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An IT-supported multidimensional approach to screen for frailty in community-dwelling older adults

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Sommario

1. Introduction

1.1. The current framework of demographic changes

Demographic changes underway in Europe and around the world will have profound implications for the planning and provision of social and health services, due to the concomitant increase in the complexity of healthcare needs of the older adult population. According to the Aging Report published by the European Commission in 2021 (1) the total population in the EU is expected to decrease by 5% between 2019 (447 million) and 2070 (424 million), with some significant differences between Member States (**Figure 1**).

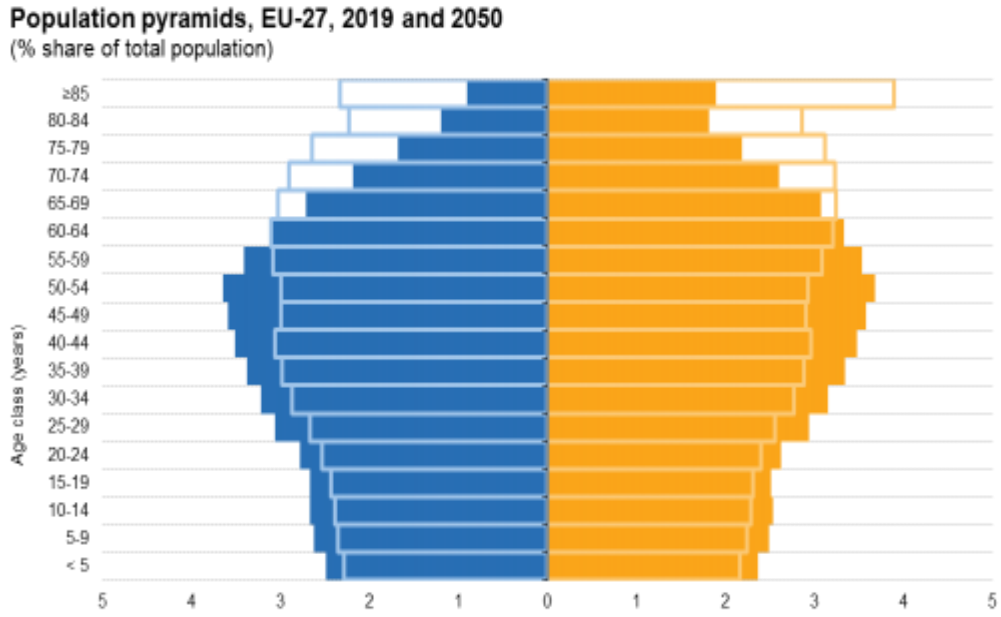

Figure 1 *The demographic transition across EUn the next three decades.Eu-27, 2019 (solid bars) and 2050 (bars with borders) (2). Man: Blue bars; Women: orange bars.*

The EU demographic old-age dependency ratio (i.e. the ratio of people aged 65 and over to those aged 20-64) will increase significantly in the coming decades: from 29% around 2010, it had risen to 34% in 2019 and is expected to increase further, up to 59% in 2070. Advances in medicine and life sciences in general led to an increase in life expectancy at birth which is expected to also increase in the coming decades: in 2019 it went from 78.7 in males to 86.1 in 2070; and from 84.2 for females to 90.3 in 2070.

Aging will lead to an increase in the cost of public spending for pensions, healthcare, long-term care, education and unemployment benefits, reaching 26.7% of Gross Domestic Product (GDP) between 2016 and 2070. Among these the costs for Health and care only will contribute to an increase in age-related spending by 2.1 percentage points between 2016 and 2070 (3) (**Figure 2**).

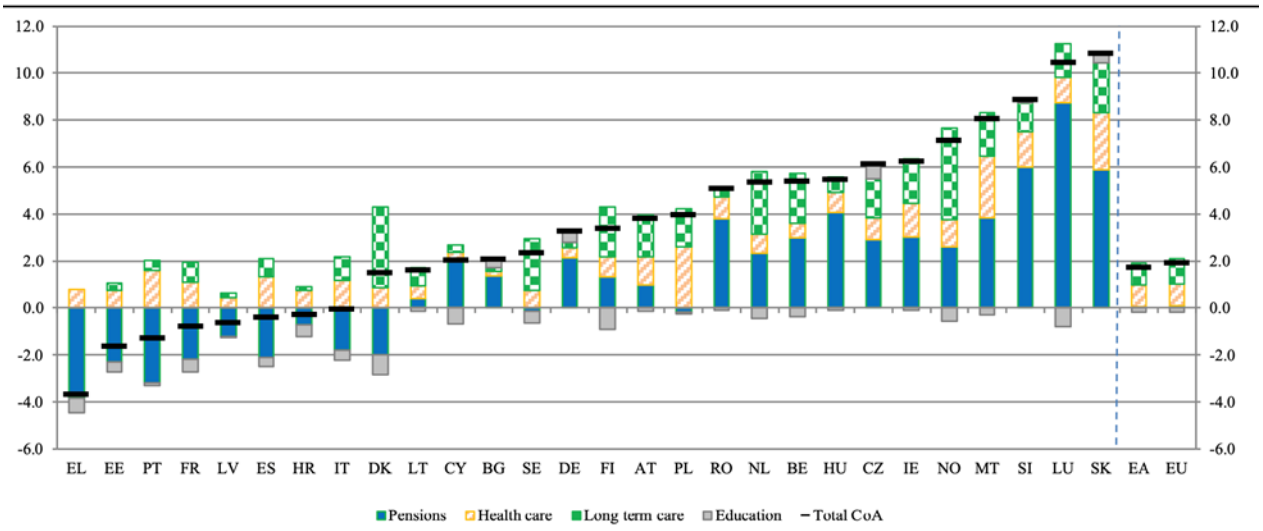

Figure 2 *Projected change in age-related expenditure (2019-2070) (2).*

The impact of demographic changes does not only concern an increase in cost, but also a slowdown in economic development, because in the framework of current development models there will be fewer and fewer people who will actively contribute to the economic and financial prosperity of European countries, in the face of an increase in state support for pensioners. Only by increasing the participation of women and older workers in the labour market could we attempt to mitigate the effects of the aging population on the weight of pensions on GDP and transform ageing into an opportunity for sustainable development.

The 2021 Aging Report outlined a "healthy aging scenario" that focuses on initiatives aimed at lowering morbidity and improving the health status of the population, in line with declining mortality rates and increasing life expectancy. Under this scenario, a person's health and well-being are considered holistically, during the entire life-course, in the perspective of disease prevention and health promotion, person-centred, appropriate and integrated diagnostic-therapeutic pathways. This approach ensures that future improvements in life expectancy occur in good health, reducing morbidity and dependency rates and healthcare spending, while improving quality of life. (4).

To this end, it is necessary to consider social impacts as a determining factor in a person's health and well-being, broadening the perimeter and including the community living and leisure environments, the working life and all health care settings. This approach involves individuals and society in disease prevention, health promotion and person-centred management of diseases, age-related conditions and social needs (5).

1.2. The policy framework

The biological process of ageing, characterised by a wide variety of intertwined molecular and cellular changes mainly related to metabolic and cell cycle disorders (6,7), leads to a reduction in mental and physical reserve, increasing the risk of disease (8). In addition to the biological processes, social dimensions such as

home, community, gender, ethnicity, and socio-economic status also affect ageing since pregnancy, and during the entire life-course. The environment where people live as children, personal behaviour, eating habits, physical activities, use of tobacco and alcohol impact how people age. To promote healthy ageing, it is therefore necessary to empower people on healthy lifestyles, such as healthy eating, physical activities, preservation of cognitive function, through safe, equitable, accessible, supportive and integrated health and social systems where no one is socially isolated, but all their needs are addressed (8).

Since 2012, the World Health Organization (WHO) has introduced the concept of "active ageing", i.e. the process of optimizing opportunities for health, lifelong learning, participation and security to improve quality of life (QoL) as people age (9). Through this definition, the WHO reiterated that aging is in itself a positive experience, as opposed to an ageist concept of ageing merely focused on the accumulation of deficits and loss of function. To promote active aging, according to the WHO, it is necessary to strengthen the positive aspects of aging as well as the importance of environmental and behavioural factors that explain the variability within the aging process. The concept of active aging has been a driver for the implementation of an increasing number of health promotion programs around the world (10).

