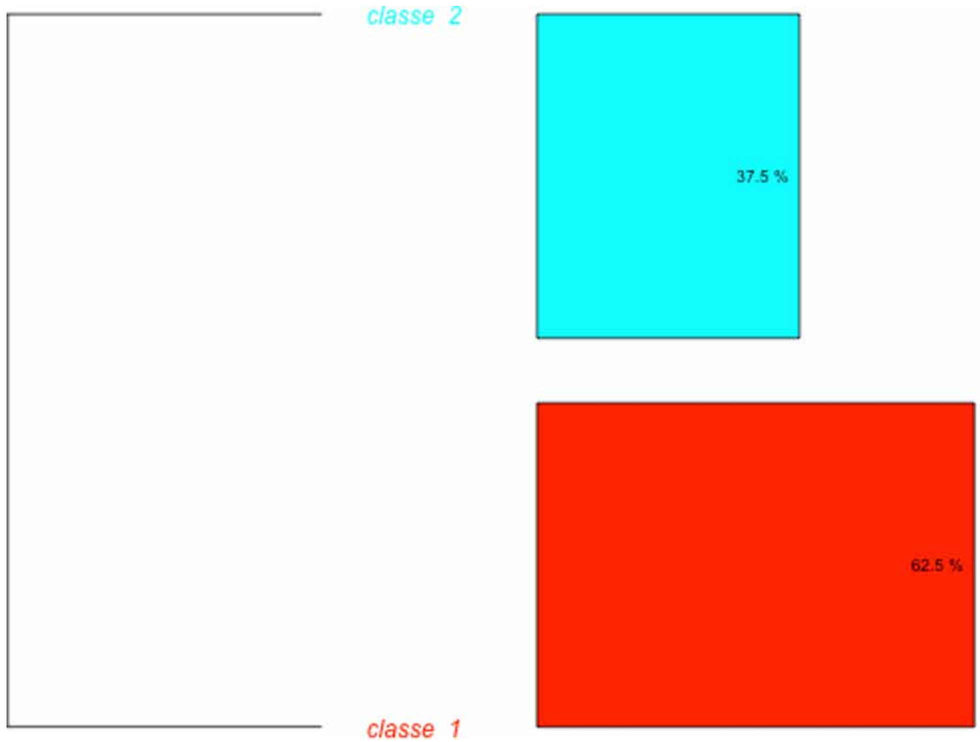


Table 5. Suggestions of patients/users for the improvement of patient safety conditions: Characteristics of the lexical group Classes' profile

	eff.s.t.	**eff.total**	**%**
Cluster 1	5	8	62.5
Cluster 2	3	8	37.5

Source: Corpus da P8; output Iramuteq profiles.csv

The patient's perspective on his/her safety, when subjected to the provision of health care, is a unique contribution, because, for the first time, the interested party in ensuring that the health system works at its fullest is heard.

It is the communion of interests of Patients and Professionals in PS that was at the origin of this work, and taking that into account, the discussion of results will be carried out in three sub-chapters, a first where the perspective of the Patient regarding PS is addressed, a second where the perspective of the Professional regarding PS will be approached, and finally the third sub-chapter where we will discuss the results obtained by the Professionals and Patients simultaneously with a particular focus on the analysis of the content of the open questions.

The Evaluation of the users' perception of safety is a factor currently considered relevant for the improvement of healthcare provision, something that appears as a new trend, contrasting with the most dated evaluations that excluded the patients' perspective regarding the quality of their care. "The patient's experience is increasingly recognized as one of the three pillars of quality in health, along with clinical efficacy and patient safety." (Doyle, Lennox & Bell, 2013), however, this experience is difficult to assess.

Patients have little knowledge about aspects of technical quality, but in general, they have no difficulties in assessing the interpersonal side (Urdan, 2001).

Self-administered questionnaires are used as a tool for collecting information in studies that aim to get to know a sample of a population based on a set of questions on a topic, in a short period of time. The limitations of this type of instrument are known, of which the loss of interest by the respondent is highlighted due to the high number of questions and the indications imposed by them.

The Culture of PS – Patients

The results obtained with the application of the questionnaire "Multidimensional approach to patient safety in public sector health institutions in the Algarve region - Portugal" (AMSDISRA) allow us to observe the perception that participating users have on the different topics related to the culture of patient safety, which includes the management and organization of the health unit, the experience and occurrences during the stay in the health unit, experience with clinical error.

Regarding the perception of the users in our study concerning the management and organization of the Health Unit, to the question "Do you think that during your stay in the health unit you were provided with health care in a safe way", 34.4% of the patients fully agree (average score of 8.16), only 1.2% disagree on the safe provision. At the hospital, 45.2% answered that they completely agreed, although at the health centres this percentage decreased to 14%. However, if we analyse the responses of users in the range of 8 to 10, the percentages of satisfaction present values of 75.1% and 63.1%, respectively. For comparison, data from the study by Mira, Vitaller, Lorenzo, Royuela, Pérez-Jover & Aranaz, (2012), indicate that less than half of Spaniards expect clinical errors to occur, while most believe they are unlikely.

An editorial by Paterson (2013) drew attention to the fact that patients' complaints are "canaries in the coal mine" that should alert us to the most profound problems and should not be ignored. In another editorial Gallagher, Mello, Levinson, Wynia, Sachdeva, Sulmasy… Arnold, (2013) focuses on the need to end the clinicians' silence, stressing the importance of clinicians talking about this subject, thus improving their care and communicating better. Sometimes, patients' complaints go elsewhere (for example, to state health departments, professional disciplinary bodies, medical societies, etc.) and there is no feedback on the complaint, or it is late and its statistics are not always disclosed.

Opinion on the Meaning of Patient Safety in a Health Unit

For patients, the relevant terms that are interconnected, namely the evident connection between *safety*, *health* and *unit* with *patient*, *doctor* and *professional*, are in line with what was mentioned by Donabedian (1985), in which patients in their majority are unaware of details of the technical domain of the care provision, however, they consider it to be important, particularly in situations that pose a clear threat to their health and well-being. In general, the patient assesses the technical quality of care indirectly, based on evidence of the professionals' interest and concern with their health and well-being.

Associated with these more relevant terms, we have co-occurrences that are particularly highlighted, evidencing the existence of aspects of patient safety with their particular characteristics from the point of view of users.

Starting with the *security* aspect, we can see that there is an association with the words *always*, *opinion*, *feeling*, *duty* and *wanting*. It is demonstrated by the associations that patients highlight the constancy and obligation of the patient's safety (*always/duty*), the need for its search and visible application (*wanting/feeling*), and the importance of the perception of it by professionals and patients for its effectiveness (*opinion*).

Collier, Sorensen & Iedema (2016), in a qualitative study carried out in patients with prolonged illness (n = 29) and family members (n = 5) in Australia on the perspectives of safety and quality, says that for these patients the safety of the patient remains important for terminally ill patients and family members. For these patients, iatrogenic damage is not considered a "single" incident. On the contrary, the damage is experienced as a result of a series of negative events. The iatrogenic damage is emotional, social and spiritual, and not just a technical-clinical misfortune and is linked to the feeling of insecurity. Thus, patient safety extends beyond strictly defined technical-clinical parameters to include interpersonal safety.

In our study, a *medical* aspect and a *patient* aspect are mentioned, which are associated with *human* and *personal*, respectively, *attention*, *technician* and *knowledge*. However, the attempt to provide patient-centred care should prevail, where the patient's voice is valued and respected. It assures better communication between the provider and the patient, which is the number one factor that contributes to the avoidance of adverse events or damage. It establishes trust and provides a "check and balance" for both parties involved (Hovey & Apilian 2014).

The mention of the provision of attention is made by mentioning the aspect described in the previous paragraph and the words "*atender" and "atendimento*" (both expressing the concept of tending to/care for someone), the first connected with *education*, *fast, better, error* and *analysis*, and the second associated with *response*, *diagnosis*, *disease* and *relationship*.

In the *health* aspect, the words *trust*, *directly*, *appropriately*, *resort* and *service* are used by patients, indicating that the patients' perception defines the existence of easily accessible care as relevant to patient safety. Accessibility to health care is one of the factors pointed out by Donanbedian (1980), as a determinant in the quality of health care provision at the community level, particularly concerning access costs.

In the *unit* aspect, there is an association with the words *treated*, *examination* and *trust*, and also with the word *meaning* that it associates itself with *physical*, *hospital* and *doubt*. This type of composition identifies that users define their safety as being informed in order to understand their care (*hospital/doubt/physical/trust*) and that this also depends on the resources and procedures in the provision (*treatment/examination*).

In the research study "Improving Patient Safety Through Provider Communication Strategy Enhancements" conducted by Dingley, Daugherty, Derieg & Persing, (2008), the analysis of 495 communication events after the implementation of the toolkit revealed a decrease in treatment time, an increase in of nurses' satisfaction with communication and higher rates of resolution of post-intervention patient problems. The resulting toolkit provides healthcare organizations with the means to implement teamwork and communication strategies in the context of care delivery.

Finally, we highlight the *professional* aspect associated with the co-occurrences of *availability*, *form*, *urgency*, *treatment* and *lack*. These state that the patient defines the existence of patient safety with the existence of sufficient human resources (*lack/availability*) and their ability to respond immediately (*urgency*), as well as the existence of adequate care provision (*form/treatment*).

Suggestions for Improving Patient Safety at the Health Facility

Regarding the suggestions for improvement on the part of the patients, we can see that the relevant terms present in the word cloud are all interconnected, namely, the evident connection between *user*, *professional*, *waiting*, *duty* and *hospital.*

The concern on the part of patients with the reduction of waiting times is notorious as an element that contributes to the improvement of the provision of care.

Starting with the *professional* aspect, we have an association with the terms *examination*, *consultation*, *treatment,* and *training*. With the aforementioned associations, patients identify that improving patient safety depends on the preparation of professionals (*training*) and the form of application of care (*treatment/examination/consultation*).

There is a strand directly associated with the word *hospital* where it co-occurs with the words *important*, *service* and *personnel*, connections that manifest the need for human resources, professional valorization and the emphasis on health units as important factors in improving the safety conditions of the sick.

There are several studies (Brasaite et al., 2016; DGS, 2015, 2017), which report the need to increase the continuing education of professionals, improving the provision of care through the adoption of new technologies that allow/free professionals to have more time in contact with patients, in conjunction with the increase in the number of professionals. The analysis of the open questions in our study for professionals revealed that the need for training, resources and changes at the service level (organization) improved the patient's safety conditions.

In our study, we can find the *safety* aspect interconnected with the words *improvement* and *diagnosis*, identifying that from the perspective of professionals it is required a reliable clinical assessment of patients (*diagnosis*) as well as an evolution of safety in general (*improvement*). These results are in line with those described in the research work of Singh, Graber, & Hofer (2016), on "Measures to Improve Diagnostic Safety in Clinical Practice".

There is also a *health* aspect associated with the words *humanization*, *existence* and *unit*. Professionals thus suggest that more sensitivity is needed in the manner of providing health care, more health services and more health in general, this last one possibly referring to healthier habits on the patient's part. Medeiros et al. (2016) note that the humanizing dimension is based on the creation of workspaces/environments that value the daily practice of professionals, with an emphasis on relational technologies, such as listening, welcoming, dialogue as well as negotiation for production and care management.

Some Concern is expressed about the *service* aspect, the professionals suggest interventions with co-occurrences such as *urgency*, *involvement* and *increase*. They consequently identify that intervention in care in situations of immediate need is relevant, the practice of unifying policies and strategies for staff, and the increase in the capacities of the health system.

As previously mentioned, the training aspect is pointed out by professionals as an aspect in great need of improvement, in their view, there is a need for diversification of the education provided to the professionals.

CONCLUSION

The illiteracy of the public regarding the subject of patient safety culminates in a lack of interest in participating in the study due to the belief that because of its lack of knowledge its opinion is not accounted for in the improvement of the care provided, this is a crystallized paradigm.

Despite the manifest dissatisfaction, there is a fear of reprisals or damage to future health care. Users with greater academic differentiation report to the Ministry of Health, Professional Orders and Regulatory Entities, instead of doing so in the first instance to the units that provided them with health care. As a result, responses appear late or are lost in the bureaucratic chain of public administration.

Most respondent users rely, with "closed eyes", on the technical capacity of professionals, even though they have some discredit in the form of institutional organization. It was also clearly evidenced that patients do not have an effective intervention in risk management solutions, and most of them are not an integral part of it.

Even though the implementation of patient safety programs based on cultural change, notification systems, risk assessment and audits is increasing in the health units evaluated, a strong investment in human factors (with the involvement of all stakeholders), effective communication and education are still necessary for patient safety.

RECOMMENDATIONS

The Health Units must consciously assess all their needs regarding the lack of human resources, the lack of elements and the work overload not only accentuate the failures but do not allow the satisfaction of the professionals and constrains the attention/service to the user/patient.

Encourage the notification of patients regarding events and the creation of feedback mechanisms regarding the treatment/evaluation of the events identified by them, the creation of a patient's office, thus enabling the effective participation of patients and their families in the entire care process.

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Chapter 12
Fall Prevention Activities and Resources in Norway:
A Review

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ABSTRACT

The relevant literature review was conducted to determine current knowledge and practices related to adult fall prevention in Norway. It included scientific publications on studies and tools. The review was extended to include the clinical studies and resources offered by the healthcare sector that was made publicly available on their websites. Results are presented in tables structured to show study objectives, approach, and results. The information offered to patients is presented per region and hospital. During the period of the last 20 years, there were numerous studies and useful information offered to the public. There is also one fall prevention program assessed in a dedicated study.

INTRODUCTION

Fall prevention and healthy aging form the areas of national interest with dedicated resources that are maintained by several stakeholders. The Norwegian Directorate publishes regular reports and distributes them to various healthcare municipalities to support their focus on the prevention and healthy aging. The authority empathizes the importance of multi-disciplinary, systematic prevention and health promotion. Many Norwegian municipalities and hospitals are compliant with that strategy and offer their information and advice for prevention, especially regarding hospital visits and treatments.

Healthcare professionals have conducted numerous studies and trials relating to falls. The outcomes are concerned with the effects and factors related to the success of prevention programs, as well as underlying clinical situations, measures taken to treat, educate, improve cost-benefits of patient care.

There are also web-based and mobile tools for patient education developed to increase patient's mobility through training and increased awareness of risk factors.

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The purpose of this chapter is to provide an overview of the most relevant literature findings on fall prevention studies and resources.

METHODS

A systematic information search was done to identify the national websites offering information to patients, such as municipalities and hospitals. Information retrieval was performed using standard web search engines.

A systematic literature review was conducted combining keywords such as fall prevention, studies, tools, and Norway. Clinical trials were also reviewed using the dedicated website (*ClinicalTrials.gov*) to include trials, completed and ongoing in Norway. The search and review focused on the publications and information published of last twenty years but included a few relevnat older research papers.

Table 1. Clinical trials on fall prevention in Norway

Research Topics	Objectives	Intervention (Number of patients enrolled)	Result Summary
The Effects of a Fall Prevention Program on Falls, Patient Safety Culture and Patient-perceived Safety. Two Cross-sectional Studies in Two Orthopedic Departments (Røyset et al., 2019)	— The primary outcome was the rate of fallers. — Secondary outcomes were the employees' perceived patient safety culture (measured with the Safety Attitudes Questionnaire) and patient-perceived safety (measured with Norwegian Patient Experience Questionnaire) — Publication Year: 2019	Behavioral: fall prevention program (3143)	— Falls were registered in 114 out of 3,143 patients (3.6%) with 17,006 days in the hospital. Ten patients had two falls, giving a fall rate of 7.3 falls/1,000 days in the hospital. — The fall prevention program revealed no significant effect on the rate of fallers, the patient safety culture, or patient-perceived safety.
Effect of a Falls Prevention Exercise Program on Health-related Quality of Life in Older Fallers Receiving Home Care. A Randomized Controlled Trial(Bjerk et al., 2019)	— This study explored the effects of a falls prevention exercise programme on health-related quality of life (HRQOL), physical function and falls self-efficacy in older fallers receiving home care. — Publication year: 2019	Other: Exercise and education (155)	— **I**ntention-to-treat analysis showed that, compared to the control group, the intervention group improved on SF-36's physical component summary as well as BBS. However, the intervention group also demonstrated a decline in the mental health subscale of SF-36. — **A f**alls prevention exercise programme based on OEP significantly improved physical HRQOL and balance in older adults receiving home care
Early Identification and Intervention in Risk of Falling Among Seniors in Bomlo Municipality	— Fall-related injuries identified in electronic patient record in primary care — Not published yet.	Behavioral: Physical exercise (20)	— Study ongoing.
Evaluation of Strong & Steady: A Group Exercise Program for Preventing Functional Decline and Falls Among Community Dwelling Older Adults	— The aim of the study is to investigate the effect of Strong and Steady (S&S) group exercise on fall risk and physical function among community-dwelling older adults over 12 months. A pre-post test study deign will be used. — Not published yet.	Behavioral: Strong & Steady exercise program Estimated: (186)	— Recruitment ongoing

RESULTS

Four tables are presenting results structured as following:

Table 1 presents clinical trials on fall prevention in Norway;
Table 2 presents fall prevention information provided in Norwegian hospital websites;
Table 3 presents fall prevention among the elderly in Norway;
Table 4 presents fall prevention smartphone applications and gamification in Norway from 2010 to 2021.

