D3.2 – Report on indicators and practices that facilitate constant good health conditions

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Disclaimer

E-VITA – European-Japanese Virtual Coach for Smart Ageing

E-VITA (EU PROJECT NUMBER 101016453)

WP3 – AHA Coaching contents and intervention programs

D3.2 – Report on indicators and practices that facilitate constant good health conditions

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Executive Summary

The aim of D3.2 "*Report on indicators and practices that facilitated constant good health*" is to provide the first contents related to health, that will constitute the basis for the use cases. The health coaching contents will be aimed at promoting, sustaining or maintaining wellbeing, optimal quality of life and healthy lifestyles in older adults, in order to strengthen the Intrinsic Capacity (IC) of the older population and so counteracting the decline or losses due to advancing ageing processes. The coaching activities provided by the e-VITA Coach will be focused on a) Personalized data collection and case analyses, with the aim of identifying specific health problems, unhealthy lifestyles and impairments in wellbeing; b) Individualized coach to improve wellbeing and quality of life by appropriate interventions and behavioural assignments. Under the supervision of health professionals, the e-VITA coach will suggest specific activities to each participant (i.e., walking, moderate physical activity; or keeping a diary with the identification of positive emotions or positive memories from the past - these two activities are directly related to wellbeing promotion) and it will monitor the course of the intervention. For instance, the virtual coach will assist older adults in planning their daily activities and homework prescriptions. It will also ask for feedback or obstacles encountered by older adults, and (in case of need) may require specific help by professionals.

In particular, the objectives of the deliverable are:

• the identification of everyday practices that facilitate constant good health conditions in the Intrinsic capacity domains, as detailed in Chapter 1 and 3;

• the identification of concrete health promotion activities from a medical (i.e. objective) perspective. Health promotion activities from a rather medical perspective represent a normative source to design persuasive and transformational interventions. However, these activities often differ from everyday practices. In order to identify these activities, expert interviews were conducted. The work is detailed in Chapter 4 and 5;

• the identification of interventions and strategies to engage older adults in health promotion activities. Interventions embody both knowledge about everyday practices (what older adults already do) and objective health promotion knowledge (what physicians think they should do). A list of both will be the starting point to design health promotion interventions (i.e. technology). The Use cases and human coach role are deeply described in Chapter 6 and 7.

Within this deliverable, the health professionals involved in each pilot site have cooperate to design the contents of the coaching based on the state of the art in the field of Intrinsic Capacity (IC).

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Table of Contents

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Lists of Figures and Tables

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Acronyms and Abbreviations

Acronym/Abbreviation	Explanation
JP	Japan
FR	France
IT	Italy
DE	Germany
TOHOKU	Tohoku University - Smart-Aging Research Center
IGOU	J.F. Oberlin University – Institute of Gerontology and Geriatrics
NCGG	National Center for Geriatrics and Gerontology
APHP	Assistance Publique – Hôpitaux de Paris
INRCA	Istituto Nazionale di Riposo e Cura per Anziani INCRA
CARITAS	Diocesan Caritas Association for the Archdiocese of Cologne, Diözesan-Caritasverband für das Erzbistum Köln e.V.
USI	University of Siegen
WP	Work Package
D	Deliverable
ADL	Activity of daily living
IC	Intrisic Capacity
ICF	International Classification of Functioning, Disability and Health
ICT	Information and Communications Technology
AHA	Active and healthy Ageing
WHO	World Health Organization
FA	Functional Ability
NICE	National Institute for Health and Care Excellence

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1 Introduction

In order to explore and define the health related use cases for the e-VITA system, the following steps were realized:

Step I: A deep analysis of the results from WP2 documents were conducted, with the aim of advancing from the first user-driven insights, by incorporating the clinical-geriatric perspective.

Step II: After the analysis of the framework of IC, an analysis of each core dimension were performed, with the aim of putting together the knowledge from the guidelines and the consortium partners' experience.

Step III: A profound systematic review of the literature, in terms of multi-domain interventions in the framework of the IC has been performed, with aim of understanding the impact of intervention like the e-Vita and exploring the practices already been delivered.

Step IV: A consultation with relevant international experts were conducted, in order to consolidate the evidence collected through WP2 and WP3 first activities, and collect input on preliminary version of the health related Use cases.

Step V: An investigation on the role of the human coach, as mediator of the system use and well-being promotion has been provided.

Step VI: The results of the activities were summarized into use cases for each core dimension of the IC, by combining the user-driven approach, the geriatric perspective with the technological capability. In addition, decision trees of the different use cases, to guide the interaction between the users and the system. Figure 1 summarized all the steps and activities conducted.

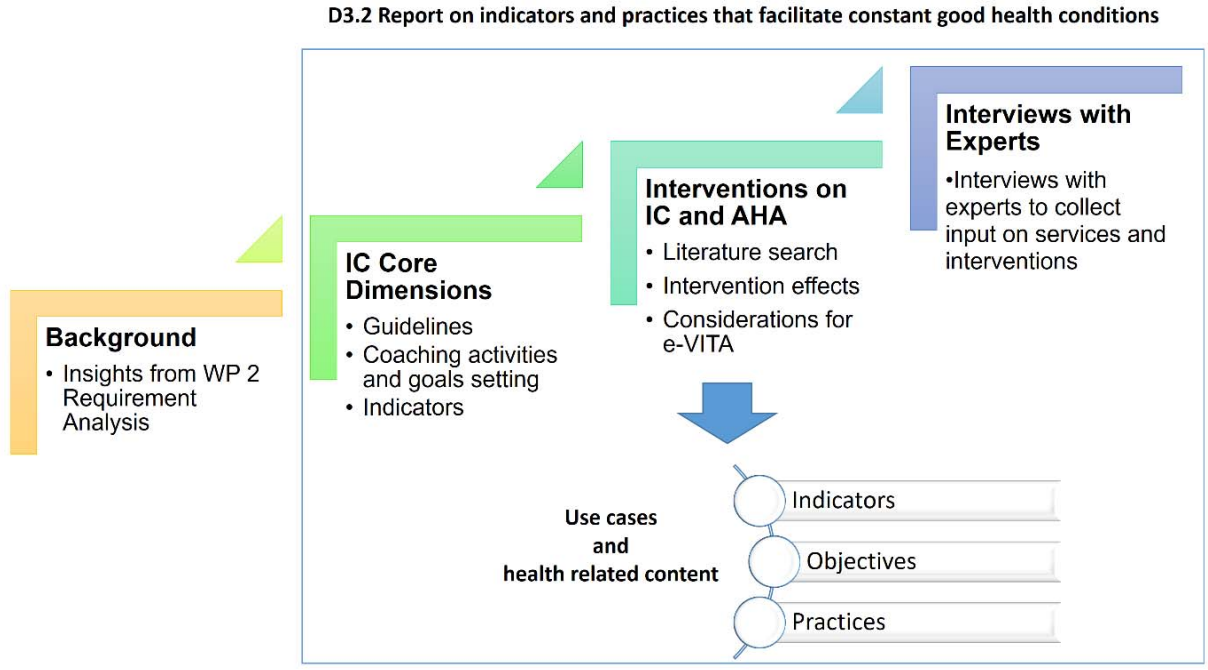

Figure 1. Conceptual Framework of the deliverable

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This deliverable is strictly connected with:

- the WP2 preliminary results, of which it represents an advancement,
- the D8.1, in which all outcomes and metrics for the assessment will be presented, taking into account the practices reported here in D3.2;
- all the deliverables of WP3, by complementing the different contents from D3.1 and D3.3 that will be summarized in D3.4;
- the activities of WP5, by giving a first idea of the communication and decision trees of each health related use cases;
- all the design and technical deliverables.

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2 Background on Intrinsic Capacity (IC)

Congruent with the worldwide population aging, the number of individuals aged 65 and older is expected to increase up to 1.5 billion in 2050 (Nations UJPDNY, 2019).