The WHO Resolution 67/13 defined a global strategy and plan of action on healthy ageing, in collaboration with Member States and other partners. Such strategy and action plan aim to address five priority areas for action (11):

1. Commitment to healthy ageing by formulating evidence-based policies that strengthen the individual capabilities of older people.
2. Aligning health systems to the needs of the older population in order to improve their capacities and to integrate services across settings and care providers.
3. Developing long-term care systems (including palliative care) to help improve universal health coverage, addressing non-communicable diseases and developing integrated, person-centred health services.
4. Creating age-friendly environments to enable autonomy and support healthy ageing in all policies and at all levels of government.
5. Improving measurement, monitoring and understanding through new indicators and analytical methods for a wide range of ageing issues.

Subsequently, the WHO Regional Office for Europe published four strategies and action plans for healthy ageing in Europe 2012-2020 (12). The first objective, “Healthy Ageing over the life-course” promotes the provision of health promotion and disease prevention services for people aged ≥ 50 years. The second objective, called “Supportive Environments”, aims at involving communities in the development of strategies to become more age-friendly, fostering their inclusion in the social context. The third objective, “Person-centred health and long-term care systems fit for ageing populations”, aims at creating high quality services

and social protection by contributing to research and dissemination of good practices in healthcare delivery and access to information (including e-Health). Health literacy is emphasised, as well as support for home care and primary care interventions aimed at promoting a proactive approach to chronic disease prevention alongside an integrated health approach.

Addressing the needs of an ageing population translates in empowering older adults, supporting independent living at home, self-management of age-related conditions and reduction of isolation. Such proactive, citizen-centred system requires citizens to take greater responsibility for their health and well-being during the entire life-course, providing information and advice on healthy lifestyles, to stay active and healthy as long as possible (13).

Such age friendly environments are beneficial to individuals and society throughout the entire life-course (14) and are enabled by digital solutions. Digital literacy ensures access and equity for all, providing a huge opportunity to deploy large scale interventions targeted at different age groups and age-related disease areas. (15,16). Strengthening integration between hospital and community services will improve the support for older adults at home, also in the occurrence of public health emergencies, such as the COVID-19 crisis, for example through secondary use of personal health data and digital innovations to protect individuals at highest risk (17). ICT can support targeted disease prevention and health promotion through mHealth interventions; can enable integrated care, especially long term, through service coordination, monitoring and interventions. In this “one health” perspective, demographic change creates opportunities and jobs for sustainable growth, through digital innovation and across sectors such as transportation, constructions and built environment, supporting older people to remain independent, active and live longer in their homes and communities, while increasing the efficiency and effectiveness of health and social care systems (18). This “Silver Economy” includes the market of eHealth and mHealth devices, robotics and games, silver tourism, age-friendly built environment, integrated care and healthy lifestyles promotion, Artificial Intelligence for risk assessment of adverse outcomes. Older adults are at the centre of the system, and can accelerate the development of products and services, share experiences with new generations, be involved in test-bed activity and earn an income.

The United Nations 2030 Agenda for Sustainable Development (19) calls for a global alliance to address the social challenges that all countries are facing, with a focus on health and training, and in relation to the inequalities that prevent sustainable development for the global society. The impact of social inequalities on population health and mortality has been well documented, as well as the fact that in many western industrialized nations there is a gradient between social class position (employment, education and/or income) and the risk of death (20). The term "health inequality" refers to the health differences between individuals or groups (21) that are preventable and unnecessary: allowing them to persist is unfair. Differences between social groups are considered health inequalities because they reflect an unfair distribution of health risks and resources. In fact, to be truly effective, health services must be able to protect the health of the entire population, and not only manage specific health conditions.

According to WHO Decade for Healthy Ageing, if living longer is dominated by poor health, social isolation or dependency on care, the implications for older people and society are negative in terms of sustainability and development. Poor health for older adults makes them less productive, earn less, retire earlier, and be in greater need for health, care and social services (22). This has consequences for individuals, industry, public authorities, health and care organizations, policy makers, investors and communities.

The ageing process is not the same for all individuals (23): the loss of ability traditionally associated with a stereotyped concept of ageing does not take into account the heterogeneity of older adults and their ageing trajectories, indeed it differs and is developed throughout a person individual life-course. Disability and dependency are not an inevitable consequence of ageing, and there is a lot we can do to transform it into an opportunity, by supporting and stimulating active and healthy living.

WHO indicates three key approaches to align health systems to the needs of older populations:

1. developing and ensuring access to person-centred and integrated services;
2. orienting systems around intrinsic capacity;
3. ensuring there is a sustainable and trained health workforce.

1.2.1. The European Innovation Partnership on Active and Healthy Ageing

In 2012 the European Commission has launched the European Innovation Partnership on Active and Healthy Ageing (EIP on AHA): a pilot initiative to face the population ageing challenge by increasing the average healthy lifespan of EU citizens by two years by 2020 (24,25). The initiative main objectives were to improve the health and quality of life of older people, the sustainability and efficiency of health care systems, and to support growth and market opportunities through innovative products and services.

The EIP on AHA provided to all the European Member States and regional ecosystems a chance to ensure to their older adults a healthy ageing, and to the younger generations the promotion of a healthy and active lifestyle by providing innovative solutions with the aim to reduce comorbidity in older age and increase the average healthy life of European population by 2 years (24). Based on this evidence, the EIP on AHA has been promoting an action focused on three general objectives (26):

1. Enhancing European population life promoting a healthy lifestyle during ageing;
2. Supporting sustainability and efficiency of health and social care systems;
3. Scaling up of good practices in digital health to improve the EU competitiveness.

From 2012 through 2020, the Partnership has been focusing particularly on the involvement of key stakeholders from the Regional and Local level (users, public authorities, industry), on services demand, offer and regulation also connecting them at the national and international levels.

Building upon a process of identification of good practices on Active and Healthy Ageing by regional and local health administrations, Action Groups and Reference Sites were identified respectively as the scientific/operational and institutional pillars supporting the EIP on AHA partnership (27).

Action Groups (AGs) are multi-sectoral groups of stakeholders ranged from academia to public authorities, and included large industry and SMEs, health and care organisations, investors and innovators, as well as end-users and patient associations, working on active and healthy ageing in the different knowledge areas that affect it. The purpose of AGs is to facilitate knowledge sharing and increase the value of national and local experiences, helping to identify areas for improvement and targeted investments at European level (28).

The EIP on AHA included six AGs:

- Adherence to prescription (AG A1);
- Falls prevention (AG A2);
- Lifelong health promotion and prevention of frailty and age-related diseases (AG A3);
- Integrated care (AG B3);
- Solutions for independent living (AG C2);
- Age-friendly environments (AG D4).

Reference Sites bring together leading regional organisations committed to investing in innovation for active and healthy ageing and to supporting the transfer and dissemination of such innovation across Europe. A Reference Site is an ecosystem based on a 'quadruple helix' model, which ensures collaboration between actors from different sectors to better understand the organisational, technical and financial challenges facing the region. This 'quadruple helix' approach ensures that a wide range of participants (public authorities and healthcare providers/industry/universities/civil society) has room for involvement. Furthermore, reference sites promote regional, social and economic development by facilitating the transfer and adaptation of knowledge from European regions to local realities and vice versa. (29).

The EIP on AHA Action Groups and Reference Sites joined forces to contribute to the implementation of three coherent initiatives supporting development and transfer of innovation on AHA: the Blueprint for the digital transformation of health and care, the Innovation to Market Plan (I2M), and the Monitoring and Assessment Framework (MAFEIP) (**Figure 3**).