Table 2. Fall Prevention information provided in Norwegian Hospital Websites

Category	Place	Information provided	Mode of information dissemination	Facility
Generelle Helsetjenester	At Home	— So often you should exercise — Exercise for you who are a little unstable when you walk — Training for you who use aids when you walk — Training for the elderly in care homes	-Webpage instructions -Use of pictorials -Brochures	Helse Norge (Helsenorge, 2019)
Generelle Helsetjenester	Outdoors	— Exercises to prevent falls - for you who feel a little unstable when you go outdoors — Exercises to prevent falls - for you who need aids when you go outdoors — Exercises and activities to prevent falls in the elderly with extensive need for help - guidance for health professionals and relatives in care homes and institutions	-Brochures	Helse Direktoratet (Helsedirektoratet, 2016)
Helse Sør-Øst RHF	At Home	— Falls - advice on how to help you avoid falls — Together for patients with falls at home - a new health service for the elderly living at home — The project has been awarded NOK 1,230,000. Innovation projects Development of a new service model to ensure that a) fall prevention measures in the first known fall are implemented, b) the patient is assessed according to common criteria, c) the patient receives fewer unnecessary hospital stays, d) specialist functions are moved out of the hospital, and e) a more cost-effective service can be offered by providing a more patient-oriented offer at a lower level of service.	-Web page -Innovation projects	Sykehuset i Vestfold: (Sykehuset i Vestfold, 2017), (Sykehuset i Vestfold, 2018)
Helse Sør-Øst RHF		Osteoporosis information		Sørlandssykehuset: (Sørlandet sykehus, 2020)

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Table 2. Continued

Category	Place	Information provided	Mode of information dissemination	Facility
Helse Sør-Øst RHF	Hospital	Prevention of falls in health institutions — Why fall prevention? — Measures to prevent falls	-Web page -Package measures which include: (i)Tools: — Driver — (ii) Knowledge base (iii) Professional resources and information materials	Lovisenberg diakonale sykehus (Lovisenberg Diakonale Sykehus, 2021)
Helse Sør-Øst RHF	Deacon's Home	Health services for the elderly (HTE) Focus areas for HTE 2016 - 2022 -Research, Professional Development, Knowledge Sharing Be a voice for quality in the health of the elderly internally and externally by focusing on -Prevention of falls and fractures in the elderly	Web page Health service	Diakonhjemmet sykehus (Diakonhjemmet Sykehus, 2020)
Helse Sør-Øst RHF	Hospital	Hip fracture -investigation and treatment People fall inside when it snows outside - Increases more indoors than outdoors - Most hip fractures indoors - Relationship between weather and hip? Osteoporosis treatment -Referral and assessment -Investigation -Treatment Non-drug measures (things you can do yourself) Medical treatment	News Webpage	Akershus universitetssykehus (Akershus universitetssykehus, 2020), (Akershus universitetssykehus, 2018)
Helse Sør-Øst RHF	Home	Fall prevention Good advice and measures you can do yourself. — What increases the risk of falls? — Medications can also be a contributing factor to falls — What can you do yourself? — Vision is normally reduced with increasing age — Poor nutrition can also be a cause of falls — The home can contain many "stumbling blocks" — "Hurry is load" — Good shoes are important to avoid falls	Webpage	Oslo universitetssykehus HF (Oslo-universitetssykehus, 2017)

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Table 2. Continued

Category	Place	Information provided	Mode of information dissemination	Facility
Helse Sør-Øst RHF	Home	Fall prevention Good advice and measures you can do yourself. — What increases the risk of falls? — Medications can also be a contributing factor to falls — What can you do yourself? — Vision is normally reduced with increasing age — Poor nutrition can also be a cause of falls — The home can contain many "stumbling blocks" — "Hurry is burden" — Good shoes are important to avoid falls	Webpage	Vestre Viken HF (Vestre Viken, 2017)
Helse Sør-Øst RHF	Hospital	2019 Fall in hospital	-Articles	Sykehuset Telemark HF (de Groot et al., 2020)
Helse Vest RHF Rogaland og Vestland.	Home	To you who have fallen or who are prone to falls - Causes of falls *Walking aids* *How to prevent falls in the event of a fall?* Home exercises are suggested.	-webpage -Pictorials - Checklist for prevention of falls and fall injuries	Helse Stavanger: (Helse Stavanger, 2020)
Helse Midt-Norge RHF	General	Competence center for movement difficulties and falls in the elderly Manuals and exercises -Otago exercises -Otago Manual -Helbostadøvelsene Mapping tool	-Webpage -Pdf documents -videos - Manuals and exercises -Mapping tool	St. Olavs Hospital (St. Olavs hospital, 2017)
Helse Midt-Norge RHF		Chronicle: Osteoporosis - a serious disease	Web page news	Helse Møre og Romsdal (Helse Møre og Romsdal, 2019)
Helse Nord RHF	Hospital	The patient falls Assessment and measures -Use of electronic boards -Increase in patient supervision Osteoporosis -Referral and assessment -Investigation -Treatment Non-drug measures (things you can do yourself) Medical treatment	Webpage	Nordlandssykehuset: (Nordlandssykehuset, 2021)
Helse Nord RHF	Hospital	New technology can reduce fall injuries -Motion sensors in bed mats and walking alarms, as well as sensors for anonymised digital surveillance in patient rooms, constitute the technology being tested.	-Technology https://www.pingvinavisa.no/ny-teknologi-kan-redusere-fallskader/	Universitetssykehuset i Nordland: (Nordlandssykehuset, 2021)

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Table 2. Continued

Category	Place	Information provided	Mode of information dissemination	Facility
Helse Nord RHF	Living at home under the auspices	The wave of strength: Fall prevention group services for the elderly The strength wave is suitable for you who meet some of the criteria below ● Want to learn more about how to exercise to prevent falls and function better in everyday life. ● Feeling a little unsteady and wanting to get better balance. ● Has fallen or is in danger of falling. ● Has noticed a change in function after illness, injury or inactivity. ● Changed need for help (eg home care, aids, security alarm). ● Want to train with others. ● Unable to use other training offers.	Fall prevention group	Tromsø (Tromsø kommune, 2021)
Helse Nord RHF	Home care, nursing homes and health centers.	Prevention of functional impairment in the elderly Method/Measures ● Management of patient safety ● Coordination of drug lists ● Proper drug use in nursing homes ● Proper drug use in home care services ● Proper drug use in the service of people with developmental disabilities ● Prevention of falls in health institutions ● Prevention of malnutrition	Webpage-Patient safety program	Finnmarkssykehuset (Utviklingssenter for sykehjem og hjemmetjenester, 2020)

Table 3. Fall Prevention among the elderly in Norway

Title	Year	Approach	Outcome
Impact of the fall prevention Otago Exercise Programme on pain among community-dwelling older adults: a short- and long-term follow-up study(Cederbom & Arkkukangas, 2019)	2019 Home	-Use of home -based fall-preventive exercise program to reduce pain over both the short term and long term -Quasi experiment -Intervention: Otago Exercise Programme (OEP) Norway, Sweden	-These results indicate that the OEP could be a suitable evidence-based program for both pain management and fall prevention among community-dwelling older people who live with pain and are at a higher risk of falling.
Effects of a fall prevention program in elderly: a pragmatic observational study in two orthopedic departments(Røyset et al., 2019)	**2019**	**-**Intervention: multifactorial fall prevention program -Primary outcome: rate of fallers -Secondary outcome: employee' perceived patient culture, patient-perceived safety.	**-** The fall prevention program revealed no significant effect on the rate of fallers, the patient safety culture, or patient-perceived safety.
Associations between gait speed and well-known fall risk factors among community-dwelling older adults(Kyrdalen et al., 2019)	**2019**	-Measurements included gait speed, depressive symptoms, executive functions, fear of falling, vision function, fall history, body mass index, medications, and comorbidity.	**-** Our results indicate that gait speed with cut-off 1.0 m/s could represent a useful tool for identifying individuals who are vulnerable but not yet disabled and could benefit from fall-preventive exercise. However, extended assessment is probably needed to personalize interventions.

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Table 3. Continued

Title	Year	Approach	Outcome
A falls prevention programme to improve quality of life, physical function and falls efficacy in older people receiving home help services: study protocol for a randomised controlled trial(Bjerk et al., 2017)	**2017**	**-**Impact of OEP and health -related quality of life in older adults receiving home help services Intervention: Otago Exercise Programme, lasting 12 weeks including home visits and motivational telephone calls. - he control group receives usual care. - The primary outcome is health-related quality of life (SF-36). - Secondary outcomes are leg strength, balance, walking speed, walking habits, activities of daily living, nutritional status and falls efficacy.	Results not yet provided.
The tensions between micro-, meso- and macro-levels: physiotherapists' views of their role towards fall prevention in the community - a qualitative study(Cerderbom et al., 2020)	**2020**	**-** explore physical therapists' (PTs) view of how they experience and perceive their role working with fall prevention in a community care setting - capability to cope with the tensions between the micro-, meso- and macro-levels in fall, prevention -Qualitative study.	Our findings indicate that the PTs' role reflects their abilities to change and improve their professional work in accordance with evidence-based knowledge.
Cost-effectiveness in fall prevention for older women(Hektoen et al., 2009)	**2009**	The aim was to estimate the cost-effectiveness of implementing an exercise-based fall prevention programme for home-dwelling women in the > or = 80-year age group in Norway.	-The study found that the reduction in healthcare costs per individual for treating fall-related injuries was 1.85 times higher than the cost of implementing a fall prevention programme. -The reduction in healthcare costs more than offset the cost of the prevention programme for women aged > or = 80 years living at home, which indicates that health authorities should increase their focus on prevention.
The Harstad injury prevention study: community based prevention of fall-fractures in the elderly evaluated by means of a hospital based injury recording system in Norway(Ytterstad, 1996)	**1996**	The aim was to describe a community-based programme to prevent fractures resulting from falls and evaluate the outcome in terms of changes in fracture rates and short-term hospital care costs. - Prospective intervention study. -intervention: last five years involved community-based interventions- e.g., the removal of environmental hazards in homes and promotion of the use of safe footwear outdoors in winter.	The observed fall-fracture rate reductions in private homes and traffic areas suggest that major parts of the interventions were effective.
Physiotherapists' perceptions of challenges facing evidence-based practice and the importance of environmental empowerment in fall prevention in the municipality - a qualitative study(Worum, Lillekroken, Roaldsen, et al., 2020)	**2020**	**-** This study aims to explore physiotherapists' perceptions on external factors, such as public policy, organisation and leadership, regarding the relation between knowledge translation and the three elements of evidence-based practice (EBP) to effectively address barriers and facilitate the uptake of EBP in fall prevention	**-** The findings of this study outline tension between policy, leadership, organisational facilitators and EBP. Leadership is influenced by policy with ripple effects for the organisation and clinicians. Organisational facilitators form structural empowerment, which is the foundation for creating an EBP environment.

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Table 3. Continued

Title	Year	Approach	Outcome
Associations between health-related quality of life, physical function and fear of falling in older fallers receiving home care (Bjerk et al., 2018)	**2018**	- to determine the associations between health-related quality of life (HRQOL), fear of falling and physical function in older fallers receiving home care - Data on HRQOL (SF-36), physical function and fear of falling (FES-I) were collected in addition to demographical and other relevant background information. A multivariate regression model was applied.	- A higher score on FES-I, denoting increased fear of falling, was significantly associated with a lower score on almost all subscales of SF-36, denoting reduced HRQOL. -This association is independent of physical measures. Better physical function is significantly associated with higher physical HRQOL. Future research should address interventions that reduce fear of falling and increase HRQOL in this vulnerable population.
The Adapted Lifestyle-Integrated Functional Exercise Program for Preventing Functional Decline in Young Seniors: Development and Initial Evaluation (Schwenk et al., 2019)	**2019**	The aim was to develop an intervention by adapting Lifestyle-integrated Functional Exercise (aLiFE) to be more challenging and suitable for preventing functional decline in young seniors in their 60s and (2) perform an initial feasibility evaluation of the program. Pre- and post-treatment changes in balance, mobility, and physical activity (PA) were also explored. Germany, Netherlands, Norway	- aLiFE has the potential to engage young seniors in regular lifestyle-integrated activities. Effectiveness needs to be evaluated in a randomized controlled trial.
Bridging the gap between research-based knowledge and clinical practice: a qualitative examination of patients and physiotherapists' views on the Otago exercise Programme(Worum et al., 2019)	**2019**	- primary objective of the present study was to examine patients and physiotherapists' views on the factors that influence the implementation of the community- and evidence-based Otago Exercise Programme for fall prevention -Qualitative study.	- The analysis yielded two main themes: the researcher's role and position in the implementation process and the tension between research-based knowledge and clinical practice.
Conceptualizing a Dynamic Fall Risk Model Including Intrinsic Risks and Exposures (Klenk et al., 2017)	**2017**	- The authors posit a dynamic fall risk model consisting of intrinsic risk factors that vary over time and exposure (activity in context). eHealth sensor technology (eg, smartphones) begins to enable the continuous measurement of both the above factors. They illustrate thier model with examples of real-world falls from the FARSEEING database.	This dynamic framework for fall risk adds important aspects that may improve understanding of fall mechanisms, fall risk models, and the development of fall prevention interventions.
Older persons' narrations on falls and falling*Stories ofcourage and endurance(Clancy et al., 2015)	**2015**	The aim of the study was to identify how older persons perceive falling, fall prevention, and fall accidents. - Six in-depth interviews were carried out and a hermeneutic phenomenological method was used to describe and interpret the older persons' accounts.	- Traditional fall prevention interventions are often risk oriented and based on generalized knowledge applied to particular cases. The findings indicate a need for contextual life-world knowledge and an understanding of fall prevention as a piece in a larger puzzle within a broader framework of culture, health, and well-being. Showing an interest in the older persons' stories can help safeguard their integrity and promote their well-being. This can ignite a spark that kindles their desire to participate in meaningful exercises and activities.

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Table 3. Continued

Title	Year	Approach	Outcome
Nursing staffs' attentiveness to older adults falling in residential care - an interview study(Clancy & Mahler, 2016)	**2016**	**-** The focus of this study was to explore how nursing staff experience safety promotion and fall prevention in residential care settings for older adults - There is limited research on fall prevention and safety promotion where the lifeworld and well-being provide a direction for care.	**-** The findings can indicate that there is a generalised understanding of the needs of older persons in residential care. The focus of the staff was more on protection and prevention than safety promotion and well-being. - Risk prevention is not enough. The residents need protection against falls but they also need to be protected from situations that can be detrimental to their well-being and compromise their dignity.
Otago exercise programme-from evidence to practice: a qualitative study of physiotherapists' perceptions of the importance of organisational factors of leadership, context and culture for knowledge translation in Norway (Worum, Lillekroken, Ahlsen, et al., 2020)	**2020**	**-** This study aimed to explore the views of physiotherapists in clinical practice and their leaders' views on the importance of organisational factors, such as leadership, culture and contextual and human resources, regarding successful knowledge translation of the Otago evidence-based fall programme in a Norwegian community. -Qualitative study.	**-** This study highlighted the importance of organisational factors in knowledge translation in fall prevention. The findings emphasise the importance of leaders' role and style in providing a supportive culture and contextual factors during the knowledge translation process. This study provides an understanding of the knowledge translation and sustainability of evidence-based practice and the Otago exercise programme for fall prevention programmes for community-dwelling older adults in Norway.
Smartphone Apps to Support Falls Rehabilitation Exercise: App Development and Usability and Acceptability Study (Hawley-Hague et al., 2020)	**2020**	-This study aims to develop motivational smartphone apps co-designed with health professionals and older adults to support patients to perform exercise proven to aid fall reduction and to explore the apps' usability and acceptability with both health professionals and patients. Several countries besides Norway participate.	-The motivational apps were found to be acceptable for older adults taking part in the design stage and patients and health professionals testing the apps in a clinical setting
Predictors of falls in the elderly by location (Bergland et al., 2003)	**2003**	The study assessed prospectively the predictive ability of health, function and balance variables regarding falls and their location - Falls which occurred during one year in a random sample of 307 women aged 75 years and over (mean 80.8 years, response rate 74.5%) living in the community were recorded and related to baseline registrations of health, medication and tests of walking and balance.	**-** The findings suggest that risk factors for indoor and outdoor falls are different. Location of fall may be an important confounder in studies of predictors of falls in the elderly which should encompass this type of information. - Outdoor falls were significantly more frequent than indoor falls (57.5 vs 42.5%).