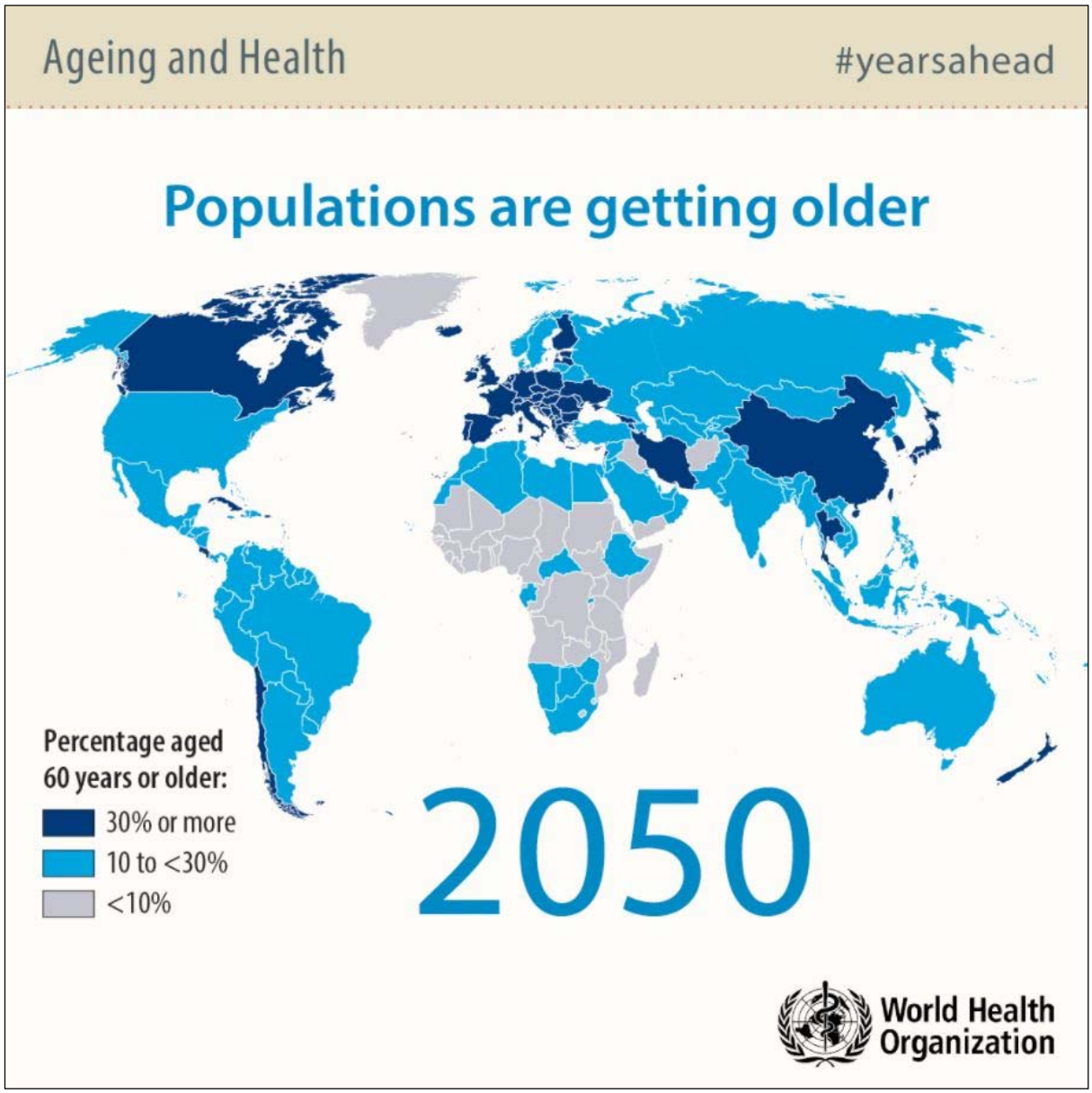

Figure 2. The worldwide population aging

This will lead to an increasing percentage of people living longer who want to stay active and healthy to fully participate in life. However, aging-related decline in biological, cognitive and functional systems may affect independence of older individuals negatively and limit their full socio-cultural and intellectual engagement (Jin et al., 2015). There is then an urgent need to address aging issues, providing supportive strategies to ensure wellbeing in older ages (Jin et al., 2015). Several models have been proposed in the attempt to capture the concept of wellbeing in older adults, such as healthy ageing, successful ageing and active ageing (Peterson et al., 2020).

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In the past, the study of aging process was strongly focused on health deficits (Belloni et al., 2019), such as diseases, disabilities, and limitations; this view was supported by the strong relationship between increase in socio-economic burden on healthcare systems world-wide and the increase in prevalence of multimorbidity and disability among populations with high life expectancy. Despite the relevance of this model, aging should be investigated more broadly, since absence of diseases does not always go hand-in-hand with aging well. For this reason, the World Health Organization (WHO) has recently proposed a more comprehensive response to population aging as the promotion of healthy aging across the life-time (Sadana et al., 2019). Healthy ageing is defined as "the process of developing and maintaining the functional ability that enables wellbeing in older age" (Organization WH 2015), independent of the presence of one or more diseases. The construct of healthy aging was recently stressed in the Baseline Report for the Decade of Healthy Aging 2021-2030, which set the goal of improving older individuals' functional ability. In this context, healthy aging involves an active engagement with life, optimal cognitive and physical functioning, and low risk of diseases that enable people to live an active and full life within their limitations (Rudnicka et al., 2020). Rather than considering healthy aging from the disease-based perspective, this functioning-based approach is oriented around building and maintaining the ability of older people to be and to do the things they have reason to value. Functional ability is referred to as the ability to (Beard et al., 2016):

- Meet basic needs.
- Learn, grow and make decisions.
- Be mobile.
- Build and maintain relationships.
- Contribute to society.

According to WHO, functional ability is made up of intrinsic capacity (IC) of the individuals, the environments in which they live and the interaction between the individual and these environments (Organization WH 2015). Intrinsic capacity (IC) was defined as "the composite of all the physical and mental capacities of an individual" (Beard et al., 2016), including ability to walk, think, see, hear and remember. Although older age is often characterized by a decline in baseline IC, the rate of decline in IC widely varies among individuals and baseline IC reflects multiple setbacks and potential recoveries (Gutiérrez-Robledo et al., 2019), (Low et al., 2011). If some older adults are able to maintain functional independence up to very advanced ages, other one's experience early onset of severe functional disability which substantially affects their quality of life. According to WHO, such biological diversity can arise from inequity, understood as the differential influences of several factors including genetics, sex, ethnicity, and environment on ageing itself (RudnicKa et al., 2020). Anyway, progressive decline in IC may be more or less tolerated up to a critical point when individuals require care and support. Furthermore, in all ageing populations, many individuals will experience a significant decline before death. Evaluation of biological age through IC can enhance understanding of the functional trajectories and vulnerabilities of individuals and populations and guide individualized preventive measures and interventions that are tailored to the persons' age, abilities and comorbidities (Althoff et al., 2017).

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2.1 Assessment and operationalization of IC

To improve operationalization of IC in clinical practice, a Clinical Consortium held in 2015 by WHO identified 5 IC core elements or domains: locomotion (physical capacity), vitality (nutrition, energy and balance), cognitive performance, psychological status, and sensory functioning (including vision and hearing) (Organization WH 2017). These domains influence each other and are in turn influenced by environmental factors. Despite early studies have supported the validity of the WHO Healthy Ageing framework built around the definition of IC (Beard et al., 2019, Chatterji et al., 2015), measures of different domains are not yet standardized and validated (Gonzalez-Bautista et al., 2020). In the Clinical Consortium held in 2019, WHO experts suggested the use of 5 tools for assessing domains of IC (Organization WH 2019): the Short Physical Performance Battery (SPPB) for locomotion, the Mini-Mental State Examination (MMSE) for cognition, body mass index (BMI) for vitality, self-reported visual and hearing impairments for sensory, and the 30-item Geriatric Depression Scale for psychology. To date, however, it is not still clear how functional measures of specific domains might depict the overall health status of older individuals (14). Broad self-reported questionnaires of well-being such as the General Health Questionnaire (GHQ) and the Short Form 36 (SF36) may capture this heterogeneity but do not consider some aspects of wellbeing, such as cognitive capacity. Another important issue is the difference between capacity and ability, which is a problem for common measures of functional status in the geriatric populations including SPPB, Activities of Daily Living (ADLs) and Instrumental Activities of Daily Living (IADLs). Impairments in SPPB, ADLs and IADLs are seen only in patients with severe functional disabilities, and these scales may not be able to capture the preclinical functional limitations which instead affect the overall quality of life and IC (Fieo et al 2011). Moreover, despite the importance of vitality, a measure for its operationalization is still lacking; vitality embraces cellular features and higher physiological systems, and its importance is related to its influence on the other 4 IC domains (Stuck et al., 1999); when the accumulation of deficits in these systems reaches a critical threshold, they become manifest in the overt losses of capacity that are commonly associated with ageing (Organization WH 2018). Despite its importance, a gold-standard tool for its quantification is not available and current measures include extremely heterogeneous features, such as lung function, nutritional status, body composition, physical strength (Gonzalez-Bautista et al., 2020).

Furthermore, the definition of an overall measure of IC is somewhat complicated by a certain degree of inter-domain relatedness. Previous evidence has shown how such inter-relatedness between IC domains may reflect physical resilience, defined as one's ability to resist or recover from functional decline following health stressors (Whitson et al., 2016). According to Gijzel et al., a higher level of correlation during external stress might be a signal of lower resilience (Veradhan et al., 2018). Consequently, a gold standard tool for IC should not merely consider the sum of abilities in the 5 IC domains but instead try to quantify the inter-relationships between IC domains. Correct assessment of biological age through IC is of extreme importance for the future; losses of IC during the aging process may significantly affect quality of life and become manifested as common problems, such as hearing and vision impairments, memory loss, walking problems, urinary incontinence and loss of positive affect. For such impairments, older people often misbelief that there is no treatment available, and may then disengage from services, lack treatment adherence, with subsequent devastating effects on their quality of life. Recent studies have also shown the prognostic impact of IC in the older populations, as it was shown to be a powerful predictor of care dependence in such setting (Gonzalez Bautista et al.,

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2020). Moreover, low balance and nutrition scores were associated with higher risk of falls and death (Charles et al., 2020). As well, declines in all domains except from sensory capacities were associated with incident disability (Prince et al., 2019). IC decline was significantly associated with increased risk of frailty, disability, falls, fractures and death (Ma et al., 2021). At this regard, recent research suggested that training of healthcare professionals about evaluation of biological age through IC may help identify early declines in physical and mental capacities and tailor effective treatments for their problems (Jotheeswaran et al., 2015). Consequently, realignment of worldwide healthcare systems towards building, preserving and maintaining the IC of older individuals has been considered an immediate priority (Araujo et al., 2017). The ambitious process of decreasing the worldwide dependent individuals through optimization of IC and promoting healthy aging across populations was underlined at the beginning of 2021 in the Integrated Care for Older People (ICOPE), published by WHO (Banerjee et al., 2021). In order to achieve these goals, it is necessary to perform 5 different actions (Takeda et al., 2020):

- Perform the screening of IC decline.
- Improve the multidimensional assessment of IC functions.
- Implement a personalized care plan.
- Monitor the personalized care plan.
- Integrate the caregivers and the community.

To translate all these goals into practice, it is necessary to find validated tools for capturing single IC domains and the whole concept of IC.

2.2 International Classification of Functioning, Disability and Health and Intrinsic Capacity

The three important concepts of healthy ageing (IC, FA, EN) have their roots in the framework proposed by the *International Classification of Functioning, Disability and Health (ICF)* compendium published in 2001 by WHO (Organization WH 2007) which highlighted for the first time the importance of functioning as a critical component of health. According to this framework, individual's health status is determined by multiple interacting factors, while disability arises from losses of interactions between individuals and both environmental and personal contextual factors.