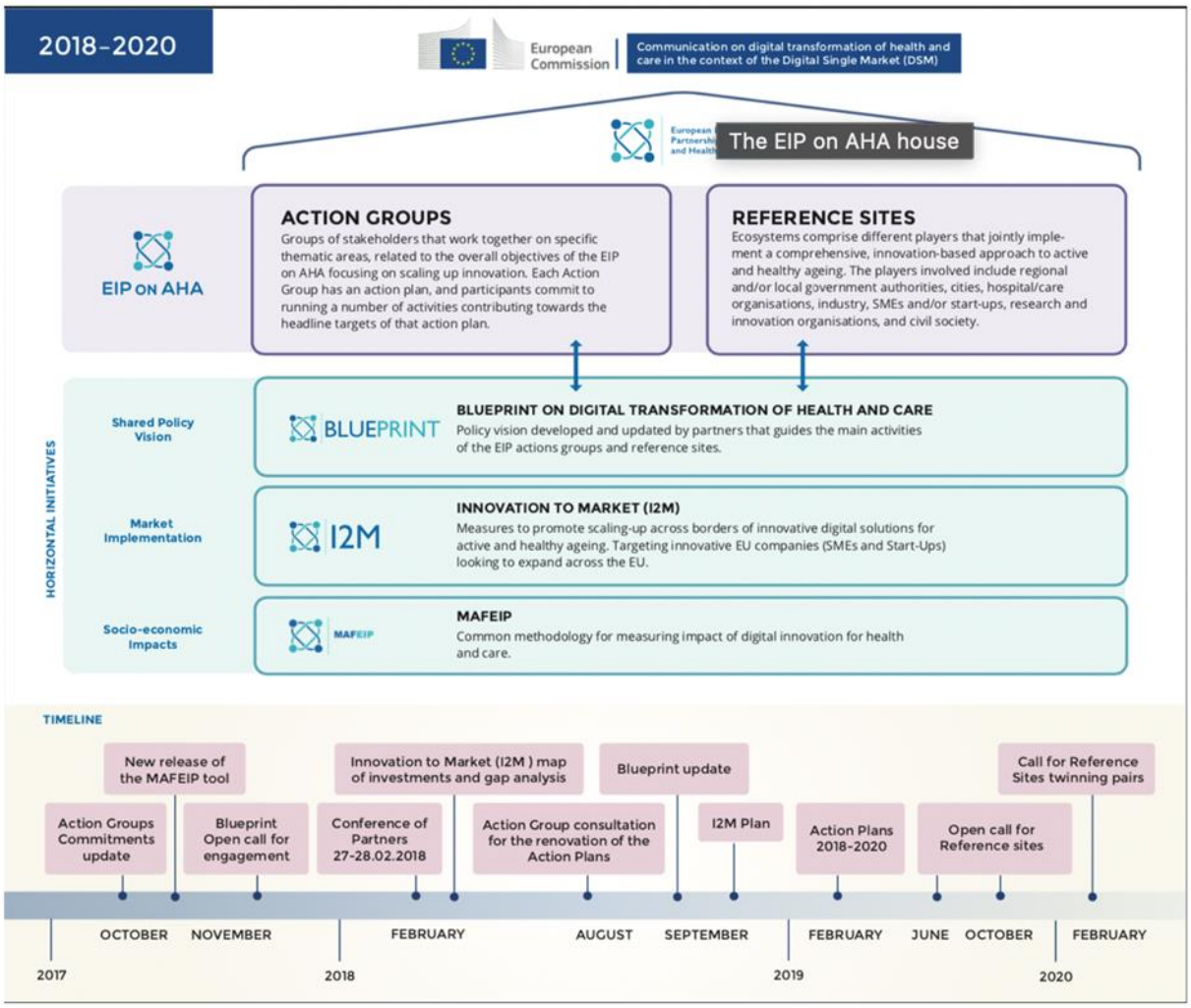

Figure 3 *European Innovation Partnership on Active and Healthy Ageing*

The Blueprint for the digital transformation of health and care (30) was an iterative process operated between the EC and the stakeholders (policy makers and other key opinion leaders) to digitally innovate health and care in Europe.

Innovation to Market (I2M) aimed to promote the matching of demand and supply of digital health and care solutions in a cross-border context.

MAFEIP (31) is a tool for the monitoring and assessment of the impact of innovative solutions and approaches to support evidence-based decision-making for all institutions and users in the health and care sector.

1.3. The organizational challenge of integrated care to address chronic diseases and multimorbidity

The ageing of the population in the EU, with the consequent increase in chronicity and multimorbidity, is leading to a growing demand for integrated care (32). "Integrated care" means the combined set of methods, processes and models that aim to achieve greater efficiency and value in health systems, effectively addressing the fragmentation of patient services and enabling better coordinated and continuous care, particularly in older adults who have a growing incidence of chronic diseases and complex needs (33). The sharing of information between healthcare professionals, patients, healthcare organizations and specialties, aims at improving the health, well-being and independence of patients, containing the economic and social burden of diseases (34,35). Through the connection and coordination of services along the continuum of care, a triple objective is pursued: improving the patient experience, the results of care and the effectiveness of health systems (36). Pursuing the triple objective presupposes the development of the organizational and technological capabilities necessary to better coordinate the services provided and successfully implement integrated care (35). The aging trend of our populations goes hand in hand with an increase in multimorbidity and comorbidity, and with a stratification of chronic diseases related to each other.

The economic burden of ongoing demographic changes requires the search for methods to integrate care more effectively, through sustainable forms of service provision. There are numerous experiences of models to address care integration, but they are divided into organizational clusters such as health, social care, housing and others. The organizations and staff working in each cluster are funded, managed and regulated separately. Therefore, in the integrated care experiences currently available, patients are surrounded by uncoordinated "islands of excellence" when what is needed is coordinated care (37). The European Commission has stated that in order to develop effective, accessible and resilient health care systems, integration of care should take place both between different levels of health care (primary care, hospital care, etc.) and between health and social care, in particular for the older adults or people with chronic diseases (38).

Integrated care models have been tried out in various forms in different health care systems around the world (39), but available evidence remains scarce due to the difficulties of scientific evaluation and analysis, as it is not based on single interventions that can be isolated from other elements (40). Evidence from case studies has shown that innovative approaches of integrating care services have led to a reduction in the number of emergency admissions and the length of stay in hospital for older adults (41,42). The validity of integrated care approaches depends above all on a context-sensitive implementation strategy and a carefully tailored digital support infrastructure (43). In the home care of older patients with chronic diseases a close integration of clinical, public health and other services is crucial to meet the specific needs of the patient to a reasonable extent (44).

WHO has identified three different approaches (39) to design and implement integrated care models focused on the needs of patients, families and the community. The first approach is based on defining the process of care to include the different components of integrated care. This approach aims to identify the best model of care, lifestyles and integration of services to improve the well-being of the population. The second approach focuses on the user and personalised integrated care strategies at all levels of the system. This approach emphasises the importance of patient involvement in the development, implementation and evaluation of the integrated care model (45). The third approach focuses on the health system and the strengthening of people's health through collaboration and information sharing throughout the health system and the involvement of stakeholders in disease management (46).

The individual integrated care model offers better outcomes for the patient with multimorbidity and/or long-term conditions, as it favours multidisciplinary care planning and customisation of services according to the patient's specific needs (47-50). The effectiveness of the integration model depends on the patient's level of health literacy to understand care plans and to adhere to ongoing changes based on patient feedback and periodic assessments. The group- and disease-specific models are mostly dedicated to the older adults and frail older adults, as they aim to support functional independence (51) and the management of chronic diseases (52). In some countries, the group- and disease-specific models are based on the stratification of the population according to social and health needs and offer integrated services according to needs (53). This model can be used to organise promotion and prevention services, assessing exposure to risk factors, or to enable patient self-management (54). The group and disease model contributes to reshaping health services to improve the care of patients with chronic diseases through collaboration between primary care, social services, and hospitals to achieve better outcomes (55).

The ageing of the population and the consequent increase in the prevalence of chronic diseases, pushes governments in all countries to improve quality of life and disease self-management and to counter the high costs of universal healthcare (56,57). The management of a patient with multiple clinical conditions raises both a clinical and a social problem, often leading to overlapping services in the management of common diagnostic-therapeutic and social symptoms (58). Joining up health and social services is critical and 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 approach allows better self-management by patient of their condition; improved development of integrated treatment plans engaging the needed health and care professionals, as well as informal caregivers at the right time, providing the most appropriate treatment for the person (59,60)

According to the Chronic Care Model, better health outcomes can be achieved with an informed and active patient and a proactive team of professionals exchanging information through clinical information systems and decision support tools. To support the management of the chronic patient, it is necessary to rely on community resources in the self-management of the disease (61-63).