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Table 3. Continued

Title	Year	Approach	Outcome
A falls case summary: Application of the public health nursing intervention wheel (Leahy-Warren et al., 2018)	**2018**	**-** Prevention and management of falls in the community could benefit from a public health systems approach by Public health nurses (PHNs) underpinned by the Public Health Intervention Wheel (PHIW). - The aim of this paper was to use a case summary to illustrate PHN practice in the context of the PHIW as applied to falls management and prevention. - This paper focuses on fall incidence and PHN response in Ireland and Norway.	**-** The PHIW model provides insight into the potential scope of public health nursing in falls, articulating PHN practice in the community.
Patient safety and falls: a qualitative study of home care nurses in Norway (Berland et al., 2012)	**2012**	**-** This study explored patient safety and falls, based on the experiences of home care nurses. -Qualitative study.	**-** This study identified the following four themes: (i) patient safety was not viewed as primary prevention; (ii) the lack of investigation into causes of falls; (iii) the frailty of older people who can no longer live at home independently and safely; and (iv) patient autonomy versus patient safety. **-** The study showed that home care nurses felt that healthcare personnel were more concerned with the treatment of falls, rather than fall prevention. In addition, home care nurses rarely focused on falls before they occurred. The patient's autonomy was placed before patient safety
Does mortality of the aged increase with the number of falls? Results from a nine-year follow-up study (Sylliaas et al., 2009)	**2009**	**-** The aim was to examine the predictive effect of prospectively registered falls on survival within a randomly selected group of elderly women. A longitudinal study, with 9 years follows up after 1year prospective fall registration was designed.	**-** Older fallers appear to have markedly increased mortality. Since falls are common among elderly people, this is a relevant fact for public health policy. Increasing age, poor self-rated health and high frequency of falls predict independently mortality in our 9 years follow up study
Medical findings in an interdisciplinary geriatric outpatient clinic specialising in falls (Smebye et al., 2014)	**2014**	**-** At present there are few outpatient clinics in Norway specialising in falls, and no data from such studies have yet been published. - The information stems from 111 patients at the Fallpoliklinikken, Oslo University Hospital, from its establishment in 2008 until 2011. An interdisciplinary study was undertaken by a nurse, a doctor and a physiotherapist.	**-** The patient group had a number of known risk factors for falls. The most frequently identified risk factors included orthostatism (26 of 110 patients, 24%), vitamin D deficiency (14 of 79 patients, 18%) and carotid sinus hypersensitivity (6 of 55 patients examined, 11%) - Falls among elderly people have varying and complex causes and a serious underlying pathology may manifest itself as a tendency to fall. This testifies to the importance of a thorough interdisciplinary study of falls.

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Table 3. Continued

Title	Year	Approach	Outcome
One-to-One and Group-Based Teleconferencing for Falls Rehabilitation: Usability, Acceptability, and Feasibility Study (Hawley-Hague et al., 2021)	**2021**	**-** The study hypothesis is that teleconferencing could enable health professionals to support patients more frequently, which is important in fostering exercise behavior. Several European countries besides Norway participate.	**-** Teleconferencing as a way of delivering fall prevention interventions can be acceptable to older adults, patients, and health care professionals if it works effectively. Connectivity, where there is no Wi-Fi provision, is one of the largest issues. Therefore, local infrastructure needs to be improved. A larger usability study is required to establish whether better equipment for delivery improves usability.
Validation of the Falls Efficacy Scale-International in fall-prone older persons (Jorunn Laegdheim Helbostad et al., 2009)	**2010**	**-** The aim of this study was to test the psychometric properties of the Norwegian version of the 16-item Fall Efficacy Scale-International (FES-I) in samples of fall-prone older home-dwelling persons recruited from the health care system and to assess if the seven-item FES-I has the same properties as the 16-item FES-I in these samples.	**-** The psychometric properties of the FES-I scale in samples of fall-prone older persons are good. -The seven-item FES-I has the same psychometric properties and discriminatory power as the original 16-item FES-I. -Despite lower function, the Norwegian sample scored lower at fear of falling than what is reported in previous studies.
Do behavioral disturbances predict falls among nursing home residents? (Sylliaas et al., 2012)	**2012**	**-** The purpose of the study was to examine whether severity of dementia, behavioral and psychological symptoms and depression can predict falls among nursing home residents, such as demographic variables, activities of daily living, and use of psychotropic drugs, when potential confounders are controlled for - 1147 nursing home residents were examined in this one-year follow-up study. - All residents were examined with the Physical Self-Maintenance scale (Activities of Daily Living - ADL), Clinical Dementia Rating Scale (CDR), Neuropsychiatric Inventory (NPI) and Cornell Scale for Depression in Dementia.	Having a high NPI score was identified as a significant and independent predictor of falls.
Risk of hip fracture in protected and unprotected falls in nursing homes in Norway (Forsén et al., 2004)	**2004**	-The study aim was to compare the probability of hip fracture in protected and unprotected falls in a real world setting in nursing homes. - Observational study.	- The odds of suffering a hip fracture for nursing home high risk residents was reduced to less than a third in protected falls compared with unprotected falls. Or, in other words, the odds of hip fracture showed a 69% reduction in protected falls compared with unprotected falls.

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Title	Year	Approach	Outcome
Seasonal variations in incidence of fractures among elderly people (Bulajic-Kopjar, 2000)	**2000**	The study aim was to investigate seasonal variations in the incidence of fall related fractures among people 65 years and older. - A prospective, population-based cohort study was performed on people aged 65 years and older followed up from 1990 to 1997, a total of 459,904 person year.	**-** Season affects the incidence of all types of fractures in elderly people. Slipping on ice and snow seems to be a causal mechanism behind the seasonal effect. Preventive measures targeting this causal mechanism are likely targeting this causal mechanism are likely to reduce the risk of fracture, but the size of the effect is difficult to estimate with certainty.
Effects of home exercises and group training on functional abilities in home-dwelling older persons with mobility and balance problems. A randomized study(Jorunn L. Helbostad et al., 2004)	**2004**	**-** The study hypothesis was that **e**xercise in older people may reduce falls and improve functional abilities. Less is known about the optimal amount of training. The aim of this study was to determine the effectiveness of home training, and whether group training in addition to home training enhances the effect. - This randomized trial included 77 persons aged 75 years and older (mean 81, SD 4.5), living at home. - Home training (HT) comprised twice-daily functional balance and strength exercises and 3 group meetings. Combined training (CT) included group training twice weekly and the same home exercises.	**-** Daily home training supervised by physical therapists improved functional abilities. Supplementary individualized group training gave no additional effect. The effect on function was not present 6 months after the end of the intervention.
[Prevention of femoral n meck fractures in the Stovner district of Oslo] (Steihaug et al., 1998)	**1998**	**-** By collecting data on hip fractures among people over 66 years of age in the Stovner district of Oslo, it was possible to evaluate a programme to prevent fall accidents in the elderly population. **-** -The programme has several approaches. It includes information for both the elderly and the personnel working with them on accident risk factors and identification and removal of risk factors at home.	**-** The incidence of hip fractures among those over 66 years of age in the Stovner district was reduced from 30/1,000 in 1990 to 16/1,000 in 1996. There was a significant downward trend during the whole period ($p < 0.001$). A similar reduction was not seen for the rest of Oslo. We believe that the programme has contributed to reducing the number of hip fractures. However, as several approaches were tried simultaneously, it is difficult to decide whether one particular approach was more efficient than the others.

Table 4. Fall prevention smartphone and gamification in Norway 2010-2021

Topic	Year	Approach/Notes	Outcome
An Augmented Reality Game for Helping Elderly to Perform Physical Exercises at Home (Nishchyk et al., n.d.)	2020	-Goal of the research is to demonstrate how augmented reality game, specifically developed for our target group, could help elderly to perform physical exercises, improve their health conditions and, as a result, prevent from falls.	-The results of the first prototype testing have shown that the game has potential to achieve the goal of the research. - It is planned to involve more users in next user testing iterations.

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Table 4. Continued

Topic	Year	Approach/Notes	Outcome
Nordic Ambient Assisted Living: Welfare technologies for active and independent living at home (Finnsson, 2019)	2019	-These are technologies and welfare services developed in the Nordic Region, which enable the elderly to lead an independent life in their own home for a longer duration. -Nordic countries participate.	This white paper is based on input from more than 70 interviewees working within health and care provision, research and technology development in the Nordic Region.
Exergaming in Older Adults: Movement Characteristics While Playing Stepping Games (Skjæret-Maroni et al., 2016)	2016	- Exercise interventions with focus on performing appropriate, rapid, timed, and well-directed steps have a valuable role in interventions and rehabilitation for older adults, and it has been found that both reactive and volitional stepping interventions reduce falls among older adults by approximately 50%. -The aim of the current study was to investigate whether game and game level affect older adults' stepping and upper body movements while playing stepping exergames. -A 3D-motion capture experiment was performed with 20 elderly (12 women and 8 men; age range 65–90 years), playing two exergames, The Mole from SilverFit and LightRace in YourShape: Fitness Evolved, on two difficulty levels.	- Even with only two games, two levels, and five trials at each, this study indicates that the choice of exergame is not indifferent when aiming to exercise specific functions in older adults and that exergames need to be chosen and designed carefully based on the goals of the intervention.
Assessing Seniors' User Experience (UX) of Exergames for Balance Training (Nawaz et al., 2014)	2014	- In order to make the games suitable for keeping older people healthy and independent and prevent functional decline and falls, there is a need for games that work on improving balance. - However, little is known about seniors' user experience of exergame technology for balance training and what factors they consider most important for using the exergames. -This study aims to evaluate user experience and preferences of exergame technologies to train balance and to identify different factors that affect seniors' intention to use exergames - Assesses exergame: The first exergame, Dance Dance Revolution (DDR), is an interactive game produced by Konami Corporation that can be played on several consoles, such as Sony PlayStation, Microsoft Xbox, Nintendo Wii, as well as on a PC	- The results of the study showed that in order for seniors to use exergames to train their balance, the exergames should particularly focus on challenging tasks, provide feedback on quality of movement, and provide setup support. Furthermore, healthy seniors did not consider safety to be a concern when playing exergames.
Twelve Ways to Reach for a Star: Player Movement Strategies in a Whole-Body Exergame (Subramanian et al., 2019)	2019	- This paper describes findings from a laboratory-based assessment of a balance-training exergame developed by the authors. The exergame was designed to elicit specific body movements during gameplay involving weight-shift (transfer of body weight from one foot to the other), which is considered beneficial for training balance	- Regarding balance-training exergames, our findings suggest that designers need worry less about "puppeteering" able-bodied players with a strict choreography to elicit specific body movements. Instead we recommend that designers embrace a less rigid design approach, where the goal is to elicit desired movement characteristics (e.g., weight-shift) through a more open and playful behavior

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Table 4. Continued

Topic	Year	Approach/Notes	Outcome
Design and development of a inertial sensor based exergame for recovery-step training VR exergame taxonomies and real-time step detection in all directions (Bourke et al., 2014)	2014	-Through incorporating stepping movements into the game play of a VR based exergame, it is envisaged that older adults can reduce their fall-risk by training their balance recovery stepping movements in all directions. This type of exercise intervention thus presents a reliable structured way of reducing fall-risk. - A total of 14 older adults each played three different off-the-shelf stepping games: ”the Mole” from SilverFit, ”Your Shape Light Race” from Xbox Kinect, and a revised version of Dance Dance Revolution from PlayStation. Silverfit's “the Mole” is specifically designed for use by older people in rehabilitation settings. - A pilot usability test was conducted in NSEP's usability laboratory in Trondheim.	- A step detection algorithm capable of detecting steps in 8 equally spaced directions was developed. - This algorithm will allow for robust detection of stepping movements in stepping exergame for fall prevention
The Move Maker – Exploring Bodily Preconditions and Surrounding Conditions for Bodily Interactive Play(Matjeka, 2020)	2020	- Move Maker is designed for elderly people to play with their grandchildren (through a suite of ready to play minigames) and for designers and physiotherapists wanting to explore and develop novel bodily play construction - The practical foundation for the game development is a set of exercises developed by physiotherapists especially for fall prevention	- Move Maker is a suite of movement-based games with a potential of challenging the players' movement abilities while at the same time offering a system to explore and develop novel bodily play constructions.
Older adults' experiences with mHealth for fall prevention exercise: usability and promotion of behavior change strategies (Arkkukangas et al., 2020)	2020	- In 2017, researchers from Sweden and Norway started a project that collaborated with older adults and physiotherapists to develop and evaluate the usability of a mobile application for smart phones and tablets customized to support fall prevention exercises based on the evidence based OEP. The development of the application included workshops where designers, researchers, older adults, and physiotherapists collaborated. This study was part of the ongoing development of the first application prototype in the development process - The aim was to explore older persons' experiences of a mobile application for fall prevention exercise, and to identify what possible behavior change techniques to include in the further development of the application	- With support, an application could be adapted for older adults to manage, motivate, and adhere to fall prevention exercise. To achieve long-term adherence to health behavior changes, behavior change strategies and techniques are recommended to be included in further development of the fall prevention application.
Designing a safety reporting smartphone application to improve patient safety after total hip arthroplasty (Krumsvik OA, Babic A, 2017)	2017	SafeTHA is a self-reporting mobile application that aims to detect and reduce adverse events that may result after postoperative total hip arthroplasty. The application encourages self-reporting among postoperative patients thorough their rehabilitation process.	Patients are able to report on areas such as level of pain, anxiety and mobility, which promotes awareness of current post-surgery status of a patient.
Pharmacovigilance mobile tool design in the field of arhroplasty (Åserød H, Babic A, 2017)	2017	Pharmacovigilance Mobile Tool was developed with the aim of improving pharmacovigilance in arthroplasty. It is concerned with the safety of medical devices and treatments in the light of understanding the risks and dangers based on the already reported safety issues.	The tool enables users to explore several information sources such as Internet resources such as the Manufacturer And User Facility Device Experience (MAUDE) web-site, clinical trials, PubMed, and local safety databases.

CONCLUSION

There are numerous solutions in the fall prevention programs, that are often multidisciplinary which is in line with the expectations of the Norwegian Directorate. Information and computer-based solutions are complementary to already existing and well-established fall prevention programs. The future is likely to bring more integrated and systematic fall prevention routines based on the current state of development.

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Chapter 13
Falls and Fall Injuries as Societal Challenges in Namibia

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ABSTRACT

Falls remain the leading cause of intentional and unintentional injuries worldwide. On average, 80% of the cases are said to originate from low and middle developing countries. The raising concerns are that a great number of children and elderlies above the age of 65 are the most affected. Falls are one of the most serious health risks especially for older adults and children in Namibia. The implications of falls on public health practice are that approximately half of older adults do not discuss their fall incidents with healthcare providers. The aim of this chapter is, therefore, to define the concept falls focusing in the Namibian context and outlining the causes, highlighting the most vulnerable groups, and identifying the preventive measures.

INTRODUCTION

According to World Health Organization (WHO) (2020) a fall is defined as an event which results in a person coming to rest inadvertently on the ground or floor or other lower level. Falls raised from 29.0 million in 2014 to about 37.3 million falls in 2020 that require medical attention in 2020 (WHO 2020; Berger, Stevens, & Burns 2014). Falls are the second leading cause of accidental or unintentional injury or deaths worldwide. Dejectedly, of 646 000 persons succumbing to falls, 80% of the cases are said to originate from low and middle developing countries. The raising concerns are that a great number of children and elderlies above the age of 65 are mostly the most affected.

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Although in China, most falls are non-fatal, for every death due to a fall, there are 4 cases of permanent disability, 13 cases requiring hospitalization for more than 10 days or missing work/school. In 2014, 28.7% of older adults reported falling at least once in the preceding 12 months while about 20–30% of older people who fall suffer moderate to severe injuries such as bruises, hip fractures, or head trauma (Berger, Stevens, & Burns 2014; WHO 2020).

The costs implications from fall-related injuries are increasing exponentially, especially among aged persons above 65 years. On average health system cost in Finland and Australia per inured person cost US$ 3611 and US$ 1049 respectively. Some studies suggest that the implementation of effective prevention strategies can bring about 20% reduction in the incidence of falls among children under 10 years of age and could results in net savings of over US$ 120 million each year.

The implications of falls on public health practice is that approximately half of older adults do not discuss their fall incidents with health care providers. Annual medical costs for older adult falls have been estimated to cost about $31.3 billion a year this is beside that the older adult population is expected to increase 55% by 2030. Fall and fall injuries are likely to raise to 48.8 million and 11.9 million respectively by the year 2030 unless effective interventions are implemented in the United State of America alone. Knowing that 80% of falls occur in low and middle countries, it is important for middle income countries like Namibia to implement preventable strategies and encourage both health care providers and individuals to play an important role in fall prevention.