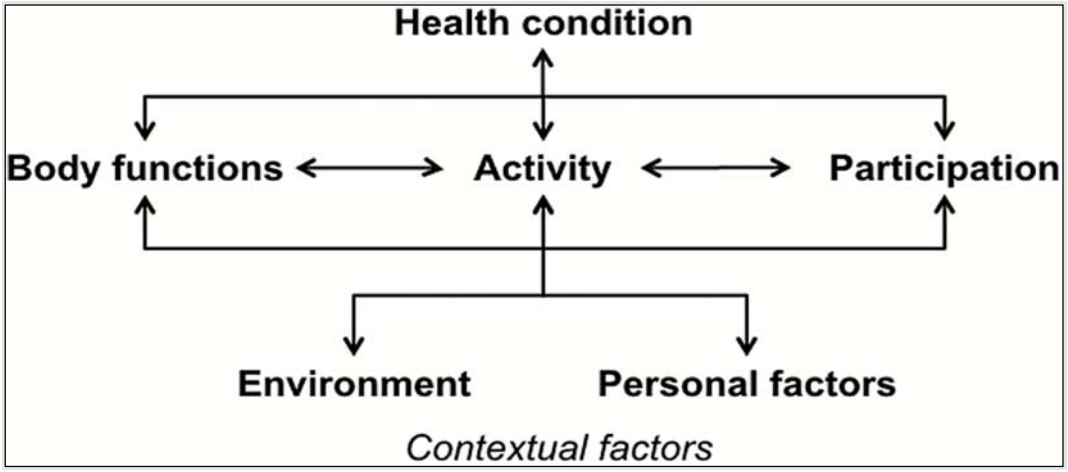

Figure 3. Multiple interacting elements determining the manifestation of the health status

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Whilst ICD-10 provides the codes for diseases, ICF describes a wide and complete range of functional states that define individual's health status, shifting the focus from diseases to global health and levels of functioning; for this reason, it was implemented in the World Health Survey Program as a global and universal tool (Ustün et al., 2003) for measuring health and disability at both the individual and population levels (Organization WH 2007). Whereas disability was previously considered as an all or none phenomenon, ICF presents disability as a continuum and recognizes it as a universal human experience (Ustün et al., 2003). In this regard, ICF is based on the principles of universality and parity, which state that both disability and functional status are features of all human beings and are not determined by background etiology (Ustün et al., 2003).

The ICF-based model depicts functioning and disability as the positive or negative results of a dynamic interaction between health conditions (diseases, disorders, or injuries) and contextual factors, including both environmental and personal factors. Environmental factors include all aspects of physical, social, and attitudinal environment that create the experience of human functioning and disability. Personal factors include age, sex, coping styles, social background, education and behavioral patterns that may affect the individual perception of disability.

The ICF interactive model identifies three distinct levels of functional ability (Organization et al., 2007):

1) Functioning at the level of body or body part.

2) Functioning of the whole person.

3) Functioning of the whole person in their complete environment.

Multiple interactions between functioning, diseases and contextual factors contribute to the global individual's health status. In this context, the intrinsic capacity construct emerged as an evolution of the WHO ICF-based recommendations (Organization Wh 2013); whereas ICF model mainly focused on deficits and limitations, the construct of intrinsic capacity emphasized the value of positive attributes, which significantly affect individual's reserves (Cesari et al., 2018); on the other side, contextual factors are part of environment and then excluded from the concept of IC as well as activities which are better recognized as outcomes rather than components of IC.

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2.3 Trajectories of functional capacity for healthy ageing

One of the advantages in using the construct of IC resides in its longitudinal pattern which is consistent with the continuous aging process at both the individual and population level (Daskalopoulou et al., 2019). Trajectories of both IC and FA particularly undergo continuous changes across the second half of the life course (Marsman et al., 2018). These continuous changes in IC and FA can be split into 3 distinct periods, which are not fixed are independent of chronological age: a phase of high and stable capacity, a declining phase, and a period of significant loss of capacity.

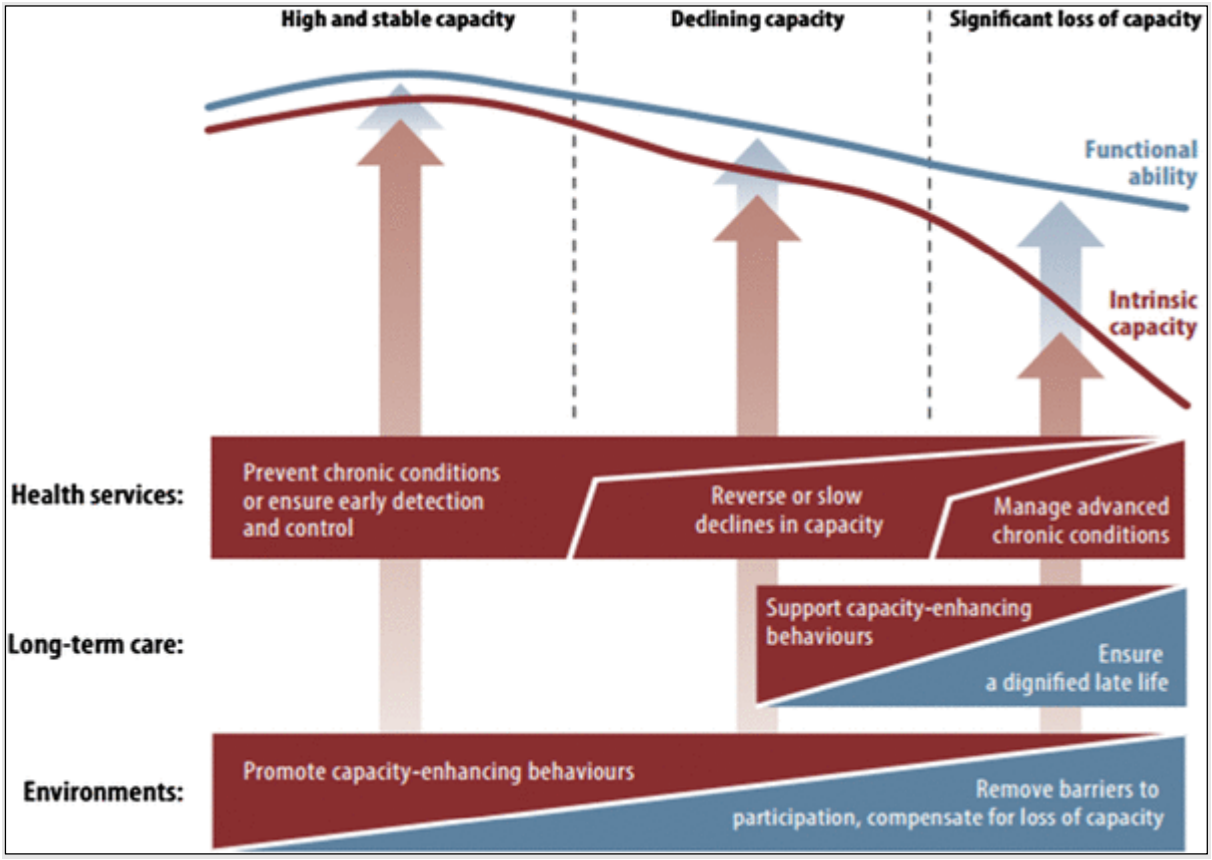

Figure 4. Public health framework for healthy ageing: opportunities for action across the life course

Investigation of IC and FA trajectories can provide more insight on specific subgroups of older adults deserving targeted interventions. The individual risk profile is evaluated through multiple observations of the individual over time and can give valuable information on which factors affect the stability or worsening of both IC and FA.

FA and IC trajectories are closely related, since IC is key for preservation of adequate FA over time (Gill et al., 2010). Recent evidence has shown that individuals with high baseline IC had also high baseline FA; similarly, a faster decline in IC led to a faster decline in FA over time (Rejeski et al., 2013) among community-dwelling older adults. Additionally, several factors influencing IC trajectory over time may consequently impact FA. Among them, age, low education, low income and less exercise were independent predictors of IC decline among older adults (Ma et al., 2021). Older individuals underwent faster IC decline compared to younger ones, and older adults with more chronic diseases had lower baseline IC level, as well as less decline in IC over time. This may be because they have low IC level which

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decrease the likelihood of further decline, or that having chronic diseases increases utilization of healthcare resources which dampens the declining trajectory of IC.

The longitudinal pattern of IC and FA strongly promotes the transition from a reactive toward a preventive model of medicine. While the clinical patterns of diseases typically determine a medical alert and response, a deviation of expected IC/FA trajectory may lead to a remedial intervention even in the absence of a specific clinical phenotype. In this view, distinction between IC and FA is critical to identify which components of health status (individual or environmental) can be addressed through targeted interventions to improve functional trajectories. At the same time, public health authorities may detect populations at special need of interventions (Belloni et al., 2020), (Althoff et al., 2017) according to baseline IC/FA level.

According to baseline capacities, WHO suggests different public health strategies to taken into account in order to maximize preservation IC/FA (Organization WH 2017):

For **older adults with high and stable levels of IC/FA,** public health strategies should focus on the following:

- ✓ Building and preserve this level of functioning as long as possible. Healthcare systems need to use instruments for early detection of diseases and risk factors.
- ✓ Designing environmental strategies to enable function encourage healthy behaviors among individuals and populations; environmental strategies for individuals should aim building personal skills and knowledge; on the other hand, broader environmental actions should include taxing tobacco and providing safer environments for physical activities.
- ✓ Environments should also enable functional ability, through removal of physical and psychological barriers to the expression of this capacity.

For **older adults with declining IC/FA,** public health strategies should focus on the following:

- ✓ In this phase, disease may have become established, so health care systems should shift their focus from prevention or cure to minimization of the impact of diseases on individual's functional capacity. Health care services are needed to help stop, slow, or reverse decline in functional capacity.
- ✓ The importance of designing environmental strategies to enable functional ability increases as capacity falls, with strategies to help people to overcome these decrements. For instance, if physical capacity becomes limited, public seating may make shopping more achievable by providing a place for an older person to rest; similarly, good street lighting may allow an older person with mild vision impairment to get home at night.
- ✓ The role of environment in enabling healthy behaviors is also importance when intrinsic capacity starts declining, but the emphasis may change in comparison with the previous phase. For instance, physical capacity may be promoted as much for building and maintaining muscle mass and balance as for reducing the risk of disease.

For **older adults at high risk of/significant losses of IC/FA,** public health strategies should instead focus on the following:

- ✓ Provision of long-term care by enabling an older person to maintain a level of functional ability consistent with their basic rights, fundamental freedoms, and human dignity.
- ✓ Ensuring the optimal trajectory of IC and enabling older people to perform with dignity the basic tasks necessary for their well-being.

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- ✓ Provision of early care to reduce declines in capacity, that might include family members encouraging older people to become more active and to eat well as well as assisting them.
- ✓ Provision of late care including support for basc tasks, such as washing and cooking; late care should be fully integrated with health systems to ensure that trajectories of capacity are optimized.
- ✓ Ensure an enabling environment to facilitate provision of long-term, early, and late care. For instance, make a home fully wheelchair accessible, or a community dementia-friendly is extremely important for someone with cognitive decline.

In any case, the gradual decline in IC/FA with individual aging certainly requires increased health and social care services from informal (i.e. family or friends) and formal caregivers (i.e., health care professionals). Increased health care needs in turn lead to augmented burden on families, stress for older adults and socioeconomic costs to societies. For this reason, it is promptly necessary to deliver cost efficient and effective interventions that optimize functional abilities at any degree of intrinsic capacity of older adults. Health and social care interventions and related policies may include technological tools and devices and provision of health and social care in the home.