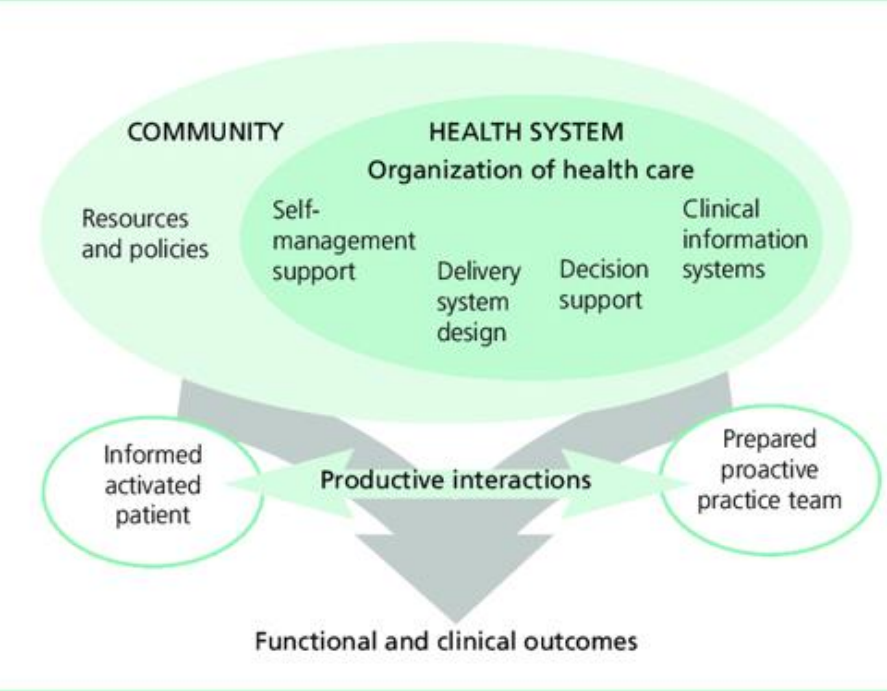

Figure 4 *The Chronic Care Model*

This shift can be supported by an ever-increasing volume of health data. Making these data available to patients and health professionals and the adoption of digital solutions is critical to the continuous improvement of diagnosis, treatment, and personalization of care (64,65).

Social Determinants Of Health (SDOH) are the conditions in which people are born, live and work, which can positively or negatively affect health. To strengthen integration, the Committee on Integrating Social Needs Care into the Delivery of Health Care to Improve the Nation's Health, Washington (USA) has identified five activities (awareness, adaptation, assistance, alignment and advocacy) that can improve health, taking into consideration the social needs linked to the community where the patient lives (**Figure 5 A**)(66).

A

Social Determinant of Health	Examples of Underlying Factors
Economic stability	Employment Food insecurity Housing instability Poverty
Education	Early childhood education and development Enrollment in higher education High school graduation Language and literacy
Social and community context	Civic participation Discrimination Incarceration Social cohesion
Health and health care	Access to health care Access to primary care Health literacy
Neighborhood and built environment	Access to foods that support healthy eating patterns Crime and violence Environmental conditions Quality of housing

B

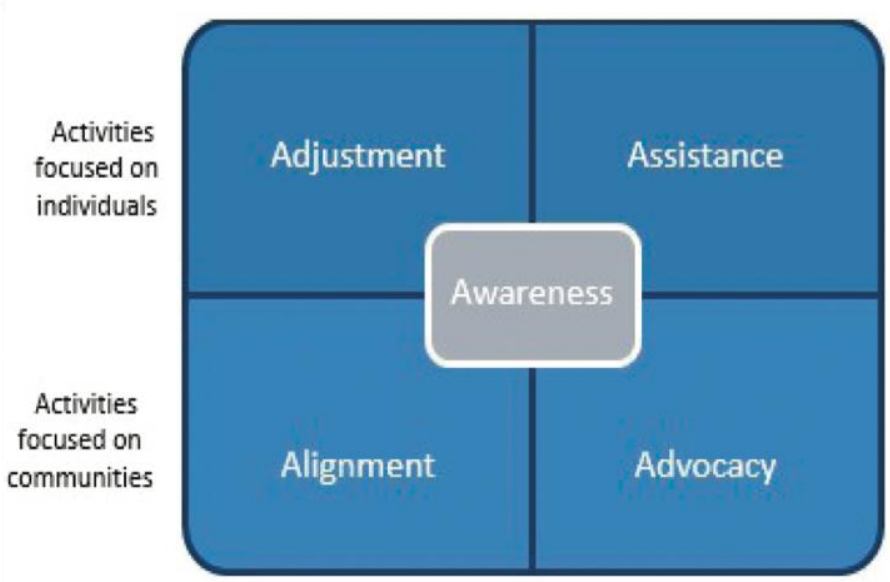

Figure 5 *(**A**) Social determinatns of health (SDOH) wich could affect pisitively or negatively people's health; **(B)** Health care system activities to strength social health care integration (66)*

The specific activities adopted vary within the healthcare system, depending on the social needs addressed. More specifically, adaptation and assistance aim to improve the provision of care to patients based on their social conditions that could reduce or defeat a risk; alignment and advocacy aim to optimize purchases and investments in social assistance resources (**Figure 5 B**). Each activity depends on the level of maturity, including digital innovation and financing models (66).

Improving health and reducing health inequalities depend on improving social conditions. In this context, the simple provision of services is no longer enough. To strengthen the health system at a social and clinical level, the combination of disease prevention and health promotion is necessary, resulting in improved health and related outcomes of the population. The results of this combination, of course, depend on the ability of healthcare systems to connect patients' needs (clinical and social) to policy makers and stakeholders (66), and to their capacity to set up and implement personalised interventions.

Information and communication technologies (ICT) have often been attributed the role of a key lever for integrated care (67). Through its inherent functionalities, ICT generally provides the potential to facilitate information transfer, eliminate redundant paperwork, and monitor progress. Digital tools allow us to improve the integration of services by strengthening collaboration between the different professionals involved. Furthermore, digitally supported services improve accessibility and ensure equity. Simply adding ICT to existing service delivery processes is not enough unless accompanied by a multidimensional approach that is consistent with the organizational and social context (68). The advantage of the new models based on integrated care supported by ICT is represented by a potential rationalization of social and healthcare processes with a possible impact on the containment of healthcare spending and the social cost of diseases. If used correctly, integrated ICT-based services can contribute to a transformation of the healthcare sector and a substantial change in the business models on which it is based. Digital solutions can contribute both to more efficient use of healthcare resources and to better targeted, more integrated, and safer healthcare (69,70). However, the traditional dividing lines between health and social care do not seem to have been crossed so far when it comes to implementing ICT-based services to support independent living and home care for those with chronic conditions. Most integrated services tend to be firmly situated within one or the other area of social or health care (71), mostly focused on patients with high intensity social and health needs, and at a late stage of disease courses. There is therefore an urgent need to validate new approaches and solutions, through large-scale pilot studies, measuring the impact and barriers to the adoption of patient-centred care models, capable of ensuring both the continuity of hospital care and territory and the integration of social resources and health care.

1.4. Digital transformation of healthcare

Digitally transformed services have been able to enhance health outcomes by improving medical diagnosis, data-based treatment decisions, digital therapeutics, clinical trials, self-management of care and person-centred care. They also created more evidence-based knowledge, skills and competence for professionals to support

health care based on technologies such as the Internet of things, virtual care, remote monitoring, artificial intelligence, big data analytics, blockchain, smart wearables, platforms, tools enabling data exchange and storage and tools enabling remote data capture and the exchange of data and sharing of relevant information across the health ecosystem creating a continuum of care (72). Large scale deployment of health digital services is hindered by organizational, technical, economic, and cultural barriers (73) that require tailored adaptations to be integrated in current services provision (74,75).

The WHO advocates people-centred health systems that are enabled by digital health, emphasizing their need of placing people at the centre through the adoption, use and scale-up of digital health technologies that strengthen health service delivery. The population aging and the economic burden of chronic diseases on health systems are the major challenges driving the urge to find innovative, cost-effective solutions (75). Such challenges could be further complicated by the emergence of pandemics, such as Covid-19, when multi-layered systemic interdependencies spread the effects of the pandemic across social, technological, economic, and healthcare dimensions (76). In this scenario, there was a strong push for innovative ways of communication and organizational approaches, while the development of digital technologies accelerated, redefining economic, learning, professional and social systems, and environments (75). These approaches should be in line with the paradigmatic shift from reactive disease management towards early diagnosis and risk stratification, health promotion and prevention, and self-management (76). Person-centred care and self-management require an effort to overcome health and digital literacy gaps that may hinder the availability of patient-based information (77). Specific design requirements are key to improve the adoption, usability, and sustainability of mHealth interventions. In this perspective, health literacy represents the most important enabler to build capacity in patient-centred, data-driven multidimensional care.