BACKGROUND OF FALLS AND FALL INJURIES IN NAMIBIA

Falls are one of the most serious health risks especially for older adults and children in Namibia. Falls are not only the leading cause of injury-related deaths, but are also a significant cause of disability and constitute about 10% of all emergence cases and more than half of injury-related hospitalizations in Namibia (Bio kinetics Association of Namibia, 2015). Approximately one in three older adults falls each year. As the number of older adults is estimated to increase rapidly over the next decade, the annual cost for fall-related injuries is expected to skyrocket, reaching $44 billion by 2020. Although most falls don't result in severe physical injuries, a fall or near-fall often produces a psychological fear of falling. This contributes to a self-imposed decrease in activity, followed by functional declines and a greater risk for falls.

According to Hartman (2015) falls occur both at home and hospitals due to the absence of frail care policy in Namibian. The state is not obliged to care for the frail patients and the responsibility to care for frail patients is left to the family or individual to fork huge sum of money to pay private frail centers/old age homes or to hire a nurse to look after them in the comfort of their homes. As common to many other aged persons, most elderlies in Namibia are not only faced with physical degeneration, but also the mental dimensions that interfere with daily life activities. Many families have no money to pay for private old age homes and many your Namibian youth migrate to towns in seek for employment. Elderly persons complains of feeling neglected by the hospitals because they are old, even though to an extent the lack of affordable frail centers has worsen the situation. The feeling of neglect, diminished physical and mental abilities put the elderlies to risks of falls. A lot of elderly succumbed injuries sustained during falls.

Coming from apartheid dispensation especially for white elderly in public hospitals become intimidating, as a person is left to the mercy of black nurse. Namibia is characterized by diverse cultures with more than 15 spoken languages. Communication barriers in hospital setting contributes to falls and related injuries. Furthermore, for a number of years injury is the fifth leading cause of morbidity in all age groups. Despite the lack of data on falls in Namibia, Madiba & Hoque (2011) noted lack of public education on injury prevention. Lack of data further made it difficult for the public officials to recognize falls and fall injuries as a serious public health problem. This chapter provides the prevention strategies focusing on education, training, creating safer environments, prioritizing fall-related research and establishing effective policies to reduce fall risks.

Risk Groups

The severity of falls is associated with the age, gender and health of the individual as discussed below:

Age

Age is found to be one of the key risk factors for falls. The risk of falls increase with age, and those aged 65 years and above stand a highest risk of sustaining serious falls and falls. This risk level may be in part due to physical, sensory, and cognitive changes associated with ageing, in combination with environments that are not adapted for an aging population.

Another high risk group is children largely associated with their evolving developmental stages, innate curiosity in their surroundings, and increasing levels of independence associated with risk taking behaviours. Falls in children can also be attributed to inadequate adult supervision related to many factors such as, poverty, sole parenthood, and living in hazardous environments. falls in older adults are perceived to as unpredictable and unavoidable accidents, pending the identification of the factors contributing and appropriate interventions can dramatically lessen the risk of a fall. In many cases, falls are caused by a loss of balance or failing to maintain the body's center of gravity (COG). The two types of balance include static balance, which refer to the ability to control postural sway during quiet standing while dynamic balance is the ability to react to changes in balance and to anticipate changes as the body moves during walking or stepping over. The ability to balance is controlled by the sensory, muscular and motor systems. The three most influential sensory systems controlling balance are the visual, vestibular and somatosensory systems which diminish with advancing age. Understanding these systems is essential to providing exercise programs that target balance for older adults. The visual system provide information about the environment, the location of the person and the direction and speed of the person's movement in the environment. The visual acuity, depth perception, peripheral field and sensitivity to low spatial frequencies decrease with age leading to elderly inability to use visual cues to control balance.

The vestibular system, located in the ears, provides information about movement of the head, independent of visual cues. The otoliths, assist in detecting the degree of head movement in relation to gravity while the fluid-filled semicircular canals with its three half circles positioned in three different planes trigger receptors that send information to the brain as the head moves. The vestibular neurons start to decrease in number and size at the age 40 years resulting in various impairments including dizziness.

The somatosensory system provides information about the body's position and contact from the skin through pressure, vibration and tactile sensors, as well as joint and muscle activities. Skin sensation via tactile, vibration and pressure sensors reduce with increasing age. Lack of input from tactile, pressure and vibration receptors makes it difficult to stand or walk and detect any change of heel-to-toe body weight, a vital aspect in maintaining balance (Biokinetics Association of Namibia 2015).

Figure 1. Falls
Source: Wisconsin Department of Health Services (2020)

Gender

While falls affect both male and females, males regularly suffer a higher death rate of falls. This is attributed to the greater burden seen among males displaying higher levels of risk-taking behaviours and hazards within occupations. The females and children generally suffer more non-fatal falls.

Nocturnal Toileting Persons

The findings from a single-center retrospective study by Charnow (2020) at Ghent University hospital, found 125 (28%) of 447 reported incident falls in 2015 to be associated with nocturnal toileting.

Most of the reported incident fall cases involved 74 cases at Geriatric department, 55 at Rehabilitation center, 34 at Gastroenterology department, 30 at Hematology department, and 30 at neurology department. Of these 447 falls, 242 (54%) occurred from 8:00 p.m. to 7:59 a.m. The most reported mechanisms of fall included 26% cases due to loss of balance while slipping accounted for 25%. Of all falls 42% sustained injuries while 58% suffered no injuries from their falls. Despite the alarming number of 28% fatalities associated with nocturnal falls in 2015, the report noted that about 20% to 25% fall incidents are not reported in incident reports.

Charnow (2020) concluded that beside that urine production in healthy individuals is lower at night-time compared with daytime, it would be expected that lower prevalence of falls were expected at night than day time. On the contrary, the study showed that the majority of falls associated with toileting happened at night-time (76%) as compared to day time (24%).

Other risk factors include:

- alcohol or substance usage
- Working at heights or other hazardous working conditions;
- socioeconomic factors including poverty, overcrowded housing, sole parenthood, young maternal age;
- underlying medical conditions, such as neurological, cardiac or other disabling conditions;
- side effects of medication, physical inactivity and loss of balance, particularly among older people;
- poor mobility, cognition, and vision, particularly among those living in an institution, such as a nursing home or chronic care facility;
- unsafe environments, particularly for those with poor balance and limited vision.

- Postural hypotension

Prevention

Research focusing on the burden of falls, exploring risk factors, effective prevention strategies along with the training of health care providers and the education of individuals and communities to build risk awareness should be prioritized. Furthermore, strategies for falls must be supported by policies that create safer environments and reduce risk factors.

The effective fall prevention strategies aiming to reduce the number, the rate and the severity of injury for older individuals, include a number of components to identify and modify risks as follow (WHO 2020; Berger, Stevens, & Burns 2014; Biokinetics Association of Namibia 2015):

- screening within living environments for risks for falls;
- Clinical interventions to identify risk factors, including medication review and modification, treatment of low blood pressure, vitamin D and calcium supplementation, treatment of correctable visual impairment;
- Home assessment and environmental modification for those with risk factors or history of falling;
- Affordability and prescription of appropriate assistive devices to address physical and sensory impairments;
- Muscle strengthening and balance retraining prescribed by a trained health professional;
- Community-based group programmes which may incorporate fall prevention education and Tai Chi-type exercises or dynamic balance and strength training;
- Use of hip protectors for those at risk of a hip fracture related to a falls.
- Set the brakes of the wheel chair when sitting or standing up.

The effective interventions for children include multifaceted community programmes; production modifications of nursery furniture, playground equipment and legislation for the use of window guards, guard rails/gates, house to house fall programmes. Equally, mass public education campaigns, and basic life support/first aid training of individuals should be provided.

Figure 2. Fall prevention
Sources: Pegalis law group, llc & EBSCO 2020

CHALLENGES ASSOCIATED WITH FALLS AND FALL INJURIES IN NAMIBIA

- Inadequate hospices to keep older persons and those in their stage of dying.
- Namibia recorded 32.4% increase of fall injuries in the construction industry by 2017. Of these 21.6% included fatalities, amputations and lacerations requiring emergency treatment
- Only 36% of the Namibian citizens are covered by Public Service Employees Medical Aid Scheme (PSEMAS) or private medical insurances, the rest of 64% are the vulnerable groups being the unemployed persons and must pay medical care out of pocket (OOP) (MoHSS 2017).

SOLUTIONS AND RECOMMENDATIONS

1. Consult Your Doctor

Your doctor can assess your risk of falls by reviewing your medications for side effects and interactions. To help with fall prevention, your doctor may replace medications with sedative effects or those that affects your thinking, concentrations.

2. Exercise

Exercises have great benefits in maintaining you're your body strength, flexibility, coordination and balance. Start with gentle movements or workout like dancing, jogging before increasing to medium and high level exercises that demand a balance body.

3. Wear Comfortable Shoes

Avoid high heels, floppy slippers and shoes with smooth soles. Have well-fitting and workable shoes to prevent falls and reduce joint pain.

4. Assess and Remove Home Hazards

Ensure that your home environment is free of hazards by:

- Remove, plastics, newspapers, electrical cords and phone cords from walkways.
- Move chairs, tables from high-traffic areas.
- Cover the slippery tiles in the house with nonslip mats and avoid walking on wet floors.
- Store clothing, dishes, food and other necessities within easy reach.
- Immediately clean spilled liquids, grease or food.
- Use nonslip mats in your bathtub or shower. A bath allow you to sit, while showering.

5. Have Sufficient Light in the House

Ensure you have bright light in the house to avoid tripping on objects, also:

- Place night lights in your bedroom and bathrooms.
- Have a lamp within reach for night needs.
- Put on the on the lights before getting up or walking the stairs.
- Keep battery touches for use during power outages.

FUTURE RESEARCH DIRECTIONS AND CONCLUSION

Falls of the elderly may results in serious physical injuries or psychological health problems. It is widely found that most of the falls in all age groups are caused by multiple factors. It is important to identify the associated risk factors to find suitable preventative actions. The success of falling prevention is associated with multifactorial interventions with special consideration of the physical exercises and child supervision.

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KEY TERMS AND DEFINITIONS

Challenges: A situation needing great mental or physical effort in order to be done successfully, or the situation that require great effort (Online Cambridge dictionary, 2021).

Falls: WHO (2018) define a fall as an event which subsequently cause a person to come to rest inadvertently on the ground or floor or other lower level.

Injuries: An injury refers to a damage body tissue caused by the absence energy transfer or energy produced by energy exchanges that have relatively sudden discernible effects (Langley & Brenner, 2004).

Risks: The possibility of something bad or dangerous happening (Online Cambridge dictionary, 2021).

Chapter 14
Integrated Care in Prevention:
Maturity and Upscaling

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ABSTRACT

Given health and health economy assessments, a common assessment framework for active and healthy ageing (CAFAHA) is ideally desirable, even if not yet fully feasible, given the activities developed within European Innovation Partnership for Active and Healthy Ageing (EIP on AHA) since 2012, now moving into its subsequent framework on healthy ageing. However, as there is diversity with respect to maturity in regions, in order to fully develop prevention practices and campaigns, assets as part of maturity need to be defined more clearly.

EIP ON AHA AND ITS ACTION GROUPS

The Strategic Implementation Plan of the European Innovation Partnership on Active and Healthy Ageing (EIP on AHA) proposed six Action Groups, one of which being Action Group A2 on Falls Prevention. Action Group A2 has been active since 2012, and work has been implemented in accordance with the Action Groups' Renovated Action Plans (2016-2018, 2018-2020). The outcomes and impact of synergies are using the Monitoring and Assessment Framework for the EIP on AHA (MAFEIP). Synergies between action groups (Bousquet et al, 2016) have been cross-cutting in overarching domains involving falls, frailty, and integrated care.

The main objective of the Action Group A2 remains focused on the contribution to foster innovation in personal health management through validated programmes and good practices for early diagnosis and preventive measures (including health promotion), with falls prevention as a first use case. A2 now also clearly underlines the need to prevent falls rather than just *aiming to help and advise organisations on their efforts to create procedures to implement practices targeting the prevention of falls*.

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Integrated, interdisciplinary and inter-professional education for all stakeholders is needed to tackle the interrelated syndrome of frailty, malnutrition, falls, chronic diseases and their social consequences. It is important to continue to educate seniors, health and social carers and entrepreneurs with focus on falls prevention. The general objective will remain to be the development of an innovative, dynamic and sustainable care system for AHA through capacity building using senior/patient-centred, multidisciplinary and inter-professional educational programmes aimed at patients, patient caregivers (both formal and informal), health and social carers, administrators and entrepreneurs.

Falls prevention activities continue to support country and regional ambitions in falls prevention, including both the development of new prevention programmes as well as the implementation of existing ones. Countries and regions include Ireland, Finland, Scotland, Algarve (Portugal), Campania (Italy), Styria (Austria), Västerbotten (Sweden) and cooperation has been established in many other countries and regions. There is cooperation also with organisations and societies including the European Geriatric Medicine Society (EuGMS) and its working groups and task forces.

The Action Group A2 Action Plan continued to emphasise activities also appearing within the Synergies Task Force (Bousquet et al, 2016):

i. Good practices and integrated care supported by the information and process model
ii. Fall risk increasing drugs and the development of guidelines for their withdrawal
iii. Maturity and assets
iv. Education

Practices are processes and pathways, characterised by their information content. Personalised care and prevention require a personalised condition and functioning assessment, i.e., health assessment, as a basis for intervention and prevention. In the case of Action Group A2 this implies a focus on falls and fall related injuries and their prevention. This represents the bottom-up view on assessment, which indeed is personalised and functioning oriented. The A2 Information & Process model was initiated for Ireland and Scotland in 2016 and was extended during 2016-2018 with more focus on process modelling. During 2018-2020, information modelling including health and risk assessment, will become further strengthened.

Regarding risk assessment (involving postural control, medical conditions, drugs, psychology, mood and environmental aspects) fall risk increasing drugs (FRID) [de Vries, 2018; Seppälä, 2018a; Seppälä, 2018b] have received special and detailed attention. They have been recognised within the Synergies Task Force and within the EUGMS Task and Finish Group on fall-risk-increasing drugs, in cooperation with Action Group A2.

AWARENESS, INTEREST, DESIRE, ACTION

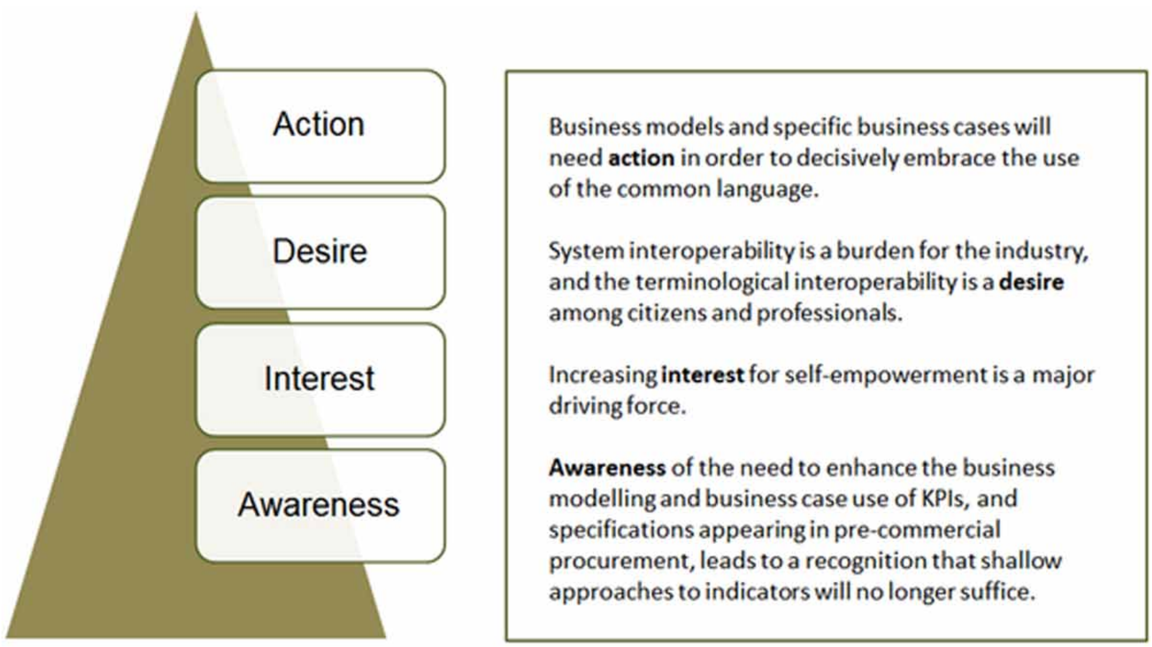
National, regional and municipal level.prevention will to go through AIDA stages including *awareness-interest-desire-action*, before a stakeholder wide service provision program, including its various tools and support systems, is ready for installation and training.

E. St. Elmo Lewis proposed the AIDA model in 1898, thereby pioneering the AIDA marketing model for advertising and sales.