However, both improvement and preservation of FA and IC trajectories require standardization of measurement approaches and metrics (*indicators*) to monitor and communicate potential positive and negative changes/deviations. It is also necessary to detect any compensatory mechanisms that a person uses to overcome decline in physical or mental capacities.

A comprehensive assessment or biomarkers for it may help understand where an individual is at any point in time compared to the general population and may be a potential predictor of functional capacity. For clinical utility, however, IC need to be decomposed into 5 sub domains that can inform clinical response. Current research supports the 5-domain structure including locomotor, cognitive, sensory, psychosocial and vitality/energy domains (Cesari et al., 2018). The instruments used to measure these domains should be tailored to specific levels of IC.

- ✓ For **individuals with overt losses of IC,** a final set of 6 screening instruments showed adequate accuracy and predictive ability for measuring functioning:
  - o Mobility: SPPB.
  - o Vitality/Energy balance-measure of malnutrition: MNA-SF.
  - o Psychosocial-measure of depressive symptoms: GDS-15.
  - o Cognitive: MMSE.
  - o Sensory-Hearing: WVT, Vision: PEEK.
- ✓ For **individuals with high levels of capacity,** use of traditional geriatric instruments may be inappropriate, as these tools were had not been tested on mid-life adults or for monitoring purposes. In such cases, more subtle biomarkers may be most informative.

Development of a composite measure of IC that encompasses all 5 domains is probably very challenging and may involve weighted scoring systems. It is likely that individual older people vary in the importance ascribed to declines of capacity in the single domains. Whether this refinement should be built into a composite score, or individual preferences better considered at the stage of collaborative care planning need further consideration.

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3 Intrinsic Capacity core dimensions

3.1 Physical Activity (i.e. Relevance and challenges for coaching older people)

Physical activity has many recognized physical, psychological and social health benefits that lead to improvement of overall quality of life in older individuals. Regularly performed physical exercises have shown to delay, prevent or reverse physiological multiorgan modifications induced by the ageing process. Improvement of physical activity across the life course has shown to be beneficial as it increases longevity, ameliorates both physical and mental capacities, reduces depression and anxiety and improves self-esteem; it prevents diseases and decreases the risk of morbidity (coronary heart disease, diabetes, and stroke); additionally, it promotes social interaction, community involvement and maintenance or creation of social networks (Rejeski et al., 2013), (Langhammer et al., 2018).

Appropriate physical training should be focused upon improvement in all core dimensions of physical health (aerobic capacity/endurance, resistance/muscle strengthening, flexibility/stretching, and balance).

Aerobic capacity and endurance: high-quality evidence supports the importance of the Aerobic Exercise Training (AET) programs of moderate-high intensity in improving of aerobic capacity, glycemic control, and lipid metabolism (Chodzko-Zajko et al., 2009) Additionally, AET programs have shown to decrease cardiovascular risk factors, mainly by lowering heart rate and blood pressure at rest and during submaximal exercise, decreasing insulin resistance and plasma lipidemia (Chodzko-Zajko et al., 2009), as well as improving arterial stiffness and endothelial functions (Santos-Parker et al., 2014).

Resistance: strengthening or resistance exercise training (RET) programs are effective in contrasting the age-related changes of sarcopenia, via improvement in muscle mass, function and strength (Chodzko-Zajko et al., 2009), (Stewart et al., 2014). In particular, RET programs involving the core and hip muscles can improve the mobility of older adults, reduce kyphosis and improve bone mineral density at the femoral and vertebral levels (Sinaki et al., 2012).

Flexibility/stretching: chronic stretching can be effective in improving joint range of movement (ROM), balance and can counteract mobility impairments and risk of falls in older adults (Sinaki et al., 2012).

Balance: is often affected in older patients, as a results of multifactorial conditions. Weakness in the core stabilizing muscles because of sedentary lifestyle and sarcopenia, loss of proprioception and control of posture can decrease balance in older individuals (Howe et al., 2011). Modest evidence supports implementation of balance exercises in a multimodal exercise program with strengthening exercises to decrease fall risks (Chodzko-Zajko et al., 2009).

European and/or Japanese

As older people, regular physical activity is one of the most important things they can do for their intrinsic capacity. It can prevent many of the health problems that seem to come with age. It also helps their muscles grow stronger so they can keep doing their day-to-day activities without becoming dependent on others. Their intrinsic capacity will increase with the more physical activity that they do. Older people should move more and sit less and do any amount of moderate-to-vigorous intensity physical activity gain some health benefits. Their health benefits will also increase with the more physical activity that they do.

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If people are 65 years of age or older, are generally fit, and have no limiting health conditions, people can follow the recommendation listed below (https://health.gov/sites/default/files/2019-11/PAG_MYW_OlderAdult_Poster.pdf).

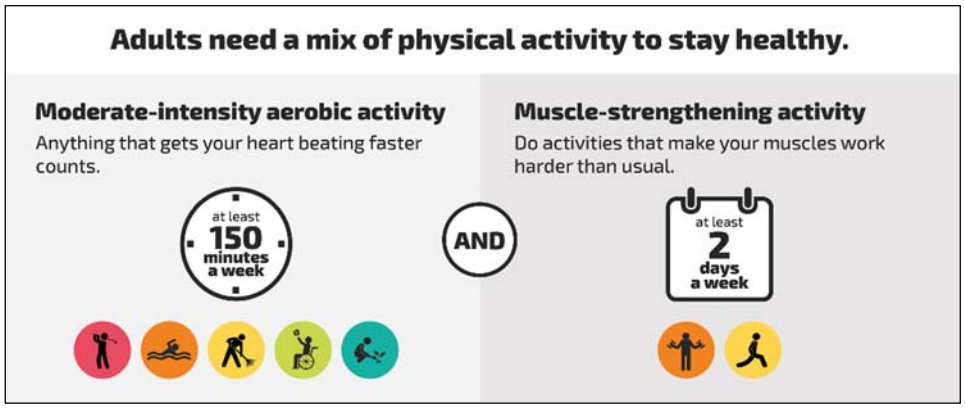

Figure 5. Adults need a mix of physical activity to stay healthy

If older people go beyond 300 minutes a week of moderate-intensity activity (60 minutes a day, 5 days a week), or 150 minutes a week of vigorous-intensity activity (30 minutes a day a week), or an equivalent combination, they will gain even more health benefits.

Multicomponent physical activity includes more than one type of physical activity, such as aerobic activity, muscle-strengthening activity, and balance training. Multicomponent physical activity can be done at home or in a community setting as part of a structured program that includes a combination of balance, muscle-strengthening, and aerobic physical activity, and may include gait, coordination, and physical function training. Recreational activities such as dancing, yoga, tai chi, gardening, or sports can also be considered multicomponent because they often incorporate multiple types of physical activity.

Older people should include stretching and balance activities as part of their weekly physical activity. Doing multicomponent physical activities can help reduce the risk of injury from falls and improve physical function. Falls are the leading cause of hospitalization and injury-related death in older people. Falls are due to a combination of environmental factors (loose rugs, clutter, poor lighting, etc.) and individual factors (organ-system abnormalities that affect postural control). Exercise, physical therapy, home-hazard assessments and adaptations, and withdrawal of psychotropic, medication, where necessary, all reduce older people's risk of falls.

WHO guidelines

In relation to its importance, WHO developed the "Global Recommendations on Physical Activity for Health" to provide guidance on methods to appropriately perform physical activity in older age. Physical activity includes recreational or leisure-time physical activity, transportation (e.g. walking or cycling), occupational (if the person still works), play games, sports or planned exercise in the context of daily, family and community activities. In order to ensure physical health and prevent non-communicable disease (NCDs), cognitive decline and depression, the following are recommended:

Individuals with no mobility loss, sarcopenia, balance impairment or risk of falls should perform at least 150 minutes of moderate-intensity aerobic physical exercise throughout the week, divided in 3 days per week, or an equivalent combination of moderate and vigorous intensity activity OR at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week, or an equivalent combination of the 2. At this recommended level of 150 minutes per week of moderate intensity

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activity, musculoskeletal injury rates are very low. In order to decrease the risks of musculoskeletal injuries, it would be advisable to encourage a moderate start with gradual progress to higher levels of physical activity.

Older adults with poor mobility (because of mobility loss, sarcopenia, balance impairments or risk of falls) should perform physical activity to enhance balance and prevent falls on 3 days per week. This consists of multimodal training programs, including progressive strength resistance training, balance, flexibility and AET that should be performed 3 days per week or 1 day a week + 2 days of normal activity. These programs should focus on important muscle groups (core, legs or arms) and be performed in a functional manner.

For patients with cognitive impairments, tailored, simple and less structured exercise programs should be considered. IT-guided exercises enriched with visual and auditory stimuli can be used to enable physical training and promote cognitive training in such individuals.

When older adults cannot do the recommended amount of physical activity due to health conditions, they should be as physically active as their abilities and conditions allow; trainers should advise chair- and bed-based exercise training as a starting point to avoid muscular injuries in such individuals.

In any case, environment should be prepared to ensure adequate physical activity and improve individual safety and self-esteem. Interventions associated with older people gaining more physical activity include providing safe spaces for walking and stimulating regular participation in exercise with friends and families.

Suggested coaching activities/Goals setting

Multimodal exercise, including progressive strength resistance training and other exercise components (balance, flexibility, and aerobic training) should be recommended for older people with declining physical capacity, measured by gait speed, grip strength, and other physical performance measures. Medication review and withdrawal (of unnecessary or harmful medication) can be recommended for older people at risk of falls. Multimodal exercise (balance, strength, flexibility, and functional training) should be recommended for older people at risk of falls.

Aerobic physical activity or “cardio” gets you breathing harder and your heart beating faster. From pushing a lawn mower, to taking a dance class, to walking or biking to the store – these types of activities and more count. As long as they are doing aerobics physical activities as at a moderate – or vigorous - intensity, they count towards meeting the aerobic guideline. Even something as simple as walking is a great way to get the aerobic activity they need, as long as it’s at a moderately intense pace.