In the 2018 Communication on the digital transformation of health and care in the Digital Single Market, the European Commission clearly outlined how “digital technologies should be seen as an integral part of health and care and geared towards the wider objectives of health systems”. Yet, the Communication also highlights how the “uptake of digital solutions remains slow and varies greatly across Member States and regions”. This is particularly relevant if we consider the untapped potential of digital health to improve quality and access to care in rural areas (65). COVID-19 has further demonstrated the need to accelerate digitalization and to focus even more on the essential uptake and implementation phase to harness the opportunities offered by digital health. This need is made clear in the recent State of Health of the EU report (78), highlighting the importance of locking in the advantages of digital innovation in healthcare delivery and public health. The report stresses the need to build on increased adoption of digital health tools, not only for emergency preparedness, but also to boost access to high-quality care for all Europeans. In this context, the EU is already moving ahead to define new strategies and frameworks with the potential to boost digitalization. The Digital Decade’s 2030 targets (79) set clear, interconnected objectives in terms of digital uptake and scale-up, digitalisation of the population and citizens’ access to medical records. Moreover, the European Commission has recently put forward Digital Rights and Principles for the Digital Decade (80) to boost European values in the digital transition. In addition,

the European Health Data Space (EHDS) (81) has the ambition to develop European exchange of health data to support healthcare delivery and health research and policy making purposes. The EHDS has the potential to address fragmentation issues and enhance Member States' collaboration, supporting the creation of a true single market for digital health where innovation can thrive, building on health data. Besides these horizontal frameworks, the European Commission also considers the digital dimension of the Europe Beating Cancer Plan (82), which seeks to tap into the potential that digitalization and new technologies offer.

1.5. Managing frailty in older adults

According to the WHO the prerequisite for healthy ageing is the maintenance of functional capacity, as the combination of the individual's physical and mental resources and the living environment. Given the same life expectancy and psychophysical conditions, the ageing process is not always the same and the trajectories of progressive depletion of functional capacity vary from individual to individual (83).

Frailty is an age-related and multifactorial condition, characterised by an increased vulnerability to adverse events of endogenous and exogenous origin and a progressive reduction in intrinsic capacity, which exposes the individual to an increased risk of adverse health outcomes and increased hospitalisation, disability and death (83)

Among older adults, frailty is highly prevalent and constitutes a major health problem. Santos and Eggiman (84) estimated the prevalence of frailty and pre-frailty in 10 European countries and showed that for those aged > 65 years frailty ranges between 5-27.3% and pre-frailty between 35-51% of the population.

The overall weighted prevalence of frailty for those above 65 years is estimated at 10.7% (95% confidence interval (CI) = 10.5-10.9; 21 studies; 61,500 participants) (85). The frailty syndrome is a complex interaction between several factors, including but not limited to natural physiological alterations seen in aging, comorbid diseases, nutritive and nutritional insufficiencies, cumulative negative environmental impact, genetics, and lifestyle choices. Frailty is often conceptualized by health care providers as a state of late life decline and extreme vulnerability characterized by weakness and decreased physiologic reserve contributing to increased risk for falls, institutionalization, disability, and death. It develops as a consequence of age-related decline in many physiological systems, which collectively results in vulnerability to sudden health status changes triggered by minor stressor events (86).

While it is recognized that the term "frailty" captures the essence of age-related vulnerability and decline, no single clinical definition of frailty is universally agreed and translated into clinical practice (87).

Overall, frailty is defined within two main paradigms: biomedical and bio-psycho-social. According to the biomedical paradigm (88), frailty is defined as a "physiological syndrome characterized by reduction of functional reserves and resistance to "stressors" due to a cumulative decline of physiological systems causing vulnerability and adverse events".

The bio-psycho-social paradigm (89) defines frailty as "a dynamic state affecting individuals with losses through one or more functional domains (physical, psychological and social), increasing overall the risk of adverse outcomes". Within this approach, several factors are taken into account, such as the medical,

environmental, educational, economical and psychological aspects, requiring overall a more holistic viewpoint of patient and their predicament.

Both models indicate different stages of frailty that are relevant in terms of prevalence and type of intervention needed:

- "**Robust**" indicates older adults without objective disease. Their functional capacity is good and older adults are able to independently carry out fundamental and instrumental activities of daily living (ADL). Furthermore, there are no social problems or unhealthy lifestyle habits.
- "**Pre-Frail**" is a healthy person with at least one chronic disease. He typically carries out frequent medical visits and has undergone hospital admissions due to adverse events related to the chronic condition. He has no evident mental, physical or social problems.
- "**Frail**" is a person who maintains his independence precariously and is at high risk of becoming dependent. He is often a multimorbid patient, who, relying on the social and family environment, achieved a delicate balance to allow basic independence. Infections, falls, changes in therapy, hospitalization, etc. can lead him to a situation of dependency which requires the need for health and/or social services/support.
- "**Disabled**" is a older adult with one or more chronic diseases who is dependent on basic ADLs and need the help of other people. Mental and social disorders are frequent. The balance between his needs and his covering capacity of the environment is broken and the patient has become dependent and disabled (90) (**Figure 6**).

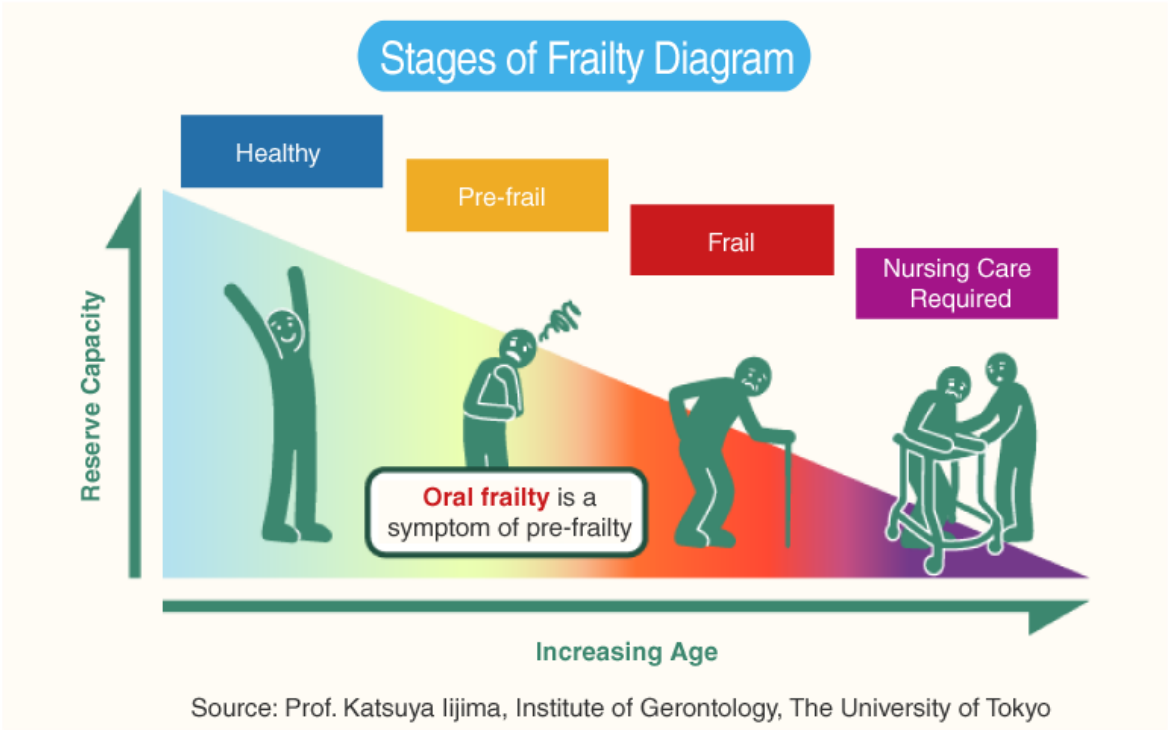

Figure 6 *The stages of frailty in older adults*

Studies underline the reversible nature of frailty and suggest the need for interventions able to slow down the progression towards disability (91).

Overall, the estimated prevalence of biomedical or physical frailty in ageing population varies greatly due to different criteria applied in its definition. A prevalence of frailty of 7,9% was found in the US (92), 8,5% in Spain (93), 7% in France (94) and 8,8% in Italy (95).

The cross-sectional analysis of data from the Survey of Health, Aging and Retirement in 10 European Countries (SHARE) (84) allowed to estimate a global prevalence of frailty of 17% (including disability) in the population over 65. A higher frequency of frailty was identified in southern Europe (especially in Spain 27.3%, Italy 23.0%, Greece 14.7% and France 15.0%), than in Northern Europe (about 11.3% in Netherlands, 12.4% in Denmark and 12.1% in Germany).

Studies performed during the last 20 years have progressively demonstrated the importance of the concurrence of multimorbidity and frailty. Chronic diseases are responsible for poor quality of life, worse functional capacity and the majority of deaths in developed countries, mainly due to cardiovascular diseases, cancer, respiratory diseases and diabetes (96-98). Moreover, multimorbidity is more frequently found in the ageing population, and poses new challenges to the health services, in terms of professional skills, resources and organizational aspects.