The mission of an advertisement is to attract a reader [awareness], so that he will look at the advertisement and start to read it; then to interest him [interest], so that he will continue to read it; then to convince him, so that when he has read it he will believe it [desire]. If an advertisement contains these three qualities of success, it is a successful advertisement [when eventually leading to action]. (St. Elmo Lewis, 1903(

For more detail and historical perspective on the AIDA funnel (see Barry, 2012; Strong, 1925; Sheldon, 1911).

Figure 1. The AIDA funnel



Within attention, key professionals representing National, regional and municipal level prevention will to go through AIDA stages including *awareness-interest-desire-action*, before a stakeholder wide service provision program, including its various tools and support systems, is ready for installation and training. Within attention, key professionals representing a broad range of care as provided in facilities, recognize their ideal Key Performance Indexes with a reasonable degree of ontological accuracy. This enables a subsequent mapping of the anticipated “KPI+Ontology” into the information and knowledge structures as already existing within the national, regional or municipal care functionality. At this point, and given the requirement that information must be shared and “moved around”, such working groups will realize the need of in the end being web-based information collection and management, and further being oriented towards care processes and intervention guidelines. When moving into the interest stage, inevitable questions like “Why are we really doing this?” turn up, and formulations of answers are then enabled by the “Language” developed during the ontologically oriented discussions on indicators, concepts and nomenclatures. By-passing the attention stage will only lead to verbose formulations of the WHY, and responses to that question will be rather shallow. This is then counteractive and will not at all promote the shift into the desire phase. Enthusiasm may appear among some policy-makers, but professionals remain sceptic. However, a successful interest stage is supported by a careful inspection and use of a DEMONSTRATOR, which will raise expectations of impact and also reveal possible needs for care organization enrichment. Once at the desire stage, the organization has enriched the 'language', and is now able to provide accurate modelling and cost-benefit analysis. External providers are also able to arrive at more accurate business models, which in the end support procurement processes. Internal commitments are natural next steps, and furthermore, this also opens up a potential of investing in service provision repositories, or participating in external efforts of providing regional or even national repositories. Actions to be taken towards installation and training must be preceded by detailed and sometimes rather painful identification of possible unsatisfactory or simply lacking ICT solutions and infrastructures.

The region or unit as a whole, and also each individual professional within that organization, will go through 'AIDA' stages including awareness, interest, desire and action, before an organization wide fall prevention program, including its various tools and support systems, is ready for installation and training.

In efforts to arrive at purchase and procurement, awareness raising will not suffice. However, the more awareness we have, the more interest we will see among those aware. Clearly, we will not see interest, if there is no awareness. This is the fundamental first step in AIDA funnel. Those interested still don't buy, so there is still no economic impact just because of interest. There is a potential impact, but no financial impact. Among those interested, campaigning aims at bring as as many as possible to reach a desire to use and procure. However, desire only is not enough, even if it brings closer to purchase as compared to awareness and interest. It is only the final action that returns the investment.

The AIDA model helps to understand the the effect of campaigning. If the funnel narrows down too much, then the impact in the end is small. Terefore the aim in campaigning is to bring over as many as possible to the next levels in this funnel. Needless to say, those remaining or getting stuck, for whatever reason, on some level, should not be forgotten. On the contrary, a campaign concentrates on all levels at the same time, and indeed on securing transitions between them.

This then has bearing on the logical form and granularity of the value proposition, as it obviously must change on different levels. The Business Model Canvas does not embrace this approach, as the Canvas assumes that the value proposition is a fixpoint that remains in its original form over the whole range of the AIDA funnel.

Understanding the AIDA funnel is important as a prerequisite for disseminating the information infrastructure and the scaling up as supported by the guideline for fall prevention implementation in regions.

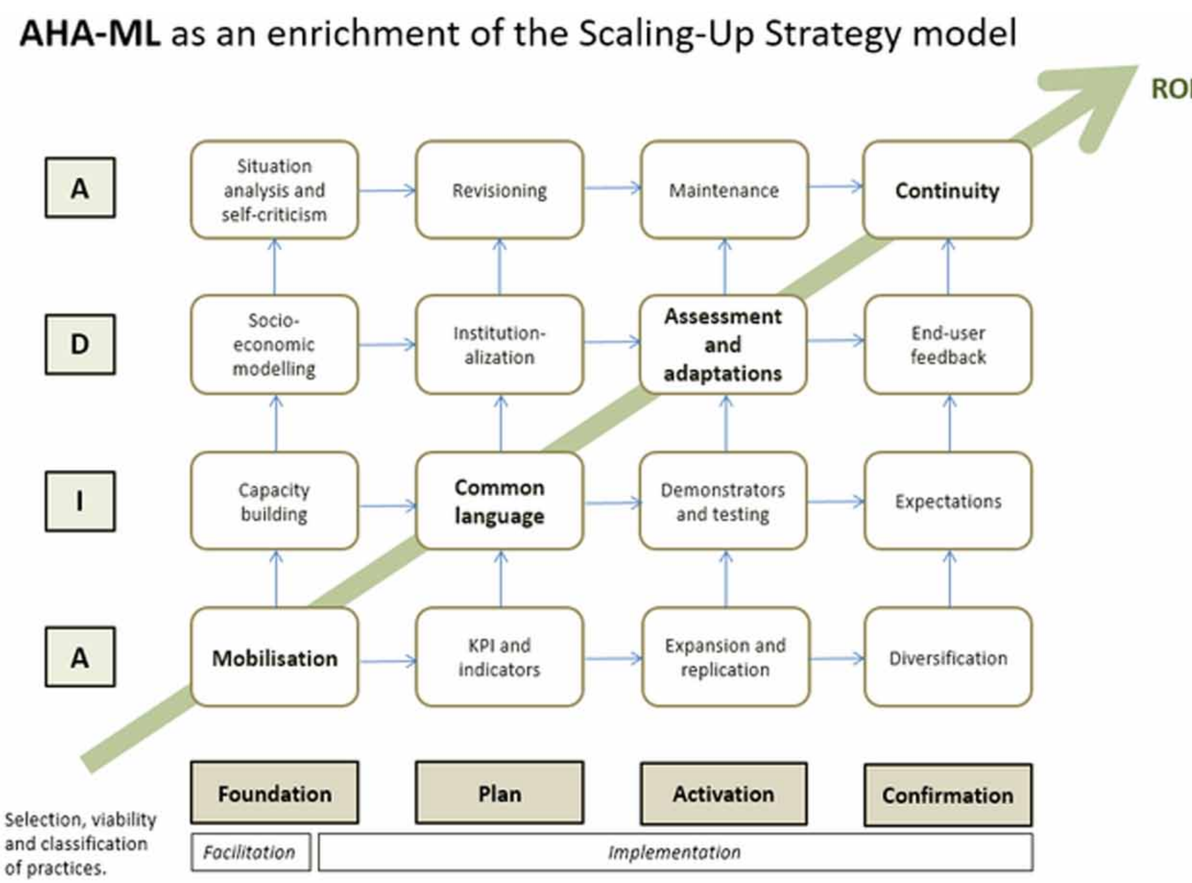
Within awareness/attention, key professionals representing a broad range of care as provided in facilities, recognize their ideal 'maximum datasets' with a reasonable degree of ontological accuracy. This enables a subsequent mapping of the anticipated 'minimum dataset' into the information and knowledge structures as already existing within the regional care functionality. At this point, and given the requirement that information must be shared and "moved around", such working groups will realize the need of in the end being web-based information collection and management, and further being oriented towards care processes and intervention guidelines.

When moving into the interest stage, inevitable questions like "Why are we really doing this?" turn up, and formulations of answers are then enabled by the "Language of Fall" developed during the ontologically oriented discussions on maximum and anticipated minimum datasets. By-passing the attention stage will only lead to verbose formulations of the WHY, and responses to that question will be rather shallow. This is then counteractive and will not at all promote the shift into the desire phase. Enthusiasm may appear among some policy-makers, but professionals remain skeptic. However, a successful interest stage is supported by a careful inspection and use of a DEMONSTRATOR, which will raise expectations of impact and also reveal possible needs for care organization enrichment.

Once at the desire stage, the organization has enriched the 'language', and is now able to number the demographic changes with information types appearing in the maximum set and the overall "Language of Fall". More accurate socio-economic modelling, combining economy as explained by the cost of resources, are now feasible, and policy-making is easier to execute. External providers are also able to arrive at more accurate business models, which in the end support procurement processes. Internal commitments are natural next steps, and furthermore, this also opens up a potential of investing in a fall prevention repository, or participating in external efforts of providing regional or even national repositories.

Actions to be taken towards installation and training must be preceded by detailed and sometimes rather painful identification of possible unsatisfactory or simply lacking ICT solutions and infrastructures.

Figure 2. The AIDA model representing the flow from initial service solution promotion to final installation



IMPLEMENTING FALLS PREVENTION CAMPAIGNS

General objectives of falls prevention:

- To make available relevant knowledge, procedures and evidence on specific falls prevention programmes and related good practices. To scale up fall prevention and fall injury prevention initiatives from local pilot studies to a practical and feasible pan-European programme including all stakeholders, where scaling-up takes into consideration the maturity of regional and local care integrations and pathways.
- To understand fall risk, including medical conditions in general with particular focus on fall risk increasing drugs and related interventions. This includes consider deprescribing of FRIDs (withdrawal and dose reduction) as related to steps in primary prevention through judicious prescribing. A2 activities are represented by developments within the European Geriatric Medicine Society (EuGMS) Task and Finnish group on FRIDs, collaborating with the EuGMS Special Interest Group on Pharmacology and the European Union of Medical Specialists (UEMS)-Geriatric Medicine Section.
- To engage in education, in a broad sense, related to falls, fall injuries and fall risk, with particular focus on falls prevention, but related to mitigation, recovery, care, and prevention of further falls, in situations after falls, not just in situations leading to injuries. This includes the development of an innovative, dynamic and sustainable care system for AHA through capacity building using senior/patient-centred, multidisciplinary and inter-professional educational programmes aimed at patients, patient caregivers (both formal and informal), health and social carers, administrators and entrepreneurs.
- To enable digital transformations related to falls prevention activities. This is based on enabling relevant stakeholders in the falls field to reach a common understanding and to involve them in the adoption of consensus-based procedures, methodologies and standards, where information & process models are adopted and further developed. Furthermore, to leverage AG A2 achievements by elaborating key information on policy-oriented data on the impact of those innovative practices and related digitalisations being implemented in falls prevention, exploiting the opportunities of existing parallel or complementary initiatives and international frameworks. This includes ensuring the sustainability of the AG A2 activity by exploiting the assets generated for both public and private entities, including policy support, innovation take up and joint research opportunities.

The formulation and content of these general objectives underline the need to prevent falls rather than just *aiming to help and advise organisations on their efforts to create procedures to implement practices targeting the prevention of falls*.

We are preventing individuals from falling, so falls prevention campaigns will need to target individuals.

Good practices, based on evidence, come into play, and also in the way they are suitably and effectively integrated into the care and falls prevention processes where the integration of care requires the use of a common language and consensus concerning procedures (Fig. 3).

Awareness raising is often based on data material and analytics showing occurrence of falls and injuries.

Figure 3. The Maturity Model for prevention campaigns

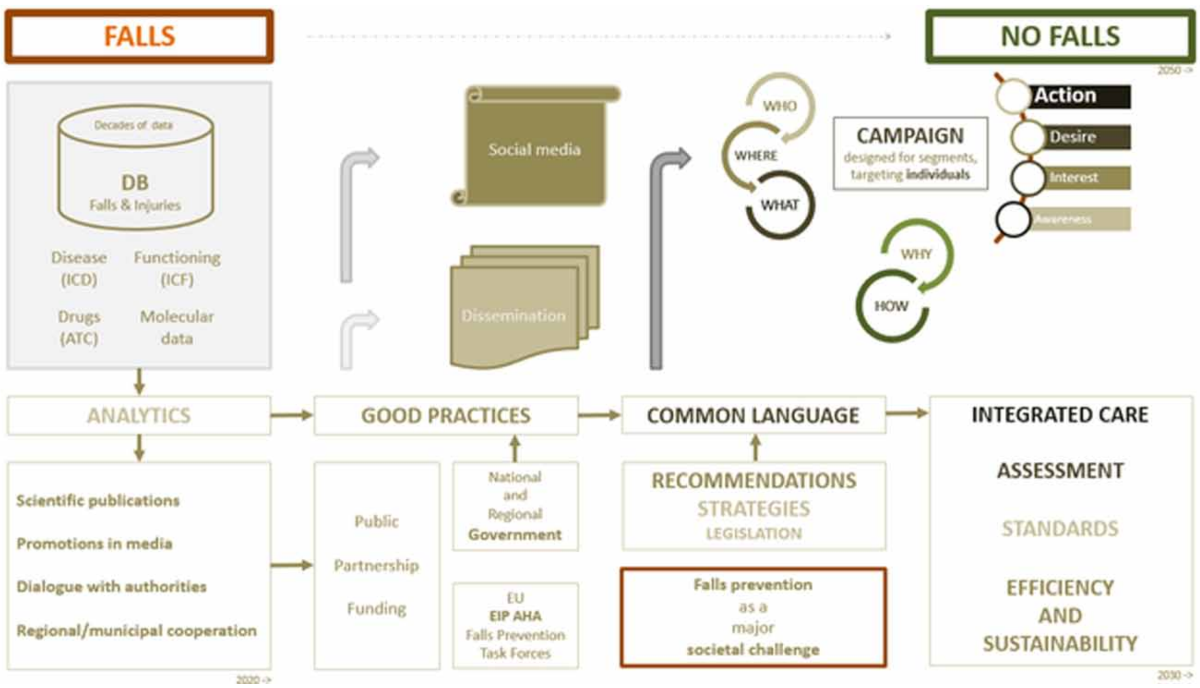
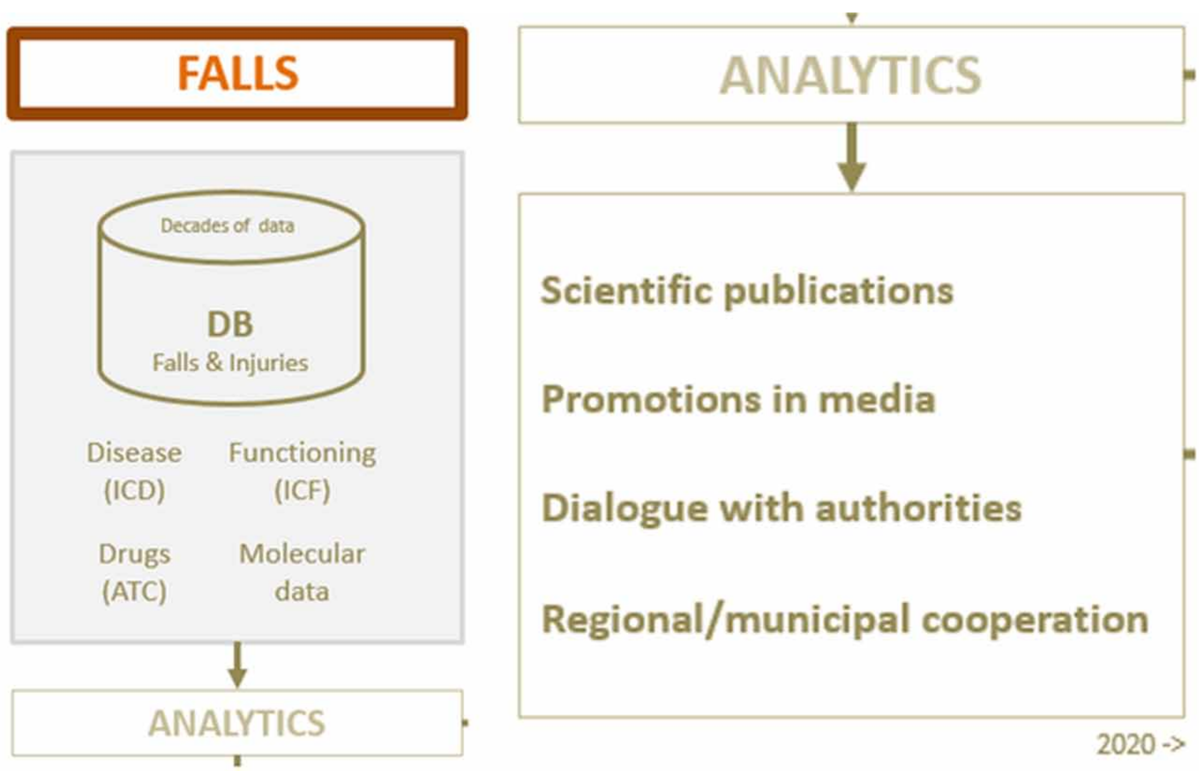


Figure 4. Data, analytics, and dissemination of results



As an example of such awareness raising, a population-based registration of patients admitted with injuries to an emergency department was done in region Västerbotten (Sweden) during 1993-2014. There are 220 014 injury events in the repository. In summary, 43% of all cases were fall injuries, 12% transportation injuries, and assaults at 4%. There were 23% fractures, of which 40% where hip fractures. With increasing age, fracture locations changed from distal to proximal, and from upper to lower extremity. Notably, fall injuries accounted for 80% of all trauma-related hospital days (Hellström, et al., 2020).