Besides aerobic activity, older people need to do things to make their muscles stronger at least 2 days a week. These types of activities will help keep them from losing muscle as they get older. To gain health benefits, they need to do muscle-strengthening activities to the point where it’s hard for there to do another repetition without help. A repetition is one complete movement of an activity, lifting a weight or doing one sit-up. Try to do 8-12 repetitions per activity, which counts as 1 set. Try to do at least 1 set of muscle-strengthening activities, but to gain even more benefits, do 2 or 3 sets. There are many ways they can strengthen their muscles, whether it’s at home or the gym. The activities they choose should work all the major muscle groups of their body (legs, hips, back chest, abdomen, shoulders, and arms) (https://health.gov/sites/default/files/2019-09/Physical_Activity_Guidelines_2nd_edition.pdf#page=67).

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Action on hazards – following a specialist's assessment, home modifications to remove environmental hazards that could cause falls should be recommended for older people at risk of falls. Multifactorial interventions integrating assessment with individually tailored interventions can be recommended to reduce the risk and incidence of falls among older people.

Activity: Multicomponent physical activity
Balance, flexibility, aerobic training, functional training, and muscle-strengthening training
Recreational activities such as dancing, yoga, tai chi, gardening, or sports

Activity: Aerobic activity
Walking or hiking; some forms of yoga; some yard work, such as raking and pushing a lawnmower; Bicycle riding (stationary or outdoors); water aerobics

Activity: Muscle-strengthening activities
Lifting weights; working with resistance bands; doing exercises that use one's body weight for resistance (push-ups, sit-ups); Heavy gardening (digging, shovelling); Some forms of yoga

Goals: Preventing Sarcopenia, frailty, and falls for older people, and keeping independent ADL and IADL

Indicators

Regular screening of physical health will be performed to evaluate baseline motor capacity and promptly diagnose even subtle physical problems that may harm overall health of the individual. This will be done by monitoring vital signs (blood pressure and heart rate), body mass index (BMI), balance (Berg balance scale), mobility loss (gait speed and grip strength), and risk of falls (Falls Efficacy-Scale International).

- Vital signs are important to determine the intensity threshold of physical training programs. In particular, calculation of target heart rate (THR) is necessary to differentiate between high- and moderate-intensity training programs. For moderate-intensity physical activity, a person's THR should be 50-70 % of their maximum heart rate (that is, 220 beats per minute minus individual's age); instead, vigorous-intensity physical activity is that at which THR falls between 77 % and 93 % of individual's maximum heart rate. Additionally, periodical calculation of heart rate at rest and during submaximal exercise will be useful to evaluate efficacy of AET programs on study participants. Similarly, blood pressure monitoring will be important to determine body tolerance to exercise and to advise individuals when interruption of physical training will be necessary (in the presence of hypertension or hypotension).
- **BMI** is important for determine physical health and to intercept individuals at risk of malnutrition or overweighting, in order to promptly adapt both physical training programs and dietary plans to individual's BMI. BMI will be calculated as weight/height^2 at the first assessment and once a week thereafter, and its value will be periodically tracked by a software implemented in e-Vita. An appropriate software implemented in e-Vita will create a record track of BMI, alerting both individuals and operators in the presence of potentially harmful decreases or increases in its levels.
- **Mobility impairment will be evaluated through assessment of balance, fear of falling and risk of falls, gait speed and handgrip strength**. Individuals with previous or acquired impairment in one of these tests will need multimodal interventions.

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- **Cardiovascular risk assessment will be performed on all individuals through combination of BMI, evaluation of lifestyle habits (smoking, alcohol consumption), and use of AGE reader.** The latter is a non-invasive device that can assess the tissue accumulation of Advanced Glycation End products (AGEs) within a minute; AGE skin levels have previously been associated with oxidative stress and cardiovascular risk, and will be measured every 6 months to determine the prognostic impact of physical interventions on cumulative individual CV risk.

Physical function as measured by the Short Physical Performance Battery (SPPB) (Guralnik et al., 2000) (physical performance). Activities of daily living (ADL) as measured by the Functional Independence Measure (FIM) (Hamilton et al., 1994) or the Barthel Index (dependency) (Mahoney & Barthel, 1965). Instrumental activities of daily living (IADL) as measured by the Instrumental ADL scale (Lawton & Brody, 1969), the extended ADL (Gladman et al., 1993), and the Frenchay Activities Index (FAI) (Schuling et al., 1993). Frailty syndrome determined by using the classification system proposed by Fried et al. (Fried et al., 2004), (Fried et al., 2001), based on assessments of grip strength, time walking, involuntary weight loss, fatigue, and physical activity. Physical activity as measured by a questionnaire (Fried et al., 2001) asking about the frequency and the time subjects had spent in the past 2 weeks performing several leisure-time and house hold activities.

3.2 Cognitive status

European and/or Japanese guidelines

Cognitive functions include a set of abilities such as memory, concentration, attention and reasoning which, when mobilized, allow the person to fully carry out activities such as communicating and learning. However, with age, certain abilities such as executive functions (e.g. concentration) and short-term memory decline. Some individuals will complain of memory problems. These memory problems are quite benign and may be an expression of age, but they may also reflect the expression of disturbing factors such as stress, fatigue, depression or even the taking of medication. However, these disorders can be increasingly important in some people and impact their daily life, in this case we speak of major neurocognitive disorders, which includes Alzheimer's disease. These neurodegenerative pathologies progressively lead to a loss of autonomy and a greater workload for carers, and institutionalization appears necessary when the disease is at an advanced stage (Wrobel et al., 2014).

However, not everyone ages in the same way. Inter-individual differences in cognitive ageing are based on what Stern calls reserve, which can be separated into two models: brain reserve and cognitive reserve. Cerebral reserve refers to the neurobiological capital with which the brain is endowed at birth, whereas cognitive reserve refers to the brain's ability to cope with disturbances (Stern et al., 2019).

Reserve is therefore dependent on both innate and non-modifiable factors such as the number of neurons, but also on environmental factors such as lifestyle, which could be controlled in order to influence cognitive decline. Among the factors that positively influence cognitive abilities are a healthy and balanced diet, physical activity, a high level of education and a high intellectual level throughout life or a rich social network. Taking care of one's health by regularly checking one's eyesight and hearing is also important. As well as the practice of cognitive activities such as reading, playing a musical instrument, games, volunteering (Moussard, 2018). These activities should be practiced throughout life, even in old age. These activities can be carried out individually or in groups, at home or outside through associations.

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Preventing neurodegenerative diseases and delaying the loss of autonomy is a major challenge in societies undergoing demographic transition. Indeed, the number of elderly people is constantly increasing and, consequently, so is the estimated number of people with neurocognitive diseases - 130 million people in 2050 according to the WHO (Prince et al., 2015). These diseases, which to date have no conclusive drug treatment (Martin et al., 2013), cause emotional as well as financial suffering for the person affected, their relatives and society (Moussard, 2018).

Through its virtual coach, the e-VITA project aims to train the user's cognitive abilities. In order to do this, the virtual coach will offer different cognitive activities involving various brain functions. Some existing paper/pencil games can be transferred to a computer format and computer applications can be used.

Suggested coaching activities/Goals setting

The Toulouse University Hospital (https://www.chu-toulouse.fr/-axe-no-3-la-stimulation-cognitive-) has described various activities that stimulate the brain, including maintaining social ties. Sharing moments of conviviality, going out with friends and family, making telephone calls, cultural activities, etc. stimulate the brain because their realization requires various cognitive capacities such as attention or planning.

Diversifying pleasures and meaningful activities is essential. It is easier to retain the information provided by an activity that is enjoyable and interesting than the opposite. Moreover, it will be easier to repeat these activities and therefore to stimulate one's cognitive abilities more regularly. It is also important to think about varying the pleasures by doing different activities in order to stimulate a wider brain network.

Implementing strategies can be useful to stimulate cognitive abilities. One strategy is to pay attention to what you are doing and try to memorize information, for example, summarize the chapter you have read and the next day remember what you have read or verbally recount what you have done in order to remember it better. Another strategy is to be organized and regular in one's activities, for example taking one's medication at a fixed time, putting the pillbox in a place where one is not likely to forget, such as on the table. Memory strategies such as mental imagery can be helpful in remembering the name of a person you have met more easily.

It is important to continue to orientate oneself in time and space. This can be done by using a calendar and trying to remember what happened the day before and the next day's schedule. When travelling, using a map or making a mental map of the environment are ways of working on spatial orientation.

Finally, it is also necessary to ensure that these auditory and visual abilities are functioning properly. It is important to carry out regular check-ups. Indeed, these abilities are essential for memorization but also for exchanges. Since the less we hear, the more difficult it is to hold discussions with others, to share moments of conviviality, and consequently our cognitive abilities are less stimulated. The same applies to visual abilities, the less we see the more difficult it is to carry out activities such as crossword puzzles, reading or even going out of the house. It is also important to detect cognitive disorders as early as possible so that personalized support can be provided as soon as possible.

Daily activities stimulate cognitive abilities. The most important thing is not to remain passive. Going out, talking, discovering new things and keeping busy cognitively are the best tools to maintain cognitive abilities.

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Activity: True/False Goals: thinking, memory
The virtual coach could propose a cognitive game by giving a statement to the person, who has to say whether the statement is true or false. The virtual coach says whether the answer is true or false and gives an explanation to the person.

Activity: Intrusive Goals: reflection, memory
The virtual coach gives a statement and then presents three other sentences. The user has to say which of these three sentences is not related to the statement at the beginning.

Activity: Capital Goals: thinking, memory and language
The virtual coach says the name of a country and the user has to say the name of the capital.

Activity Cognitive Application Goals: various cognitive functions
The virtual coach could propose to the person to perform cognitive activities proposed by an application e.g. CogniFit, Scarlett brain games for seniors, Peak etc. The application offers a wider range of activities that can be both verbal and visual, which stimulates a wider range of cognitive functions: spatio-temporal orientation, calculation, manipulation, orientation, language etc.

The NICE guidelines (NICE 2015) included many interventions to prevent cognitive decline in cognitively intact individuals:

- Encourage individuals to stop smoking, be more active, decrease alcohol consumption, improve diet and, if necessary, lose weight and maintain a healthy weight.
- Increase people resilience, by improving their social and emotional wellbeing.
- Plan sessions of cognitive stimulation therapy, motivating individuals to participate in exercise, cognitively stimulating games and social networking.
- Ensure an adequate and healthy diet by:
    - Reducing the intake of saturated and hydrogenated fats (associated with risk of cognitive decline, MCI and Alzheimer's disease).
    - Increasing the intake of polyunsaturated (n-3 PUFA) and monounsaturated fats (protective against cognitive decline in several studies), as well as fish consumption.
    - Ensuring adequate intake of vitamins B9 (folate) and B12 that can reduce the risk of cognitive decline and dementia.
    - Securing adequate intake of fruit and vegetables as a source of antioxidants against cognitive deterioration, dementia and AD.
    - Use alcohol with moderation. Light-to-moderate alcohol use may be associated with decreased risk of dementia and AD.
- Acknowledging and reinforcing the competencies of the individual.
- Promoting a positive view of life and social relationship (i.e. underlying the feeling of life satisfaction).
- Using cognitive control strategies to focus on positive and suppress negative information (ie. Remember the past positively).