As frailty and multimorbidity have been found in 46.2% of the population and there is a frequent overlapping with disability (88), it becomes extremely important to develop interventions aimed at the early detection, prevention and management of frailty conditions. Due to the complexity of the problem, frailty and multimorbidity need to be considered with a more holistic approach, requiring an integrated, multi-domain and multi-professional strategy especially focusing on community-based settings and primary care services.

The WHO in the consensus statement to promote a new approach to aging and resilience (99) reiterated that the maintenance of intrinsic capacity and the capacity for self-care must be addressed throughout the lifespan. The term frailty has been used by policymakers, care planners and stakeholders involved in the management of aging people and societies, to describe populations at risk of adverse social, psychological and medical outcomes.

In the context of frailty, the European Commission has also launched a call to action, supporting initiatives at European level, such as the EIP on AHA, and the Joint Action on Frailty Prevention ADVANTAGE (100), as well as funding numerous projects that address different aspects of aging and functional capacity. The EIP on AHA A3 Action Group has focused its multinational collaboration towards frailty screening, assessment and management actions to enable healthy and active ageing. The A3 Action Group launched key results such as the extraction of comprehensive policies across Europe for active and healthy aging (101), and overviews on frailty as a public health concept (5). This has allowed experts to build bridges between two ways of conceptualizing the frailty of older people, clinical and biopsychosocial, developing a new comprehensive concept of prevention and management of frailty that includes clinical management and public health initiatives (102).

Since 2013, Campania Reference Site (RS) has been actively participating in the coordination team of the A3 Action Group, contributing to the development of reference documents of the group (102-106). The activity

of Campania RS in the A3 AG integrates health promotion, disease prevention, screening, early detection and monitoring of frailty through the assessment of older adults along different dimensions (107).

The EIP on AHA A3 Action Group approach is based on a concept of frailty as a reversible multi-domain condition, to be identified early, especially in the context of primary care and community settings, in order to prevent disability (108).

The role of lifestyles, therefore of primary prevention, in determining frailty is indispensable, just as secondary prevention plays a very important interaction in the management of the different moments of frailty, in reference to chronic conditions. The health needs of older adults increase based on the degree of frailty (**Figure 7**) and are accompanied by a loss of Activities of Daily Living (ADL) and an increase in pharmacotherapy, in itself posing more risk of adverse health outcomes. Sustainability of interventions to prevent frailty depends on the severity of frailty, but above all on the level of interaction with the patient, considering that institutionalization and hospitalization can lead to a rapid worsening of the patient's health conditions in all domains of frailty (87).

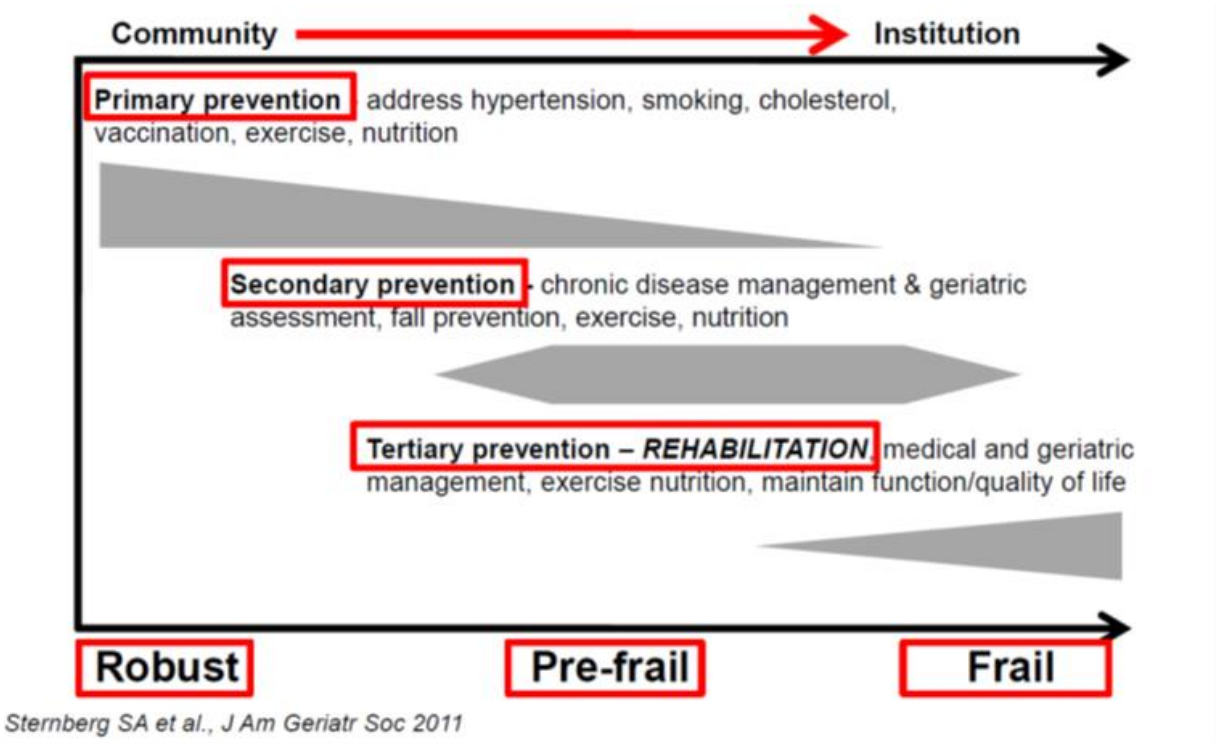

***Figure 7** Opportunities for prevention of frailty (87)*

An integrated approach based on the interaction of numerous professionals and informal figures from the community, primary and hospital care, to address frailty risk factors is therefore essential.

As part of Joint Action ADVANTAGE, a large European group of stakeholders has designed a framework for a comprehensive ecosystem to be involved in integrated care for older adults. This approach includes building age-friendly environments that avoid inequalities in the access to social and health care services, as well as coordinating well-informed and trained human resources. **Figure 8** summarizes the integration of functionality

into a permanent community-to-hospital approach that has been promoted by A3 Action Group and Joint Action ADVANTAGE stakeholders.

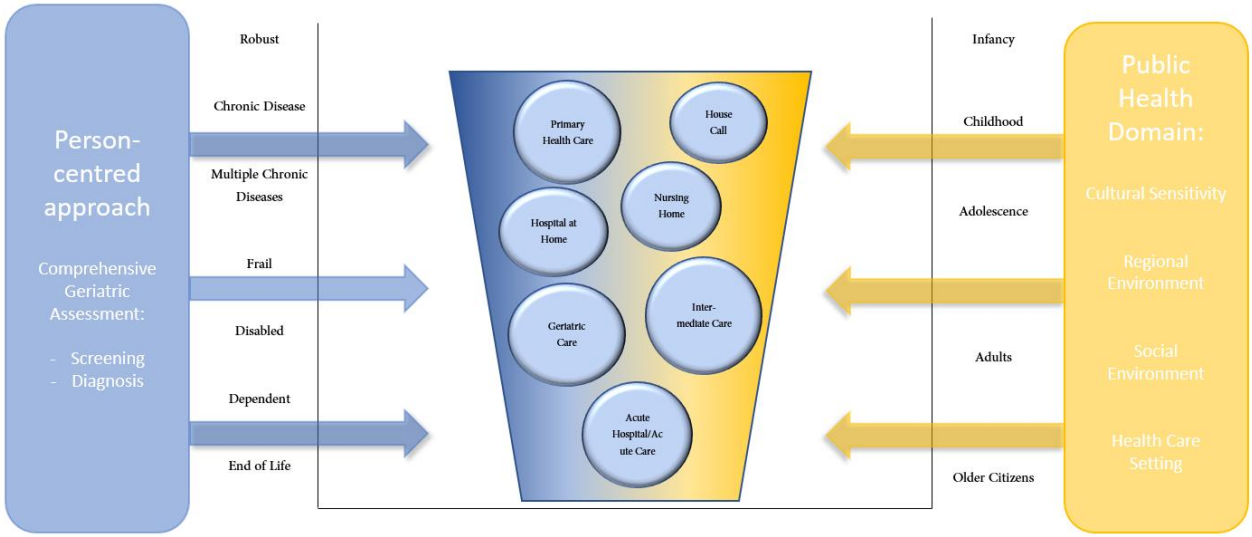

Figure 8 *The link among the two concepts of frailty management by the A3 action group of the EIP on AHA (109)*

1.5.1. The SUNFRAIL model

Frailty varies over time based on changes in the socio-economic and physical conditions of individuals. Therefore, the syndrome is commonly known as a relative and dynamic state, without a well-defined threshold (109).