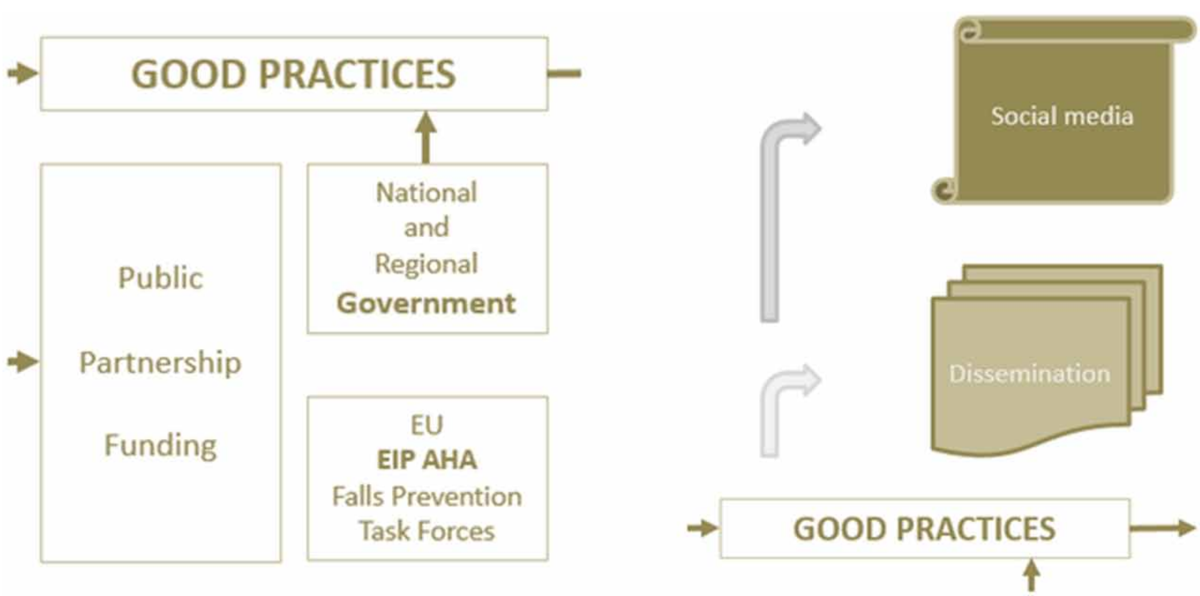
Data in the repository was originally not structured as based on classifications, e.g. like using WHO's Family of International Classifications (Eklund, 2016). However, during later stages of data collection, and later on, when other classes of data was merged with the repository, information ontology was considered and partly implemented, e.g., for encoding disease and drugs.

For classifications of functioning involved multiple-valued scales, algebraic methods (Eklund, et al., 2014) need to be used e.g. in order to manage computations with missing values.

Results have been published scientifically with many publications over the two decades (for example Bergström, et al., 2008). Major findings have been formulated and promoted in promoting in several local and national newspapers (e.g. Svensson, et al, 2017). Results have been discussed in dialogue with national and regional authorities, in order to establish awareness raising campaigns in cooperation with regions and municipalities.

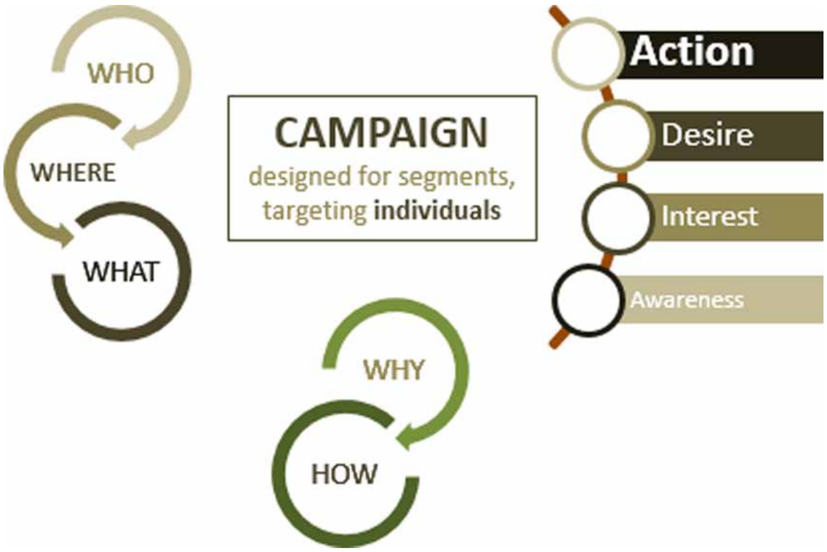
Methodology in analytics considered making use of a wide range of statistical tools and AI techniques, the latter as based on well-proven Bayesian, neural and logical approaches (Eklund, 1994; Eklund et al, 1995).

Figure 5. Good practices rooted in governance and advocated through social media to the public



Conversion and inclusion of analytics into good practices is non-trivial, but EIP on AHA has shown a variety and spectrum of good practices (Illario, et al., 2015, Illario, et al., 2016) in active and healthy ageing, both twinned between regions and as upscaled within regions.

Figure 6. WHO-WHERE-WHAT-WHY-HOW and AIDA

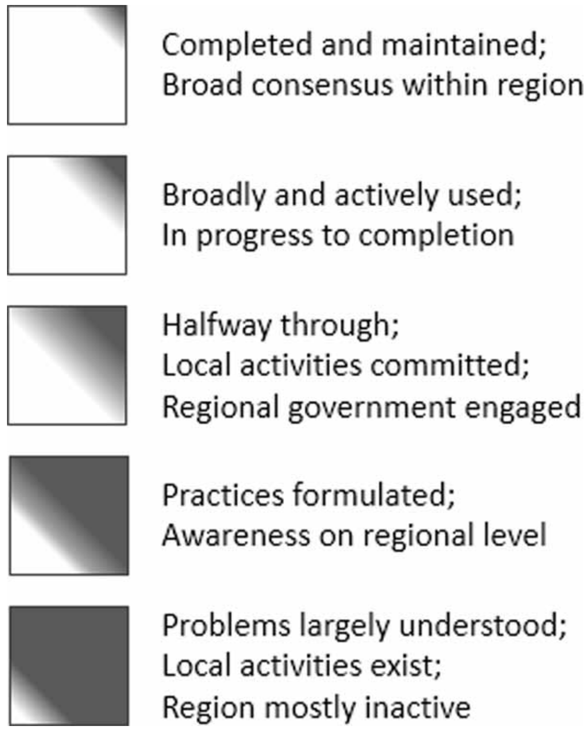


The WHO-WHERE-WHAT-WHY-HOW of falls prevention is in this context very important to specify in finest possible granularity. WHO uses WHAT information and WHERE in point of care? WHY is all this done, and HOW do we act and communicate? All these ingredients must appear in fine-granular detail in order to enable implementation and upscaling, where consistency is prerequisite to increasing the pace of local implementations. Who campaigns for awareness raisin, and how? Where and with what is interest and desire generated? How and where do we bring older persons to actually act in favour of lowering their risk of falling?

Figure 7. The Healthy Ageing Maturity Model

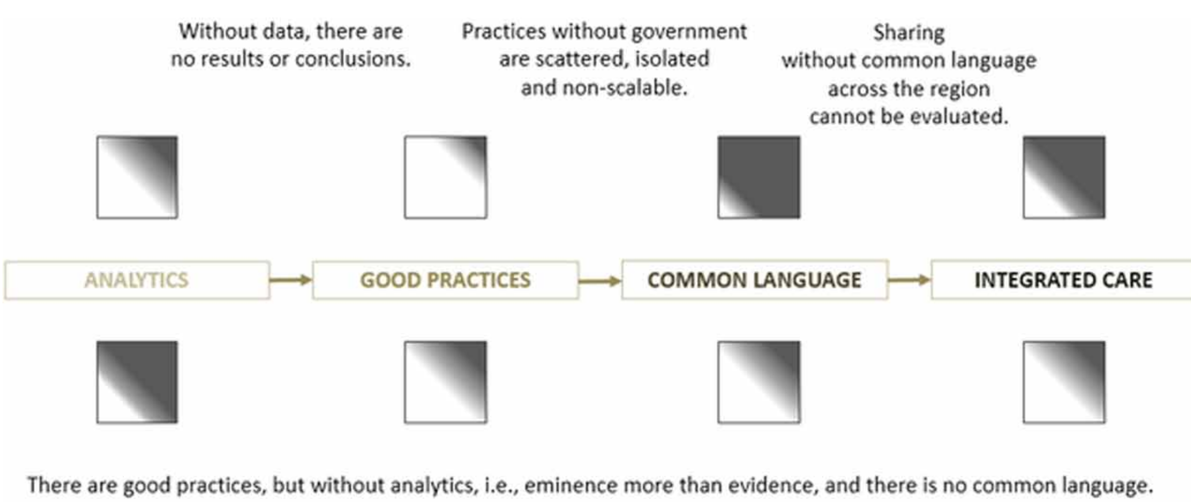
Making older people act in favour of their own well-being, as supported and promoted by the surrounding society, requires maturity in analytics, good practices, commonality of language and detailed process views for integrated care.

Figure 8. Levels of maturity



The need for having repositories for analytics purposes may in regions be largely understood, but regions may remain inactive concerning data gathering. Local activities may be committed to certain good practices but the region at large may be only halfway through concerning broader upscaling and completion within the region. Broad consensus within regions is very rare, but a necessity for successful regionwide prevention campaigning.

Figure 9. Examples of maturity



CONCLUSION

Given health and health economy assessments, a *Common Assessment Framework for Active and Healthy Ageing* (CAFAHA) is ideally desired, even if not yet fully feasible given the activities developed within A2 and the EIP on AHA as a whole. However, as there is diversity with respect to maturity in regions to fully develop falls prevention practices and campaigns, assets as part of maturity needs to be defined more clearly. Some regions may have good portions of data and related analytics, however they differ regarding practices and the use of a common language related to processes and information. Other regions are stronger on practices and in local areas, even from viewpoints of integrated care, but may be weaker on collecting data to enable analytics for validation and verification. Very few regions, if any, are fully matured with respect to analytics, good practices, use of a common language and Integrated Care. This requires the need to establish a falls prevention related maturity model, describing the maturity of regions in these aspects, supporting them to close gaps and strengthen their long-term approaches to falls prevention and other related campaigns. By doing this, the bar will be raised from simply fostering innovation in falls prevention to actually preventing and proving it works.

There is diversity with respect to maturity in regions, in order to fully develop prevention practices and campaigns, assets as part of maturity needs to be defined more clearly. Some regions may have good portions of data and related analytics, no matter how they differ regarding practices and the use of a common language related to processes and information. Other regions are stronger on practices and in local areas, even from viewpoints of integrated care, but may be weaker on collecting data to enable analytics for validation and verification. Very few regions, if any, are fully matured with respect to analytics, good practices, use of a common language and Integrated Care. This requires the need to establish a prevention related maturity model, describing the maturity of regions in these aspects, supporting them to close gaps and strengthen their long-term approaches to falls prevention and other related campaigns. By doing this, actions e.g. within injury prevention in general, and injurious falls prevention in particular, will raise the bar from simply fostering innovation in falls prevention to actually preventing and proving it works. This obviously won't be achieved quickly, but, for the aim of falls prevention, these aspects aim to increase the understanding of maturity that affects the way regions will build up and enrich their falls prevention programs.

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KEY TERMS AND DEFINITIONS

Falls Prevention: Preventing falls and injuries caused by falls.

Chapter 15
Information and Process in Health

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ABSTRACT

Cooperation and partnership in healthy ageing enhances and enriches the underlying information and process models within integrated care. On information, functioning oriented data as part of health and social data describes medical conditions and functioning capacity of the older person. Similarly, the notion of a good practice, as embracing a conglomerate of guidelines, is also well understood but less so in terms of process substance. Process structure granularity is often quite coarse and less formal, comparable to process descriptions annotated with clinical guidelines. This chapter describes an algebraic framework for representation of functioning data typically found in contexts of integrated care processes in healthy ageing.

INTRODUCTION

Information ontology is mostly relational so epistemological enhancements are required as soon as we want to work logically with ontology. In health and social care it has been acknowledged that information and process should go hand in hand, so that whenever information or knowledge management system modules are used, we should always be aware of the "location" in the process where this information is consumed e.g. for documentation purposes or knowledge is applied in decision-making.

Whereas information has been in focus even with less logical considerations, process structures have been very little subject to ontology and logical investigation. BPMN (Business Process Modeling Notation) has grown to become almost a de facto standard for process modelling when dealing with care pathways and integration of care.

On information, we will in this chapter focus on WHO-FIC (World Health Organization - Family of International Classification) classifications. We will focus on ICF (International Classification of Functioning, Disability and Health), and its generic 5-scale of values.

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We will also show how the 6th and 7th values connected with 5-scale can be interpreted in the context of dealing with missing data, and how the extended 6-scale can be connected with algebraic operations being able to compute with missing data.

Conventional data analysis using numerical and statistical methods need to handle missing data by actually adding values where data is not to be found. Data is added then using some assumptions about the data, like in various missing data models (Tseng et al, 2019).

On process and pathways within integrated care, the Who - Where - What - Why - How of prevention is in this context very important to specify in finest possible granularity. Who uses what, i.e., which information and where in point of care? Why is all this done, and how do we act and communicate? All these ingredients appear in fine-granular detail in order to enable implementation and upscaling, where consistency is prerequisite to increasing the pace of local implementations.

INFORMATION AND ITS LOGIC

Two-valuedness in logic is traditional, as it is primarily used in mathematics. A mathematical statement is either true or not true. That is the essence of mathematics. However in practical applications, levels of certainty, levels of truth, come into play, and we must immediately distinguish truth levels from probabilities.

Probability is also fundamentally two-valued in the sense that samples are drawn into sets, and samples are either inside sample sets or outside. Membership in sample set cannot be graded beyond two levels, because otherwise the machinery of probability theory will not work. This is a fundamental weakness of probability theory, and indeed a fundamental weakness of the statistical machinery underlying all of evidence-based medicine. Samples may be drawn as based on criteria, one may say in defense, but such criteria are formulated in binary valued logic. Cutoff values are often used. For example, age over 55 is eligible, but not 55 or less. A laboratory value of 150 or over may qualify for inclusion, but 149 or less will not. Once sampling has been completed, the statistical machinery deals with sets, and starts e.g. to count numbers of occurrences within those sets given further criteria, and may start to computer mean values within selected subsets.

Hypothesis testing is typically applied which gives strengths of belief in certain claims. However, the underlying sampling is yet binary, since the statistical machinery is unable to compute with logical many-valuedness. Logical and probabilistic uncertainty is thus fundamentally different.

In logic, we have terms (or expressions) and sentences (or statements) as basic ingredients within the inference mechanism. A term might look like $a*b$, where * is a binary operator as part of the underlying signature of the logic, and the value of $a*b$ is semantically a member in some algebra. In this abstract example, a and b are values representing observations or local aggregations. A sentence might look like *able.to.act*($a*b$), where similarly its value is a 'truth value'. In many-valued logic, with graded truth, we depart from binary logic, thus enabling all statements to embrace many-valued truth.

CLASSIFICATION OF FUNCTIONING, DISEASE AND INTERVENTION

ICF is part of WHO-FIC, and WHO-FIC maintaining a browser for ICF. There are also translations to a number of languages, and more translations are desired.

ICF was officially endorsed by all 191 WHO Member States in the Fifty-fourth World Health Assembly on 22 May 2001 as the international standard to describe and measure health and disability.

ICF's hierarchical structure is the following:

```
ICF
    Components
        Chapters
            Sections
                Items
                    Subitems
```

Here is an example for one ICF item, and its location in the ICF item hierarchy.

```
ICF
    Body functions
        Chapter 1 Mental functions
            Global mental functions (b110-b139)
                b110 Consciousness functions
                b114 Orientation functions
                b117 Intellectual functions
                b122 Global psychosocial functions
                b126 Temperament and personality functions
                b130 Energy and drive functions
                    b1300 Energy level
                    b1301 Motivation
                    b1302 Appetite
                    b1303 Craving
                    b1304 Impulse control
                    b1308 Energy and drive functions, other specified
                    b1309 Energy and drive functions, unspecified
                b134 Sleep functions
                b139 Global mental functions, other specified and unspecified
            Specific mental functions (b140-b189)
...
        Chapter 2 Sensory functions and pain
...
        Chapter 3 Voice and speech functions
...
        Chapter 4 Functions of the cardiovascular, haematological, immunologi-
cal and respiratory systems
...
        Chapter 5 Functions of the digestive, metabolic and endocrine systems
...
        Chapter 6 Genitourinary and reproductive functions
```

```
...
        Chapter 7 Neuromusculoskeletal and movement-related functions
...
        Chapter 8 Functions of the skin and related structures
...
    Body structures
...
    Activities and participation
...
    Environmental factors
...
```

Item **b1300** is a subitem of item **b130**. For **b130**, ICF describes and defines it as follows:

b130 → Energy and drive functions

General mental functions of physiological and psychological mechanisms that cause the individual to move towards satisfying specific needs and general goals in a persistent manner.