Individuals with cognitive impairment should be additionally:

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- Provided with regular orientation information (day, date, time, weather, names of people) to help them remain orientated in time and place. Provide auditory and visual stimuli (audio, video, digital newspapers, family albums) to promote communication, orientate the person to current events, stimulate memories and enable them to share and value their experience.
- Tested for impairments in instrumental activities of daily living (IADLs) and executive functions (Trail making test) to evaluate difficulties managing finances or shopping, and eventually referred for medical assessment.

Indicators

Regular assessment of cognitive status will be performed by using several tools to monitor all cognitive dimensions involved in determining overall cognitive health and to detect even subtle changes in cognitive status that deserve to be addressed with adequate interventions.

- Age- and education-adjusted mini mental status examination (MMSE) and Montreal Cognitive Assessment (MoCA) will be performed at the time of the study enrollment and periodically every 6 months. They are both routine cognitive tests based on administration of a 30-point scale. The MoCA is more sensitive for discrimination between normal cognition and either mild impairments or dementia, whereas MMSE is more appropriate to monitor moderate-severe conditions.
    - MMSE > 24 and MoCA > 26 (normal cognition): these patients should:
        - Be monitored and trained to prevent the onset of mild cognitive impairment (MCI) which increases the risk of developing dementia, functional disability and dependency among older patients.
        - Be asked periodically about problems with memory, orientation, speech and language.
        - Follow interventions included in the NICE 2015 guidelines.
    - MoCA < 26: as above + specific training programs focused on reinforcement of affected cognitive domains (memory, language, naming, visuospatial and executive functioning).
- Trail making test and Memory Assessment Scale long delay list recall will be performed every 6 months to both assess and train executive functions which have been associated with medication adherence.
- Additionally, all individuals will undergo a 6-month screening of instrumental activities of daily living (IADLs) to measure the impact of cognitive abilities on daily functioning (finance and medication management, social interaction and so on) and to tailor appropriate interventions.

Creation of a scale measuring the feeling of competence towards one's cognitive functions. This scale would be filled in regularly, to see if the feeling of competence increases with the use of the virtual coach.

3.3 Vitality (Nutrition & Energy Consumption)

European and/or Japanese guidelines

Nutritional status can be affected negatively by physiological changes that can accompany ageing, in turn with an impact on vitality and mobility. Interventions that improve nutrition and encourage physical exercise, when integrated into care plans and delivered together, can slow, stop or reverse declines in intrinsic capacity.

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Ageing is accompanied by physiological changes that can negatively impact nutritional status. Sensory impairments, such as a decreased sense of taste or smell, or both, may result in reduced appetite. Poor oral health and dental problems can lead to difficulty chewing, inflammation of the gums and a monotonous diet that is poor in quality, all of which increase the risk of malnutrition (Kshetrimayum et al., 2013). Gastric acid secretion may be impaired, leading to reduced absorption of iron and vitamin B12. The progressive loss of vision and hearing, as well as osteoarthritis, may limit mobility and affect elderly people's ability to shop for food and prepare meals. Along with these physiological changes, ageing may also be associated with profound psychosocial and environmental changes, such as isolation, loneliness, depression and inadequate finances, which may also have significant impacts on a diet. Insufficient intake can be the consequence of reduced muscle and bone mass and increases the risk of frailty.

Consuming a healthy diet throughout the life course helps to prevent malnutrition in all its forms as well as a range of non-communicable diseases and conditions including diabetes, heart disease, stroke, and cancer. However, the increased production of processed food, rapid urbanization, and changing lifestyles have led to a shift in dietary patterns. People are now consuming more foods high in energy, fats, free sugars, or salt/sodium, and many do not eat enough fruit, vegetables, and dietary fiber such as whole grains.

Energy intake (calories) should be in balance with energy expenditure. The effectiveness of different nutritional interventions has been recently revised in an umbrella systematic review (Poscia et al., 2018). It was concluded that vitamin D supplementation is highly effective in preventing falls and fractures while other oral supplements (vitamins, amino acids...) and protein-based formulas are effective in promoting weight gain and reducing the risk for malnutrition. On the other hand, mealtime assistance and dietary enrichment programs (with conventional foods and/or powdered modules in order to increase the energy and protein density of meals) could have a favorable effect on caloric and protein intake and functional status. Educational interventions involving counselling or workshops seem to be beneficial for improving nutritional indices such as caloric and protein intake and the risk of malnutrition.

According to WHO recommendations for a healthy diet (WHO 2015), all individuals (independent of their nutritional status) should:

- Ensure an adequate intake of fruits, vegetables, legumes, nuts and whole grains, with at least 400 g (5 portions) of fruits and vegetables a day.
- Decrease the intake of free sugars to less than 10 % of total energy intake and to less than 15 % for additional health benefits. This can be achieved by limiting the consumption of foods and drinks containing high doses of sugars (e.g. sugar-sweetened beverages, sugary snacks and candies), and eating fresh fruits and raw vegetables as snacks instead of sugary ones.
- Ensure an intake of total fat not exceeding 30 % of total energy intake to avoid unhealthy weight gain, with a shift in fat consumption from saturated fats (e.g. fatty meat, butter, palm and coconut oil, cheese) to unsaturated ones (e.g. fish, avocado, nuts, sunflower, olive oils).
- Keep salt intake to less than 5 g per day (equivalent to approximately a teaspoon) to prevent hypertension and reduce the cardiovascular risk. This can be achieved by:
    - Not adding salt, soy sauce or fish sauce during the preparation of food.
    - Not having salt on the table.
    - Limiting the consumption of salty snacks.
    - Choosing low-sodium products.

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- Moderately increasing the consumption of potassium, which can mitigate the negative effects of sodium on blood pressure.

Individuals at risk of malnutrition (MNA < 24) or with a recent shift of BMI towards the lower thresholds should:

- Integrate oral diet with supplementary foods (in ready-to-eat or milled form), which are modified in their energy density, protein, fat or micronutrient composition, to help meet the nutritional requirement of older people.
- Mealtime interventions including family-style meals and social dining, especially for people living alone or for people who are socially isolated.

In cases of rapid weight loss or gain, refer the individual to a physician or a specialist.

Suggested coaching activities/Goals setting (i.e. weight loss for vitality)

Oral supplemental nutrition with dietary advice should be recommended for older people affected by undernutrition.

Beyond protein supplementation, vitamin D (Moreira-Pfrimer et al., 2009), (Beaudart et al., 2014), polyunsaturated fatty acids (n-3 PUFAs; EPA and DHA), (Smith et al., 2011), (Smith, 2016), and creatine (Brose et al., 2003), (Candow et al., 2019), (Tarnopolsky et al., 2007) (Tarnopolsky & Safdar, 2008)) have documents skeletal muscle benefits and may be safely combined with exercise therapy in older people. The efficacy of protein-based multi-ingredient supplementation in older people was recently demonstrated by Bell et al., who found that whey protein, creatine, EPA/DHA, and vitamin D enhanced lean mass, strength, cognition, n-3 index, and lowered markers of inflammation on older males (Bell et al., 2017), (Bell et al., 2018), (Bell et al., 2018).

The Mediterranean Diet has been inversely associated with cardio-metabolic disorders and with polypharmacy in older patients (Vicinanza et al., 2017) as well with frailty (Ntanasi et al., 2017). Thus, in the PREDIMED study, aimed to increase adherence to the Mediterranean Diet in community-dwelling men aged 55 to 80 years and women aged 60 to 80 years, the intervention consisted of individual and group nutrition education, including frequent motivational interviews and positive recommendations adapted to the participant's clinical condition, preferences, and beliefs.

The DASH diet has been proposed as an adequate dietary pattern for healthy ageing and disease prevention, especially when accompanied by a higher intensity, brief aerobic training, effort- based, brief resistance training, and structured physical activity (Winett et al., 2014). Importantly, a higher protein intake is also recommended.

Thus, the management of malnutrition in older age needs to be multidimensional. Various types of interventions are effective in reversing these patterns of malnutrition and have been shown to delay care dependency, improve intrinsic capacity and revert frail states.

Activity: Mediterranean Diet This diet is based on the consumption of minimally processed foods, including most of the dietary protective factors, such as vegetables, fruits, unrefined grains, fish, vegetable proteins from pulses, vegetable fats mainly from olive oil, moderate consumption of red wine, and more rarely poultry. Activity: DASH Diet

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This diet emphasizes fruit, vegetables, fat-free/low-fat dairy, whole grains, nuts, and legumes, and limits saturated fat, cholesterol, red and processed meats, sweets, added sugars, salt, and sugar-sweetened beverages,

Goals: Consuming a healthy diet throughout the life course, and preventing malnutrition among older people.

Indicators

All individuals will undergo weekly assessment of body mass index (BMI), calculated as weight/height^2 to evaluate adherence to diet plans and to intercept any subtle deviations from optimal BMI towards undernutrition or overweighting and to promptly adjust diet plans to patient's needs.

All individuals will undergo monthly assessment of their nutritional status by administration of the Mini Nutritional Assessment (MNA) questionnaires; individuals with MNA < 24 will be considered at risk of malnutrition and deserving specialized interventions and more accurate diet plans. MNA administration will be followed by individual nutritional history, including information regarding any food allergy or intolerance which may have decreased adherence to diet plans.

Physical performance of all individuals will be assessed every 6 months through evaluation of gait speed and grip strength to assess body composition and refine dietary plans.

Mini Nutritional Assessment Short-Form (MNA-SF), weight (BMI), and "Yubi-wakka" (finger-ring) test: a self-screening method for sarcopenia, and a predictor of disability and mortality (Tanaka et al., 2018).