In clinical practice the concept of frailty is still based on deficit models rather than on the development of capabilities. Researchers have developed screening and assessment tools for the early detection of functional deficits, which are coded to distinguish between frailty and disability. Most instruments are also targeted at a single dimension/domain, are difficult to administer due to numerous items and score calculations, and often target advanced frailty and disability. All these factors explain why none are currently and widely used in daily practice. In daily clinical practice an approach based on targeted screening in outpatient clinics and hospitals is followed by a comprehensive geriatric assessment (CGA) to allow individualized and person-centred interventions (110).

Studies highlight the reversible nature of frailty and suggest the need for interventions capable of slowing the progression towards disability (111). According to this approach, the assessment of frailty requires an overall analysis of the physical-functional, socio-environmental-economic, educational and psychological contributions. Although numerous tools are already available, there is no recognized gold standard in the literature (112). Tools such as the Phenotype of Frailty (113) and the Frail scale (114), are more focused on the analysis of the physical domain, are time-consuming and are poorly used in daily practice, especially in primary care settings (112).

To develop methods to detect and measure frailty in routine clinical practice, and especially in primary care, utilizing existing patient data records represents a current challenge, as well as to develop effective preventive and curative measures (86).

Multiple factors such as ethnicity, income, social isolation, chronic diseases, health conditions and environmental factors (115-120) can elicit frailty syndrome. Although numerous models have been built regarding the care of frail older adults (121,122), there is no international consensus for a common definition of frailty. For this reason, many tools have been developed over the years to identify, measure and evaluate frailty, with extreme variability, instructions and domains assessed (123,124).

“Reference Sites Network for Prevention and Care of Frailty and Chronic Conditions in community dwelling persons of EU Countries” (SUNFRAIL) is a European project, financed by the European Commission, under the Third Health Program (Grant n. 664291). The project involved multiple stakeholders of the A3 Action Group in the EIP on AHA (5) to pioneer the identification and implementation of innovative approaches, to standardize existing procedures on frailty and multimorbidity, and to develop new integrated techniques on the methodological and organizational levels in order to create standardized interventions that can take advantage of innovative approaches to this relevant health issue. The SUNFRAIL Consortium worked together to integrate the biomedical paradigm of frailty (88) with the "bio-psycho-social" paradigm (89), in order to take into account all the different factors that influence the individual's health status towards frailty: environmental, physical, educational, socio-economic and psychological. The model identified by the SUNFRAIL project takes into consideration the bio-psycho-social areas of frailty and the importance of evaluating frailty risk factors and prevention to respond to patients' needs and maintain independence.

This can be done through a “multiple gateway system”, where frailty and its risk factors can be identified across the health, social and community-informal systems. Appropriately trained professionals and companions can identify frailty and its risks and activate a first "alert" for further prevention activities, professional/specialist investigations and diagnostics.

At the same time, the identification of risks linked to socio-economic areas can activate a specific response within these specific contexts (community-social). (**Figure 9**)

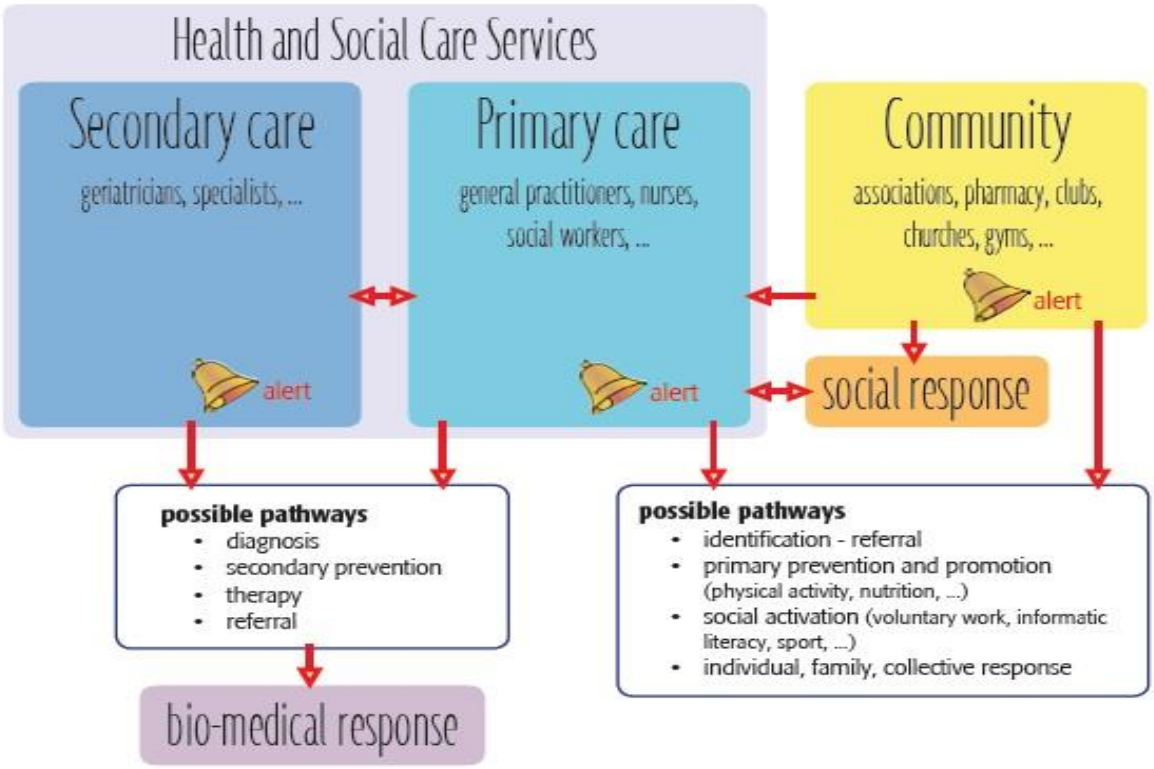

Figure 9 *The SUNFRAIL service model*

The SUNFRAIL project produced, as a result, a tool for the early identification of frailty in over 65 population in different settings (108), in order to generate alerts orienting subsequent diagnostic assessments for health promotion, disease prevention and targeted interventions (125-128). The screening tool, which consists of only nine items, can be used by General Practitioners or other health service professionals and community actors, such as Community Nurse, that can connect specific items to other in-depth tools for the assessment of specific dimensions (**Figure 10**).

QUESTIONNAIRE NUMBER		ID
Date and Place		
PROFESSIONALS		
Professional	☐ Nurse ☐ GPs ☐ Other professionals	
	☐ Social workers ☐ Community actors ☐ Caregiver	
BENEFICIARIES		
Gender ☐ M ☐ F	**Age** ☐ 65-74 ☐ 75-85	**Level of education** ☐ Low (without studies, Primary school) ☐ Medium (Secondary school or vocational degree) ☐ High (University, Master or PhD degree)
QUESTIONS		
1. Do you regularly take 5 or more medication per day?	☐ Yes	☐ No
2. Have you recently lost weight such that your clothing has become looser?	☐ Yes	☐ No
3. Your physical state made you walking less during the last year?	☐ Yes	☐ No
4. Have you been evaluated by your GP during the last year?	☐ Yes	☐ No
5. Have you fallen 1 or more times during the last year?	☐ Yes	☐ No
6. Have you experienced memory decline during the last year?	☐ Yes	☐ No
7. Do you feel lonely most of the time?	☐ Yes	☐ No
8. In case of need, can you count on someone close to you?	☐ Yes	☐ No
9. Have you had any financial difficulties in facing dental care and health care cost during the last year?	☐ Yes	☐ No

Figure 10 *The SUNFRAIL tool*

SUNFRAIL allows to carry out a very early screening, based on the first contact of the older adult with the primary care services, community and specialists, to guide him/her to subsequent insights concerning the identified frailty domains (physical, neuropsychological, social). The SUNFRAIL questions were selected from tools used internationally: specifically, the Edmonton Frailty Scale (129), the Tilburg Frailty Indicator (130), and the Gerontopole Frailty Screening Tool (131).

2. Aim of the study

The demographic changes taking place in Europe and worldwide will have profound implications in the planning and delivery of social and health services, due to the increase in the complexity of the health needs of the older adult population (1). Although it is not an inevitable condition of aging, frailty is characterized particularly in those over 65 years old by a dynamic state of vulnerability with weakness and reduction in the physiological reserve which entails an increased risk of lower quality of life, falling, institutionalization, disability, and death (86). The prevalence of frailty is age related (85) and is therefore linked to the demographic development patterns of the population, with different implications in terms of health needs that must be managed differently depending on the time of onset and the socioeconomic context of individuals. The older adult at risk of frailty presents losses in one or more domains of human functioning (physical, psychological, social) caused by the influence of a number of variables and which increase the risk of adverse outcomes (132). A proactive and integrated approach to frailty prevention is therefore essential, strengthening the interaction between all professionals involved in health and the social system, and also engaging informal caregivers.