Inclusions: functions of energy level, motivation, appetite, craving (including craving for substances that can be abused), and impulse control
Exclusions: consciousness functions (b110); temperament and personality functions (b126); sleep functions (b134); psychomotor functions (b147); emotional functions (b152)

Applications using ICF in general, and specific items in particular, will need to decide how to relate their application context to such descriptions.

One approach in doing so is to select keywords from ICF's text, and connect it with meaning and semantics from the application context. For instance, the text says ”physiological and psychological mechanisms” where some contexts might emphasize physiology more than psychology, other contexts the other way around, or some contexts may consider both.

Gradation for value and truth may be kept separate, but may also sometimes be allowed to overlap. ICF in WHO-FIC is a typical example.

xxx.0 NO problem → (none, absent, negligible,…) → 0-4%
xxx.1 MILD problem → (slight, low,…) → 5-24%
xxx.2 MODERATE problem → (medium, fair,...) → 25-49%
xxx.3 SEVERE problem → (high, extreme, …) → 50-95%
xxx.4 COMPLETE problem → (total,…) → 96-100%
xxx.8 not specified
xxx.9 not applicable

The underlying algebraic structure of the generic scale was briefly discussed in (Eklund, 2016).

In the 2001 version of ICF, for component BODY FUNCTION, the generic qualifier (0-4) uses 'impairment'. BODY STRUCTURE also uses 'impairment' in the generic qualifier, has a second qualifier (0-7) to indicate nature of change, and a third qualifier (0-7) to indicate localization. ACTIVITIES AND PARTICIPATION uses ’difficulty’. ENVIRONMENTAL FACTORS uses ’barrier’ and ’facilitator’, respectively, for a negative and positive scale. In the ICF – A Practical Manual (2013), all generic scales use ’problem’.

Note in the example above on **b130**, in inclusion, how the contextual meaning e.g. of ”craving” needs to be detailed. It is also important to note how e.g. ”sleep functions (b134)” are excluded, so that e.g. MODERATE or SEVERE problem with energy and drive functions must not be intertwined and connected to problems with sleep.

Both **b130** and **b134** may, of course, be included in selected subsets of ICF items, but they need often be treated separately and exlusively. This is important also in the ICF core Sets (Selb et al, 2015).

ICD, the classification of diseases, is also part of WHO-FIC, and it has a long history. The meeting of the International Statistical Institute in Vienna in 1891 initiated preparations of a classification of causes of death. The work was lead by Jacques Bertillon (1851-1922) who at that time was Chief of Statistical Services of the City of Paris. The classification prepared by Bertillon and his group was based on the classification of causes of death in Paris, which had been merging English, German, and Swiss classifications. The Bertillon classification was over next years to come broadly accepted.

Up to 1945, Bertillon’s list was still called the International List of Causes of Death, but was now extended or complemented with a International List of Diseases, capturing morbid conditions that are part of trains of events eventually leading to death. This was also when the distinction between morbidity and mortality statistics.

The International Health Conference in June and July 1946 entrusted the Interim Commission of the World Health Organization to prepare the next decennial revision of ‘The International Lists of Causes of Death’ and to establish a International Lists of Causes of Morbidity. As a follow-up the International Conference for the Sixth Revision of the International Lists of Diseases and Causes of Death was held in April 1948. Later that year, the First World Health Assembly endorsed the report of the Sixth Revision Conference, and the result was the Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death.

The 7th revision, ICD-7, from 1958, was called International Classification of Diseases. ICD-8 comes out in 1968, ICD-9 in 1979, and ICD-10 in 1999. A stable version of ICD-11 was released in 2018, and ICD-11 will officially come out in 2022.

WHO-FIC embraces also ICHI for intervention classifications, to be released.

The trilogy ICF/ICD/ICHI is now seen as an important multimodal classification scope, where respective classifications need to be connected and combined in various contexts involvning health conditions and integrated care.

Early versions of ICD supported statistics of diseases and causes of death. ICD codes are now used also encoding diseases in diagnostic processes, but is still purely a disease classification. Various approaches to harmonizations are on-going so that e.g ICF and ICD can co-act and interact, and ICHI needs further to be connected in this trilogy.

However, the underlying formal information structures and logics supporting such harmonizations are shallow and poor as “health ontology” adopts *description logic* (DL) as its underlying mathematical logic, mainly for the reason that “web ontology” and its Web Ontology Language OWL used DL for its axiomatization.

The basis for such approaches is the conviction that ”web ontology” and ”health ontology” is governed by one and the same underlying logic. This claim and basis is very suspicious, as description logic as a logic is barely more than a propositional logic.

Individuals in description logic and OWL correspond to logical constants in some signature. Concepts in description logic, called classes in OWL, are unary predicates with binary values in the range of the predicate, so semantically they are sets (of semantic values of the constants). Roles in description logic, called properties in OWL, are binary predicate, i.e. relations i ntheor semantic views.

Note how relations $R \subseteq X \times Y$ are the same as mappings $f: X \to PY$, i.e., mapping elements in X to subsets of Y. This is the fundamental basis of operations in description logics, i.e., description logic is just barely richer than propositional logic and seen as a very basic form of predicate logic.

Description logic is in fact a lambda calculus, and can be extended to enable the use of terms over a signature. Furthermore, such terms provided, in category theory, by term functors extendable to monads, need not be arranged only over the category of sets, but can be arranged over the Goguen category of many-valued sets, e.g., with quantales for many-valuedness. This enables to fully embrace all subtleties of the many-valuedness of ICF as explained about.

For a detailed explanation of these categorical constructions, see subsection 7.3 in (Eklund et al, 2014), and below for an introduction management of many-valuedness using algebras.

ICF’S 5-SCALE AS AN ALGEBRA

Note how xxx.0 to xxx.4 are simply names or codes for the levels in the scale. It is tempting to pick out the numbers 0 to 4, and even worse, to compute with them arithmetically. Clearly, COMPLETE “is more” than SEVERE, as 4 is more than 3, but transforming the set

$L = \{NO, MILD, MODERATE, SEVERE, COMPLETE\}$

to the set of digits, as symbols,

$N_4 = \{0, 1, 2, 3, 4\}$

will immediately, and unfortunately, invite to computing with these digits as numbers, and then arithmetics comes into play. This then indeed adds more semantics to the members in L. In fact, adding N_4 makes L come with a companion function

$f: L \to N_4$

where $f(NO) = 4, \ldots, f(COMPLETE) = 0$. Note how we do not arrange it like $F(NO) = 0, \ldots, f(COMPLETE) = 4$, for reasons explained later.

This is in any any case not explicitly written or recommended in ICF manuals. Mapping xxx.0 to the value 0 and xxx.4 to 4 is often adopted, but nowhere written or recommended in ICF.

However, this does not mean it is forbidden to add such semantics. On the contrary, we *do* want to compute with those values, but we must understand that there are many ways to mathematically interpret L, and thereby many ways to equip L with more structure and computational mechanisms. Using simple arithmetics simply because that's the only mathematics that is known, is not an appropriate justification for using arithmetics.

In that particular transformation, someone might indeed simply want to adopt arithmetic functions for values in N_4, e.g. by using mean values and rounding decimals so that the result continues to reside in N_4. For instance, a rounded mean value will do. We can write this more precisely as

$$a \oplus b = ROUND\left(\frac{a+b}{2}\right)$$

for $a,b \in N_4$, using a binary operator $\oplus : N_4 \times N_4 \rightarrow N_4$. Note that this operation is blind concerning the arrangement being *f*(*NO*)=4,…, *f*(*COMPLETE*)=0 or *f*(*NO*)=0,…, *f*(*COMPLETE*)=4.

Here we come to a fundamental disadvantage in using such calculations. Suppose we have three values $a,b,c \in N_4$. We will not always have $(a \oplus b) \oplus c$ corresponding to the rounded mean value

$$ROUND\left(\frac{a+b+c}{3}\right)$$

Nor will we have

$$(a \oplus b) \oplus c = a \oplus (b \oplus c)$$

i.e., associativity of that binary operator. This is devastating as it means you cannot perform operation with more than two values expecting the result to be independent of the order of computation. Aggregation is always all-in-one in the sense that only the aggregated result is considered.

There is another subtlety which opens up when we examine this situation, namely, the property of commutativity of the operator. The $\oplus$ operator is commutative, i.e.,

$$a \oplus b = b \oplus a$$

but always requiring commutativity of operation may be a restriction rather than a feature.

For an operator *: $L \times L \rightarrow L$, it cannot be generally and universally required that, e.g.,

MILD*MODERATE = MODERATE*MILD

For example, concerning the combined or aggregated functioning given handling stress and socializing,

d2401 Handling stress → MODERATE problem
d9205 Socializing → MILD problem

we may aggregate a combined situation like "handling stress WHILE socializing" as compared to "socializing WHILE handling stress". Could we imagine a situation where

MILD*MODERATE = MILD

whereas

MODERATE*MILD = MODERATE

when looking at different situation, e.g., when socializing is stress relieving as different from stress increasing. Social hormones like Oxytocin and arginine vasopressin come into play, where stress increase involves several neurological pathways including the amygdala (Jones et al, 2017). Handling stress while and because of socializing then may involve social anxiety, even as a disorder as defined by DSM-V ("persistent fear of one or more social or performance situations in which the person is exposed to unfamiliar people or to possible scrutiny by others."). For others, socializing provides stress relief.

What we say here is that simplifying the context where data resides, and where levels of functioning are to be aggregated, will also need less utility of sophistication in mathematical structures and computations related with contextual data.

Another example, where the order in binary operations makes a difference, can be found in drug treatments. In hypertension treatment it is often recommended to use smaller doses with several complementing drugs rather than increasing the dose for one drug. This comes from side-effect growing exponentially as doses grow linearly. A typical example is seen with ARB (angiotensin receptor blocker) and CCB (calcium channel blocker) as alternatives for treating essential hypertension. Starting with one of them and with a smaller dose, should one start with ARB and later on add CCB if need, also with a smaller dose, or first CCB and then ARB. Will the body react to treatment differently with first ARB and then CCB as compared to first CCB and ARB. Of course, the body will react differently, and the outcome will be different.

These examples clearly show that binary aggregation cannot be assumed always to be commutative.

Note also ICF's alternative names e.g. for MILD as 'slight' or 'low', and for SEVERE as 'high' and extreme'. Clearly, 'low' and 'high' are more like negated counterparts, but 'slight' and 'extreme' not similarly so.

The percentages are also not to be understood as universally fixed, as they need to be calibrated in different domains with reference to relevant population standards as percentiles.

Coming back to *L*, we may see it as an algebraic structure. As a partial order structure with a smallest (*NO*) and largest (*COMPLETE*) element, or as a complete lattice, it is a total order or a lattice chain, in this case a 5-chain

NO < MILD < MODERATE < SEVERE < COMPLETE

This would correlate with xxx.0 < xxx.1 < xxx.2 < xxx.3 < xxx.4. However, here we must be careful about what is 'good' and what is 'bad'. 'Good', i.e., NO (problem) is often and intuitively seen as a high value, not a low value, so algebraically the order is really

COMPLETE < SEVERE < MODERATE < MILD < NO

Note also how aggregating any condition level a with *COMPLETE* into a*COMPLETE* might be expected to result in an aggregated *COMPLETE*. Further we expect e.g. that $a*b \leq a*c$ whenever $b \leq c$, which is a built-in property of the quantale. For instance, *MILD***SEVERE* ≤ *MILD***MODERATE*, but could be either of *MILD***SEVERE* < *MILD***MODERATE* or *MILD***SEVERE* = *MILD***MODERATE*, depending on the application context.

This indeed justifies to use the mapping *f*(*NO*)= 4,…, *f*(*COMPLETE*)=0 instead of *f*(*NO*)= 0,…, *f*(*COMPLETE*)=4.

As a lattice it is a distributive lattice with the following tables for the minimum ($\wedge$) and maximum ($\vee$) operations

Figure 1. The distributive lattice of the 5-chain

$\wedge$	0	1	2	3	4
0	0	0	0	0	0
1	0	1	1	1	1
2	0	1	2	2	2
3	0	1	2	3	3
4	0	1	2	3	4

$\vee$	0	1	2	3	4
0	0	1	2	3	4
1	1	1	2	3	4
2	2	2	2	3	4
3	3	3	3	3	4
4	4	4	4	4	4

Now looking at different ways to aggregate according to binary functions *: *L*×*L*→*L*, we will have a total of $5^{5 \cdot 5}$= 298 023 223 876 953 125 such functions to choose from. However, not all of them are interesting. We need e.g. require associativity (*a***b*)**c* = *a**(*b***c*), i.e., * to be a semigroup, which drastically reduces that number. Further, we typically might want * to be order-preserving in both variables or * to be distributive over the maximum operation, which brings us to quantales (Eklund et al, 2018). For that particular 5-chain, we have a total of 1003 semigroup that provide the 5-chain with the algebraic structure of a quantale. Below we see one of these semigroups, and where the semigroup is non-commutative as 1*2=1 and 2*1=2, i.e., *SEVERE***MODERATE* = *SEVERE* and *MODERATE***SEVERE* = *MODERATE*.

Figure 2. A non-commutative quantale for the 5-chain

$*$	0	1	2	3	4
0	0	0	0	0	0
1	0	1	1	3	4
2	0	2	2	3	4
3	0	3	3	3	4
4	0	4	4	4	4

Interesting is now what happens when we include the 6th and 7th values from ICF's generic scale. For instance, if we add 'xxx.8 not specified' and use it to represent a "missing value" or a value "not (yet) known", we will have a 6-point lattice. The question is now, where in relation to the 5-chain will this 6th "not known" value be situated, and more importantly, how can we compute with that values in

{*NO, MILD, MODERATE, SEVERE, COMPLETE, Not Known*}

Before showing concrete example, we will here provide a brief algebraic description of quantales.

QUANTALES FOR COMPUTING WITH MISSING DATA

Quantales are semigroups over complete lattices so that the semigroup operation is join preserving in both variables. Many-valued terms and logical expressions using such algebras are discussed in (Eklund et al, 2014), using category theoretical instrumentation involving monads as used in algebra and topology (Eklund et al, 1993).

To be more precise, let Q be a set, the base set of elements in the quantale. Further let $*, \wedge, \vee$ be binary operations over Q so that $(Q,*)$ is a semigroup and $(Q, \wedge, \vee)$ is a complete lattice. Let us further denote the top element in the lattice by T ("true", e.g. as NO loss of functions) and the bottom element by F ("false", e.g. as COMPLETE loss of function).

We may remark that there are 5 semigroups on a 2-pointed set, 24 semigroups on a 3-pointed set, 188 semigroups on a 4-pointed set, 1 915 semigroups on a 5-pointed set, and 28 634 semigroups on a 6-pointed set. There is only one (complete) lattice on 2-pointed and 3-pointed sets, two lattices on a 4-pointed set, 5 lattices on a 5-pointed set, and 15 lattices on a 6-pointed set. For comparison with binary operations without any properties (often called magmas), there are $2^{2 \cdot 2}$=16 such operations on a 2-pointed set, $3^{3 \cdot 3}$=19 683 operations on a 3-pointed set, $4^{4 \cdot 4}$=4 294 967 296 on a 4-pointed set, $5^{5 \cdot 5}$=298 023 223 876 953 125 on a 5-pointed set, $6^{6 \cdot 6}$=10 314 424 798 490 535 546 171 949 056 on a 6-pointed set, and so on.

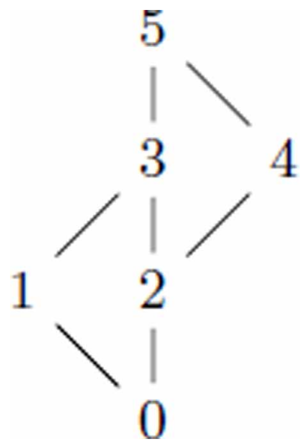
For comparison, 0-100%, all aligned in one single chain, is the most simple and least informative algebraic structure!

In applications we have to pay special attention to this strong condition as F is a very much unescapable value for the semigroup operation. One may see it as 'halt', 'stop' or 'dead' state, or something similar as representation for a state where aggregation involving the semigroup operation enables no escape whatsoever.

There are two quantales on a 2-pointed set, 12 quantales on a 3-pointed sets, 129 quantales on a 4-pointed set, 1 852 quantales on a 5-pointed set, and 33 391 quantales on a 6-pointed set. For 7 elements there are hundreds of thousands of quantales, for 8 elements millions.