3.4 Psychological and social support

European and/or Japanese guidelines

According to most recent WHO and international guidelines, interventions to improve psychological wellbeing in older age include:

- Emotion regulation to increase positive feeling (using up-regulation) or to decrease negative emotions (using down-regulations).
- Enhancement of positive feelings of life satisfaction and positive view of life and social relationships.
- Use of cognitive control strategies to focus on positive and suppress negative information (i.e. remembering the past positively).
- Well-being interventions focused on approaches of expressive writings gratitude, good actions and kindness.
- Physical exercise should be considered adjunctive to structured psychological treatments to improve IC of older people.
- Referral to a specialist when a diagnosis of depression is suspected.

Social interventions which have shown to be beneficial in older age include act by reducing loneliness and are mainly of 2 types:

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- Individual-based approaches, composed of a two-step procedure: the lonely persons need to be reached, their personal loneliness understood and they need to receive support to access appropriate services that are mainly focused on:
    - Supporting and maintaining existing relationships.
    - Supporting new social connections.
    - Psychological approaches.

  These interventions promote participation and may be addressed by:

    - Ensuring adequate education and learning opportunities in older age.
    - Recognizing and enabling older people in volunteering activities, according to their individual needs, preferences and capacities.
    - Encouraging people to participate fully in family community life (i.e., involving older people in political processes that affect their rights.
- Community-based approaches (structural enablers), by building new structures and channels to enable social interactions.

Research shows that social aspects like isolation or loneliness have a negative effect on active and healthy ageing. An isolated life in old age can significantly increase the risks of physical and cognitive impairments as well as diseases (e.g., Mushtaq, 2014). Social interventions that aim to reduce social isolation and loneliness respectively mainly represent group activities. Such interventions provide older adults with spaces for group support and social exchange with like-minded people.

Technology can play a significant role in maintaining a healthy lifestyle for older adults (Bobillier Chaumon et al., 2014), (Chou et al., 2013). For instance, pedometers or smartwatches can provide motivation to remain active. Said that, continuous and sustained usage remains a major challenge. However, the convergence of health aspects and long-term social embeddedness are vital factors of sustained appropriation of health-related technologies of older adults. Thus, social elements should also accompany the appropriation of health-related technology, either offline or online.

Advancing age is accompanied by the loss of friends and family, but also by the emergence of sensory, cognitive and physical disorders (Chung et al., 2016). These are all risk factors for the development of mental or neurological disorders. According to the WHO (https://www.who.int/fr/news-room/fact-sheets/detail/sant%C3%A9-mentale-et-vieillissement), more than 20% of adults aged 60 or over have a mental or neurological disorder. Among the main disorders are major neurocognitive disorders (dementia), depression, anxiety, substance abuse. Mental disorders have an influence on physical disorders and vice versa. These pathologies are not without consequences for the quality of life of the elderly and can lead to suicide. However, they are often misdiagnosed and the stigma of mental disorders does not allow people to seek help. Actions can be taken to promote ageing well but also to prevent these pathologies from taking hold.

Suggested coaching activities/Goals setting

Group activities include physical activity classes, technology classes, community cafés, cooking or backing courses, mentoring programs in schools, among others like walking, cycling together or visiting museums and cultural events. Such interventions provide a social space for older people to get together and work towards specific activities as a group. Such activities help building new relationships and social resources and thereby reduces loneliness (Cattan et al., 2005), (Dickens et al., 2011), (Health Quality Ontario, 2008). Internet usage has also proven to be effective to reduce social isolation and loneliness in old age (Chen and Schulz, 2016), (Cotten et al., 2013, 2012), (Fokkema and Knipscheer, 2007),

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(Moody, 2001), (Sum et al., 2008). Messaging services can hence provide opportunities for exchange between individuals and groups. Social exchange can take place online and offline, but ideally, the online activities (such as exchange in messaging services) supplement the offline activities (e.g., exercise or technology classes).

The first aspect of intervention concerns the promotion of mental health. This involves the transmission of information on risk factors, the identification of risk situations but also of symptoms of illness. Then there is the identification of these symptoms at an early stage by a trained professional (ANESM, 2014; WHO, 2019).

The second part concerns their management and the management of suicidal crisis situations. Lifestyle modification is recommended. This includes having a regular rhythm with bedtime and wake-up times; regular physical activity; relaxing activities such as yoga, relaxation, meditation or sophrology; avoiding the consumption of alcohol and other substances; encouraging regular social activity and maintaining one's usual interesting activities. Therapeutic support may also be necessary as well as the use of medication (HAS, 2017; WHO, 2019). New technologies can support activities of daily living and enable older people to age well (Ganesan et al., 2019).

Activity: Goals:

1. Blending exchange spaces

The virtual coach could provide hooks for social exchange online, based upon offline activities. This provides an opportunity to sustain both offline and the online exchange.

2. Competitive elements

The virtual coach should include competitive elements, so that group members could battle for who achieves the most physical related goals within a certain time frame (e.g., who achieved the personal step goals each day within a week the most often).

3. Group activities

The virtual coach should motivate participants for group activities of all kinds, e.g. walking together, visiting museums, meeting at cafes or cooking together.

4. Relaxing activities

Relaxing activities should be offered to participants by the virtual coach. These activities could be incorporated into a daily routine e.g. 15 minutes of meditation before going to sleep or occasionally to relieve anxiety states.

5. Provide knowledge

It is important that participants know the symptoms of mental disorders with a higher prevalence (depression, anxiety, substance abuse, suicidal risk) and the possibilities of support. The virtual coach could offer information sessions or memos about these conditions. This would enable participants to identify and react to them as early as possible.

6. Measuring and alerting

The virtual coach could regularly check the participant's mood and analyse these results continuously in order to alert the person with a message when for at least two weeks the mood is mainly assessed as negative. In addition to this alert system, the virtual coach could inform the participants about the possibilities of support

Ministry of Internal Affairs and Communications, JAPAN

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Indicators

All older individuals should be screened for psychological well-being by investigating performance in 5 major areas (suicide ideation, sleep disorders, anxiety, depression, and personality). individuals should be tested for the presence of depression or deviations from normal psychological wellbeing through self-administered questionnaires investigating various dimension of psychological and social well-being.

- Anxiety assessment will be performed every 6 months by administration of the State-Trait Anxiety Inventory (STAI), which has good consistency among older adults.
- The Geriatric Depression Scale with 5 items (GDS-5) will be used to detect the onset of depressive symptoms. Individuals with GDS > 5 will be referred to a specialist for further investigation.
- The Geriatric Suicide Ideation Scale (GSIS) will be used to assess the presence and severity of suicide ideation, loss of personal and social worth and perceived meaning in life among older adults.
- Sleep quality will be assessed by combination of sleep sensors worn on the wrist and administration of the Pittburgh Sleep Quality Index (PSQI).

Measuring social connectedness, family relations and loneliness is not an easy task, as these aspects are, to a degree, subjective. For instance, they depend on personal preferences and a tendency towards introversion and extroversion. However, literature offers indicators to assess social isolation in the form of the 6-item Lubben Network Scale (LNS) (Lubben et al., 2006). To measure loneliness, the De Jong Gierveld scale (2010) is an appropriate tool. These scales will be embedded within the coach. An analysis of the data will provide insights into the effectivity of our social interventions which also allows to adapt and modify them.

3.5 Sensory support

Hearing and vision disorders are increasingly common among older patients, even if frequently overlooked and underdiagnosed. This is particularly bothersome, especially when looking at their disabling effects and associations with increased morbidity and disability among older individuals (Liljas et al., 2016).

Guidelines from the WHO on community-level interventions to counteract declines in IC underlined the strong association between vision loss and negative outcomes, such as depressive symptoms, decreased quality of life and impaired social and physical functioning (Vellas et al., 2018). Cataract is the most important cause of vision loss

Similarly, hearing loss was associated with detrimental effects on quality of life, depression (Chen et al., 2015), cognitive impairment and decline (Loughrey et al., 2018), physical deterioration and disability (Chen et al., 2015); these effects are often perceived as disabling, even among elderly with mild hearing deficits (Vellas et al., 2018), (Ciorba et al., 2012). Untreated hearing loss affects communication and contribute to social isolation and loss of autonomy. Moreover, the coexistence of hearing and vision impairments in the so-called dual sensory loss (DSL) has been found to strongly predict functional disability and was associated with poor quality of life and increased depression rates (Jaiswal et al., 2018). Consequently, interventions aimed at preserving and, whenever possible, improving sensory functioning may have a multidimensional impact and improve physical, cognitive and functional capacity of older individuals.

Ministry of Internal Affairs and Communications, JAPAN

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European and/or Japanese guidelines

Sensory impairments (e.g., poor vision and hearing capacity) have important implications for the health status and functioning of the individual (Crews & Campbell, 2004). In 2015, sense organ disorders represented the second leading cause of years lived with disability and counted for more than 68 million disability- adjusted life-years (DALY) (GDaH, 2016).

The prevalence of vision impairment significantly increases with age (Cigolle et al., 2007), and such trend is reported worldwide (Stevens et al., 2013). Vision impairment may increase the risk of subsequent care dependence (Cigolle et al., 2007) by acting on/enhancing different clinical mediators (e.g., depression (Renaud & Bédard, 2013), mobility impairment (Salive et al., 1994), and falls. Visual impairment may also limit physical activity and social engagement. Interestingly, the prevalence of vision impairment has been decreasing over the last twenty years in high- as well as in low-and-medium-income countries (Stevens et al., 2013), indicating the great potentialities for improving the populations' health status by intervening on this condition (GDaH, 2016).

Hearing impairment results in an even greater burden of disease in older populations (Beard et al., 2016), although a weaker association has been reported between hearing loss and declines in physical capacity (Cigolle et al., 2007). Nevertheless, studies have shown that hearing impairment may still play an important role in the onset of negative health-related outcomes (e.g., incident care dependence and institutionalization), perhaps following a gender-specific pattern (Chen et al., 2015). Systematic reviews and meta-analyses have also demonstrated that amplification is beneficial in individuals with untreated sensorineural hearing loss in terms of quality of life by acting on the reduction of psychological, social, and emotional burdens of the condition (Johnson et al., 2016), (Chisolm et al., 2007).

Suggested coaching activities/Goals setting

Ageing is often associated with loss of hearing and/or vision that limits mobility, social participation and engagement, and can increase the risk of falls. Sensory problems could easily be addressed by simple and affordable strategies such as the provision of corrective glasses and hearing aids, cataract surgery and environmental adaptations.

Older people should receive routine screening for visual impairment in the primary care setting, and timely provision of comprehensive eye care. Screening followed by provision of hearing aids should be offered to older people for timely identification and management of hearing loss.