We usually don't expect to be able to compute with missing or unknown values, i.e., for any number n we would have n+NaN=NaN. A typical way around this, when dealing with numerical values, is to replace or estimate the missing or unknown. When computing algebraically and logically with symbolic and order values in a lattice, we may assign one or more elements to represent unknown types of elements, so that these elements appear kind of on the "sideline" of the mainstream elements. A typical situation is within a non-chain lattice of a finite number of elements where a subchain of elements is designated so that "sideline" elements will become annotated and related with that mainstream subchain,

Figure 3. A 6-pointed (complete) lattice with two 'sideline elements'



Note in Fig. 1 how element '1' can be understood as unknown but intuitively expected to be sidelined mainly with elements '0', '2' and '3', whereas element '4' is more "optimistically" sidelined with elements '2', '3' and '5'. Incidentally, that 6-pointed lattice is the lattice product of a two-valued chain with a three-valued chains. This is very appealing in applications. The semigroup operation can be viewed as becoming the "third" logical operator, related with sup (Or, join) and inf (And, meet) of the lattice. Interesting features are e.g. non-commutativity appearing among many of these semigroup operations.

An element e in a quantale Q is a *unit* if $x*e = e*x = x$ for all $x \in Q$, i.e., e is an identity with respect to the semigroup operation. The unit, if it exists, is unique. A quantale with a unit is called a unital quantale.

From application point of view, operation with a unit leaves values otherwise unchanged. This may be desirable e.g. if the unit is interpreted as a 'not yet known' value, or similar. We wish to compute with 'not yet known' values, but we may not want 'not yet known' values to severely affect the outcome in a sequence of operations involving 'not yet known' values.

Units may be top values in the lattice, i.e., $e=T$, in which case the quantale is called integral. However, more commonly, we might provide semantics where the 'not (yet) known' value is a sideline element with respect to a subchain. In Fig. 4, either element '1' or element '4' could in this case be candidate for being a unit. For the lattice in Fig. 4, there are 1 268 semigroup operations providing the structure of a quantale.

For these quantales, 22 quantales are unital with element '1' as the unit, and 12 quantales are unital with element '4' as the unit. Note how element '4' as a 'not yet known' value is more "optimistic" as compared to to '1' as a 'not yet known' value, as lattice operations with '4' keeps values in the upper part of the lattice. The semigroup operation for one of those 12 quantales is

Without providing specific justification of applicability of this particular quantale, we may note that it is non-commutative. For instance, 1*2=0, whereas 2*1=1. Intuitively, within certain locations in the table, something weaker before something stronger aggregates to worse than something stronger before something weaker. Obviously, this cannot be a general reading for all the elements as, for example, 2*3=3, whereas 3*2=2.

This simple example shows the diversity of quantales and some of its special elements.

Such special elements may typically appear in modelling related e.g. with health states in medical diagnosis and evaluation of human functioning, quantum states in nuclear physics or risk levels in economics.

Figure 4. A non-commutative unital quantale for the lattice in Fig. 3

$*$	0	1	2	3	4	5
0	0	0	0	0	0	0
1	0	0	0	0	1	1
2	0	1	2	3	2	3
3	0	1	2	3	3	3
4	0	1	2	3	4	5
5	0	1	2	3	5	5

The top element may be special in the sense of fulfilling

$$T*T = T \tag{5}$$

and in such a case the quantale is said to be *balanced*. From application point of view, this should again be investigated from the viewpoint of establishing appropriate interpretations.

Further special quantale elements include dualizing and cyclic elements related with residuated lattices and Girard quantales. Detail on the properties of such elements can be found in (Eklund et al, 2018).

ICF'S 6-SCALE

From ICF point of view, and looking at the generic 5-scale together with one of xxx.8 and xxx.9 understood as ´not (yet) know' or ´(still) missing', extends ICF 5-scale to a 6-scale, we can now see how the missing value can be located in various positions as "sidelined" with the 5-scale.

Some positions make no practical sense, like having 'missing' being 0 or 5 in a 6-point lattice. Further, adopting a meaning where 'missing' is 2 or 3 in the chain, lattice (15) in Fig. 5, is intuitively also a non-practical default for missing values.

For six elements, we have the following 15 lattices:

Interesting lattices are those where we have a subchain of 5 elements, and one element being "sidelined" to that chain. For instance, in lattice (9), the sidelined element 1 is below the top and above the bottom element but undordered or unrelated to all other elements. Lattice (11) is similar, but then elements 2 or 3 are underordered with respect to each other.

Lattices (2) and (5) have sideline elements that are in a "more optimistic way" ordered with respect to the other elements. For instance, in lattice (2), elements 2 and 3 would correspond to MILD and MODERATE, respectively, so by default, the missing value, the sidelined element 1, is worse than NO (problem) but better that SEVERE (problem).

Figure 5. All 15 lattices over 6-point sets

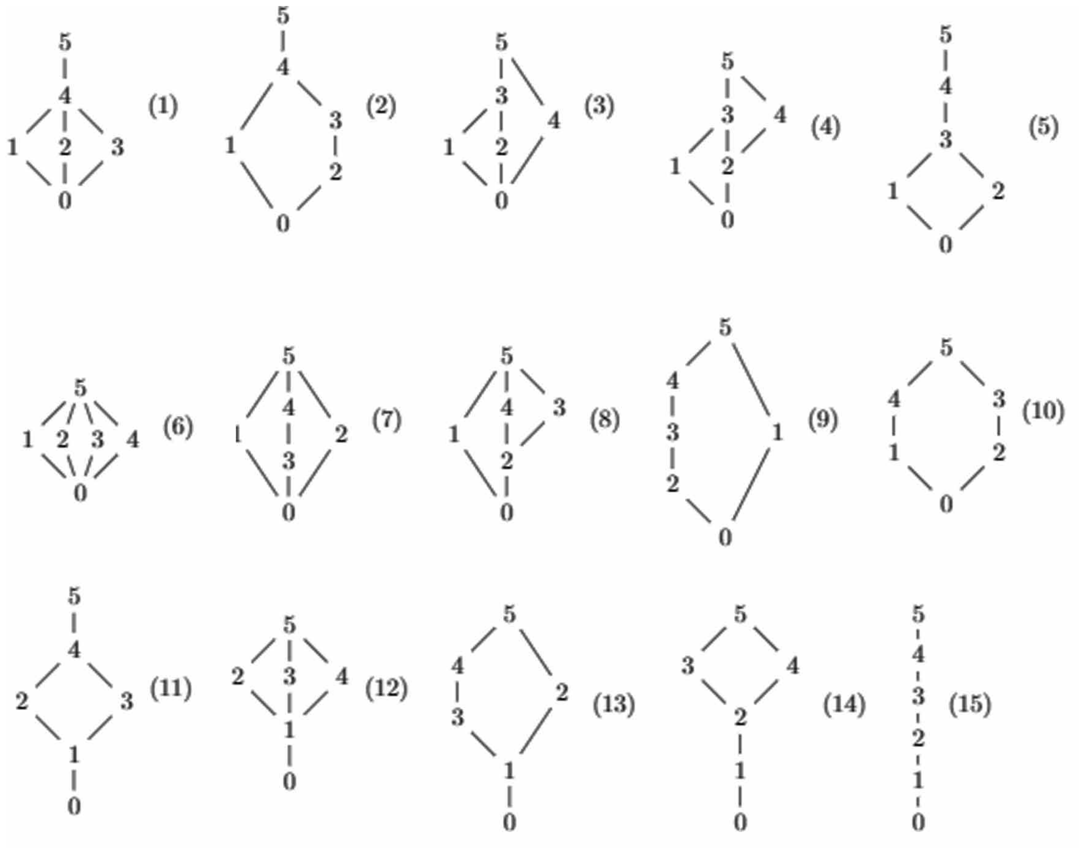
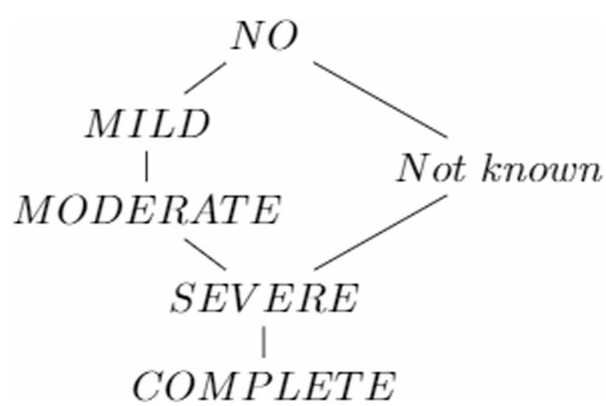


Figure 6. Lattice (13) with ´not (yet) known' as "optimistically" sidelined with the generic 5-scale



There are 2 830 quantales for the 6-point lattice (2). Of these, 57 are unital with the sidelined 'not known' as the unit, so that

x*Not Known = Not Known*x = x

for all values *x* in the generic 5-scale, i.e., aggregation with unknown values is not affected or enforced by missing values. Clearly,

Not Known*Not Known = Not Known

reflecting *ex nihilo nihil fit*.

One of the 57 semigroups as unital quantales is presented in Table 1.

Table 1 Quantale nr 6.13.1160 in the Catalogue of Quantales. http://www.glioc.com/files_glioc/CatalogueQuantales.pdf

*	Not known	NO	MILD	MODERATE	SEVERE	COMPLETE
Not known	Not known	NO	MILD	MODERATE	SEVERE	COMPLETE
NO	NO	NO	MILD	MILD	SEVERE	COMPLETE
MILD	MILD	MILD	MILD	MILD	COMPLETE	COMPLETE
MODERATE	MODERATE	MILD	MILD	MILD	COMPLETE	COMPLETE
SEVERE	SEVERE	SEVERE	SEVERE	SEVERE	COMPLETE	COMPLETE
COMPLETE	COMPLETE	COMPLETE	COMPLETE	COMPLETE	COMPLETE	COMPLETE

Note how this particular semigroup is non-commutative as *SEVERE*MILD = COMPLETE* whereas *MILD*SEVERE = SEVERE*.

For comparison, the rounded mean is shown in Table 2.

Table 2 Rounded mean.

$\oplus$	Not known	NO	MILD	MODERATE	SEVERE	COMPLETE
Not known	Not known	Not known	Not known	Not known	Not known	Not known
NO	Not known	NO	MILD	MILD	MODERATE	MODERATE
MILD	Not known	MILD	MILD	MODERATE	MODERATE	SEVERE
MODERATE	Not known	MILD	MODERATE	MODERATE	SEVERE	SEVERE
SEVERE	Not known	MODERATE	MODERATE	SEVERE	SEVERE	COMPLETE
COMPLETE	Not known	MODERATE	SEVERE	SEVERE	COMPLETE	COMPLETE

This show how sterile arithmetic functions really are, and also how they are context independent.

Clearly, the choice of table is application dependent, and must be justified its application context, but this indeed shows the variety if choices as compared to simply using arithmetics and rounded means, which are not justified at all, since they are often seen as having no alternative calculation.

Lattices (13) and (14) would be used for corresponding ”pessimistic” starting points for missing values.

PROCESS AND ITS STRUCTURE

The OMG (Object Management Group) family of languages and notations, include UML, SysML (Systems Modeling language), BPMN (Business Process Modeling Notation) CMMN (Case Management Model and Notation) and DMN (Decision Model and Notation). UML's Structure Diagram is an information model, whereas UML's Behaviour Diagram is a process model. UML's Behaviour Diagram is part of SysML, which is a process model expanding the process model side of UML. SysML is intended e.g. to support systems-of-systems modeling in engineering and manufacturing. BPMN differs from SysML, and BPMN's syntax enabling data flow with underlying tokens can be provided with a semantic based on our approach to many-valued logic. Whereas the underlying logic of BPMN has been explained, the underlying logic of CMMN and DMN is more in its infancy.

An information and process view of Ireland's national falls prevention program AFFINITY was developed during early 2016 as BPMN based integrated care process models. The purpose of the National Falls and Bone Health Project AFFINITY (Activating Falls and Fracture Prevention in Ireland Together) is to implement the 'National Strategy for the Prevention of Falls and Fractures in Ireland's Ageing Population', and to develop a robust governance framework to monitor progress, ensure accountability and sustainability.

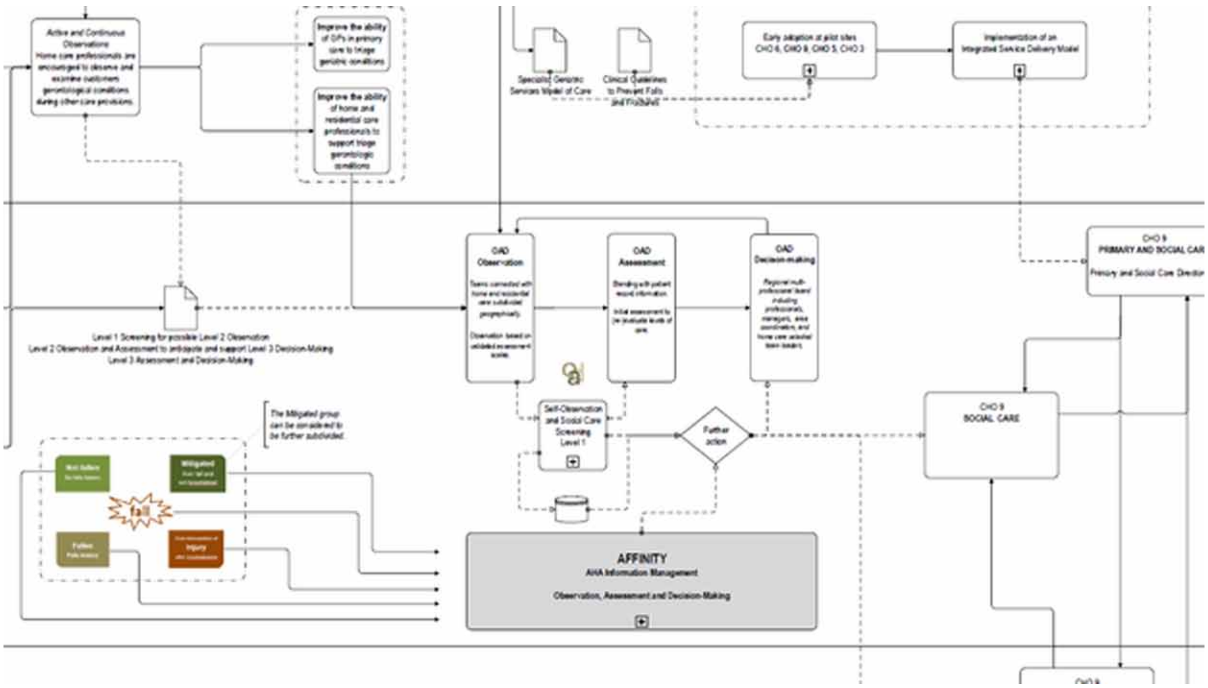
Cooperation between AFFINITY and its European partners e.g. within EIP AHA (European Partnership for Active and Healthy Ageing) intended during 2016 to enhance and enrich the underlying **information and process models** in support for the **embedding of practices** and the **upscaling of the embedding**.

On **information**, fall risk assessment is part e.g. of an overall geriatric assessment (Burns et al, 2009), in turn part of medical and social data describing the medical condition and functioning capacity of the older person. Similarly, the notion of a good practice, as embracing a conglomerate of guidelines is also well understood, but less so in terms of **process** substance. Process structure granularity is often quite coarse and less formal, comparable to process descriptions annotated with clinical guidelines.

Cooperation during 2016 intended to show how to move from well described pathways and processes to enable the use of information, structure and analytics. The **Who - Where - What - Why - How** of falls prevention is in this context very important to specify in finest possible granularity. *Who uses which information and in which point of care? Why is all this done, and how do we act and communicate?* All these ingredients must appear in fine-granular detail in order to enable implementation and upscaling, where consistency is prerequisite to increasing the pace of local implementations.

The NIMS (National Incident Management System) picklist is a very good basis for a first version of **Who** and **Where**. The HSE *Guide to Falls Screening and Multi-factorial Falls Risk Assessment in Primary Care* contains a good portion of **What**, and some specific subsystems to be described in the process view. The **Why** is partly in AFFINITY's *What needs doing, by Whom and How,* including enablers and actions as **How**.

Figure 7. Subprocess view related to integrated care within AFFINITY



Work during January-May 2016 resulted in a process oriented demonstrator *The Healthy Future of **Older People** in Healthy Ireland* as an enhancement of existing management pathway descriptions so that relevant information is clearly identifiable within specific parts of the pathway.

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KEY TERMS AND DEFINITIONS

ICD: International Classification of Diseases.
ICF: International Classification of Functioning, Disability, and Health.
ICHI: International Classification of Health Interventions.
Quantale: Semigroup that is sup-distributive over a complete lattice.
Semigroup: Associative binary operation.
WHO: World Health Organization.

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