A number of prevention strategies can be employed to preserve hearing. The effect on the auditory system of exposure to loud sounds or noise is cumulative and irreversible, and effective treatment is limited (Daniel, 2007), (Hong et al., 2013), (Harrison, 2012). However, noise-induced hearing loss is completely avoidable: prevention is thus paramount, and efforts to preserve hearing and prevent tinnitus should be made wherever hazardous noise is present (Gunderson et al., 1997), (Basner et al., 2014), (Hong et al., 2013), (Rabinowitz, 2000), (Zhou et al., 2013), (Ferrite & Santana, 2005), (Levey et al., 2011), (Ivory et al., 2014), (Griest et al., 2007).

Safe listening levels depend on the intensity (loudness) and duration of exposure (World Health Organization; 1997 (http://www.who.int/pbd/deafness/en/noise.pdf, accessed 10 October 2014)), (Hong et al., 2013). These two factors are interrelated (Hong et al., 2013) and contribute to the overall sound energy level to which the individual is exposed. Effectively, the total amount of sound energy to which an individual can safely be exposed remains constant: the sound energy of lower volumes listened to over long periods of time is the same as those louder sounds heard for over a short period.

Ministry of Internal Affairs and Communications, JAPAN

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Regular screening of hearing and vision impairment are recommended among older people to detect even minimal deficits and ensure prompt rehabilitation when needed. According to WHO guidelines, older individuals should receive routine screening for visual and hearing impairment in the primary care setting, and timely provision of comprehensive eye/ear care.

- Individuals with normal vision or those with low vision who have been appropriately treated (corrective lenses, surgery): regular monitoring by performing 1-year screening.
- Individuals with low vision should be:
    - Referred to a specialist for investigation of the most common causes of vision impairment in older adults (presbyopia, cataract, glaucoma and age-related macular degeneration) and to be appropriately treated (corrective lenses, surgery).
    - Ensured adequate modification of the environment (working with colour and contrast to enhance individual's vision).
    - Ensured support during performance of daily living and activities.
    - Provided physical training by implementation of combined (visual and hearing) stimuli to physical training app and avoiding potentially harmful physical exercises.
- Individuals with no hearing impairment (normal audiometry and no abnormality in performing auditory exercises):
    - Screen older adults for hearing loss by periodically questioning them about their hearing. Audiological examination, otoscopic examination and the whispered voice test are also recommended.
    - Prevent hearing loss by avoiding overexposure to noise and detecting minimal change of hearing thresholds.
- Individuals with hearing impairments:
    - People with sudden onset of hearing impairment should be referred to an otolaryngologist. Hearing aids are the treatment of choice for older people with hearing loss, as they minimize the reduction in hearing and improve daily functioning.
    - Promotion of audiological rehabilitation through community case finding and outreach activities.
    - Environmental modifications including decrease in background noises and improvement of intensity of hearing stimuli.

Activity: Providing corrective glasses and hearing aids, and adaptation to the environment will help maintain mobility, social participation, and involvement in the elderly and prevent falls.

Goals: Routine screening for visual impairment and screening followed by provision of hearing aids by apps.

Indicators

Detection of hearing impairment will be based on combined screening with administration of HHIE questionnaire and an online hearing test recommended by WHO every 3-6 months. Combination of the 2 will allow to overcome limitations of single-method assessments.

Hearing Handicap Inventory for the Elderly (HHIE): administration of one-question relatively simple questionnaires has shown to be as accurate as more complex ones or a handheld audiometric device in detecting hearing impairments but is associated with a moderate degree of false positives, despite its accuracy in detecting even mild deficits (25-40 dB) (Feltner et al., 2021).

Ministry of Internal Affairs and Communications, JAPAN

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HearWHO app is based on digits-in-noise technology and uses antiphasic digit stimuli to detect a wide range of hearing losses, including sensorineural, conductive and asymmetrical losses. Hearing screener will be used at the time of study enrollment and regularly every 3 months to monitor hearing health over time. The app will track a record of individual hearing status over time; individuals with hearing impairment will be alerted to refer to the specialist for further investigation and eventually implantation of hearing aids.

Detection of vision impairment and screening of vision capacity will be performed each year using a Snellen chart to measure for visual acuity. Low vision will be defined in the presence of visual acuity < 6/18 in one eye and equal to or better than 3/60 in the better eye.

Hearing: Acoustics – audiometric test, e.g., Mini Hearing Test (Mimi Hearing Technologies GmbH); Vision: Landolt broken ring test, Red green test

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4 State of the art of interventions on IC and AHA

4.1 Literature search and Study Selection

The methodology of this systematic review was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines with the main aim of analyzing the efficacy of multi-domain interventions for older people, grounded on the IC. A systematic review of the literature was conducted in July 2021. The data were collected from PubMed, Scopus, Embase, Google Scholar and Elsevier databases, analyzing manuscripts and articles of the last 10.5 years (from January 2011 to June 2021), in order to obtain the latest evidence in the field. The inclusion criteria are as follows: (1) randomized controlled trials, quasi-experimental studies, or prospective or retrospective cohort studies, pre-post study with or without control groups; (2) testing of a multidomain intervention to prevent frailty and improving healthy habits in people aged ≥ 65 years; (3) classification in terms of (pre) frailty status according to an operationalized definition. Systematic and narrative reviews were excluded. A multi-domain intervention was defined as an intervention that intervenes in at least two different domains, including exercise therapy, nutritional intervention, hormone, cognitive or psychosocial interventions (Danison et al., 2015). As we refer to Intrinsic Capacity, we have included papers on multi-domain interventions on at least three areas within locomotion, cognitive, psychological, vitality and sensory. Based on consultation with the multidisciplinary research team, multi-modal intervention studies were searched using the following search terms, and the combination thereof: olde*, elde*, intrinsic capacit*, functional ability* / functional status / functional trajectory*, healthy aging / successful aging, pre-frail, virtual agent, coaching, self-management, multi-domain intervention, robotic*. The full search string is provided in Table 1.

Table 1. Search strategy characteristics.

Order	Terms
1	Olde* OR elde* AND “intrinsic capacit*”
2	multicomponent OR multicomponent OR multidimension* or multi-dimension*
3	1 AND 2
4	Olde* OR elde* AND “functional abilit*” OR "functional capacity" OR "functional status" OR "functional trajector*”
5	4 AND 2
6	Olde* OR elde* AND “Healthy aging”
7	6 AND 2
8	Olde* OR elde* AND “successful aging”
9	8 AND 2
10	Olde* OR elde* AND “active ageing” OR “healthy ageing” OR “successful ageing”
11	10 AND 2
12	1 AND pre-frail
13	12 AND 2
14	1 AND virtual agent AND 2
15	1 AND coaching AND 2
16	1 AND self-management AND 2
17	1 AND multidomain intervention AND 2
18	1 AND robotic* AND 2
19	Limit to English AND yr=2011 -Current

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After the preliminary search, 327563 articles resulted from PubMed, 40250 from Scopus, 40098 from Embase, 91898 from Google Scholar and 4924037 from Elsevier. The findings were analyzed and screened by four experts of the team, a bioengineer, a clinical neuropsychologist, a statistician and a geriatrician. In particular, three review authors independently reviewed titles and abstract retrieved from the search in order to determine if they met the predefined inclusion criteria. The full text articles were subsequently analyzed. The first screening was based on the analysis of the title of the findings. After the first step, 61 articles resulted from PubMed, 23 from Scopus, 16 from Embase, 33 from Google Scholar and 55 from Elsevier. A second screening was based on abstract analysis and deduplication of the findings. After this step 41 papers included from Pubmed, 18 from Scopus, 0 from Embase, 11 from Google Scholar and 33 from Elsevier. Another researcher (a statistician) confirmed the accuracy of the papers selection and screened for any possible omission.

4.2 Data collection

After the screening based on the inclusion/exclusion criteria, conducted on the full text articles, the studies were selected as follows: 9 from PubMed, 3 from Scopus, 0 from Embase, 0 from Google Scholar, 0 from Elsevier database. Figure 1 shows the flowchart search strategy applied.

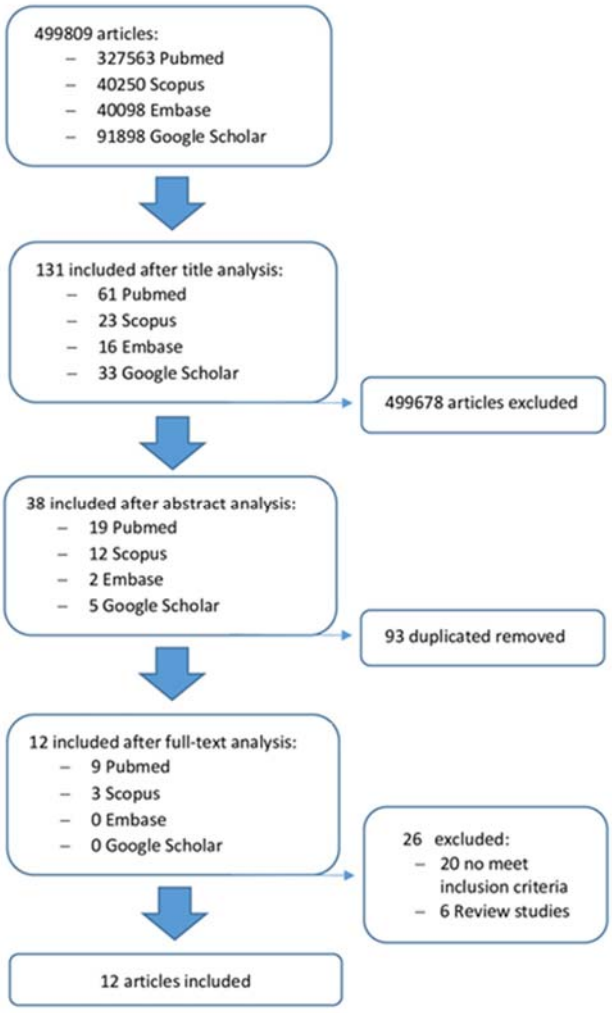

Figure 6. The flowchart search strategy.

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4.3 Results and Study quality evaluation

A total of 12 papers were included. The quality evaluation of the 12 population-based studies was performed based on the PEDro scale, suggested for evidence-based reviews (Maher et al., 2003). The final score was settled when 3 authors reached agreement after repeated review and analysis. Of the twelve studies considered, the PEDro score ranged from 4 to a maximum of 10 (Table 2).

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