The present study aimed to design and validate a digitally supported frailty screening and prevention intervention in community-dwelling older adults, taking into consideration all the different factors that influence the individual's health status: environmental, physical, educational, socio-economic and psychological.

The specific objectives of the research are the following:

1. Literature review of available tools for multidimensional frailty screening in the community-dwelling older adult population;
2. Design of a model for frailty screening to be linked to prevention and health promotion services;
3. Design of a study protocol for the validation of the digitally supported frailty screening model in community-dwelling older adults;
4. Analysis of the results of the validation study.

3. Methodology

3.1. Literature review on multidimensional tools for frailty assessment

As the SUNFRAIL tool is the first gateway between patients/beneficiaries and formal/informal services, a narrative review was carried out to identify further scales for the definition of a dataset, useful for the implementation of prevention and health promotion interventions for an independent and healthy life of community-dwelling older adults, based on an in-depth multidimensional evaluation. The objective of the narrative review is to identify more detailed and sensitive screening tools, to be linked to the elements of the SUNFRAIL tool, evaluate compromised domains and develop appropriate intervention strategies for frailty screening for community-dwelling older people, optimizing resources (133).

This review uses the International Narrative Systematic Assessment (INSA) (134) tool for narrative reviews as a method. This narrative review uses the Population Implementation Comparator Outcome Study (PICOS) approach reported in **Table 1**.

Population	older people, aged 65 years or older
Implementation/indicator	frailty domains tool(s) (polypharmacy, weight loss, physical activity, medical visits, falls, memory loss, loneliness, support network, economic constraints)
Comparator	n/a
Outcome	multidimensional frailty screening or frailty prevention in community-dwelling older adults
Study	review, systematic review, and meta-analysis

Table 1 *The SUNFRAIL+ Population Implementation Comparator Outcome Study (PICOS)*

The review selection was performed using the Embase and PubMed databases. A side search was performed to identify other relevant articles, especially in those domains where the search did not yield satisfactory results. The narrative review focused on the 9 domains of frailty that are covered in the SUNFRAIL screening tool. The search strings considered are included in **Table 2**.

SUNFRAIL frailty Domains	**Search Strings**
Polypharmacy	(frail elderly OR frailty OR elderly population) AND (tool OR screening tool OR assessment tool OR instrument OR test OR outcome measurement OR questionnaire) AND (review OR systematic review) AND (Polypharmacy)
Weight loss	(frail elderly OR frailty OR elderly population) AND (tool OR screening tool OR assessment tool OR instrument OR test OR outcome measurement OR questionnaire) AND (review OR systematic review) AND (weight loss) AND (nutrition)
Physical activity	(frail elderly OR frailty OR elderly population) AND (tool OR screening tool OR assessment tool OR instrument OR test OR outcome measurement OR questionnaire) AND (review OR systematic review) AND (physical activity) AND (walking)

Medical visits	(frail elderly OR frailty OR elderly population) AND (tool OR screening tool OR assessment tool OR instrument OR test OR outcome measurement OR questionnaire) AND (review OR systematic review) AND (medical visits)
Falls	(frail elderly OR frailty OR elderly population) AND (tool OR screening tool OR assessment tool OR instrument OR test OR outcome measurement OR questionnaire) AND (review OR systematic review) AND (falls)
Memory loss	(frail elderly OR frailty OR elderly population) AND (tool OR screening tool OR assessment tool OR instrument OR test OR outcome measurement OR questionnaire) AND (review OR systematic review) AND (cognitive decline)
Loneliness	(frail elderly OR frailty OR elderly population) AND (tool OR screening tool OR assessment tool OR instrument OR test OR outcome measurement OR questionnaire) AND (review OR systematic review) AND (loneliness)
Support network	(frail elderly OR frailty OR elderly population) AND (tool OR screening tool OR assessment tool OR instrument OR test OR outcome measurement OR questionnaire) AND (review OR systematic review) AND (support network)
Economic constraints	(frail elderly OR frailty OR elderly population) AND (tool OR screening tool OR assessment tool OR instrument OR test OR outcome measurement OR questionnaire) AND (review OR systematic review) AND (economic constraints)

Table 2 *The SUNFRAIL+ search strings*

The search was restricted to reviews published between January 2010 and December 2021 and was limited to the English language. The inclusion criteria of this narrative review were: frailty domains measurement in older people, aged 65 years or over. The following papers were excluded: articles focused on the definition and models of frailty; observational, cross-sectional or randomized controlled trials; papers focused on a specific topic or illness or adverse outcome. The review articles on the domains of frailty that do not include a comparison of the assessment tools used in literature will be excluded on the basis of the full text.

In step 2, an independent reviewer listed the available assessment tools for each item on the y-axis and compared the tools according to the needs of health systems for IT-supported frailty screening intervention in primary and community care on the x-axis. Each tool was evaluated according to the match against the following needs:

- used on older adults living at home;
- validation through a peer-reviewed study;
- number of items, as completeness of questions and time required for administration;
- specificity, as the ability of the instrument to clearly distinguish healthy subjects from those in which the specific domain is impaired. This was assessed by the reviewer by analyzing the nature of the questions (qualitative/quantitative) and the presence or absence of a final score;
- ease of use, as the need for specific preparation in order to administer the instrument;
- usability by different professionals (doctors, nurses, social workers, etc.).

The reviewer scored each match against the need through a three-point Likert scale (1 being “barely addresses the need”; 2 being “partially addresses the need”; 3 being “fully addresses the need”).

3.2. An innovative model for frailty screening: SUNFRAIL+

The centrality of nursing services in the promotion of health in the older adult population through prevention, education and health information is certainly a topic that has been discussed and added to the agenda of public health systems in recent years (135). Many Italian regions and all actors involved in the working groups activated by the Programma Mattone Internazionale Salute (ProMIS), the Italian Ministry of Health program for the internationalization of regional health systems (136), have been involved in various ways in the implementation of the family and community nurse (FCN) professional pro-file. Italian regions are progressively introducing FCN into their health system in a pilot form or through dedicated policies, defining its boundaries, actions and relations (137,138). The FCN is pivotal for meeting the twin challenges of an aging population and the increasing incidence of long-term conditions in order to prevent adverse events and enable health systems to encourage and ensure the improvement of health and well-being in-stead of focusing exclusively on the treatment of illness (139). Primary care for older adults with multimorbidity is characterized by the fragmentation of care services (general practitioners, geriatricians, territorial specialists, rehabilitators, FCNs, etc.). In this sense, information technology (IT) represents a very powerful tool to support prevention and healthcare activities. In fact, IT has become increasingly wide-spread and available in recent years, although it is currently only partially validated (109). A new service model for frailty screening of community-dwelling older adults has been developed through the SUNFRAIL+ platform, an IT tool that supports healthcare professionals by linking the items of the SUNFRAIL tool to additional scales aimed at assessing frailty domains and enabling the development of adequate intervention strategies. The screening model involves the administration of the SUNFRAIL tool for the identification of the following frailty risk facts according to a biopsychosocial approach:

- Prescription Adherence and Polypharmacy;
- Nutrition;
- Physical activity;
- Adherence to medical visits;
- Falls;
- Cognitive decline;
- Loneliness;
- Support network;
- Socio-economic conditions.

Based on the “alerts” from the SUNFRAIL tool, healthcare professionals will carry out further investigations through validated scales for the evaluation of the domain identified as at risk. This will allow us to confirm/not confirm the presence of risk factors in the older adults and define an intervention strategy.

This IT-supported multidimensional approach improves the availability of data on the target population so that healthcare professionals can develop targeted interventions in the sectors identified as at risk. In this model,

the FCN can serve as the first point of contact for individuals and families and play a leading role in disease prevention and health promotion, referring to specialists when more expertise is needed. The model can also be used by other professionals who work closely with the older adults, such as, for example, family doctors, social workers, or in other health and social-health settings.

3.3. Study Protocol

The SUNFRAIL+ study protocol was developed through a prospective observational cohort study. The study will carry out a multidimensional assessment of older adults, through the SUNFRAIL+ platform, which allows the linking of each item of the SUNFRAIL tool with a cascading multidimensional in-depth assessment of the bio–psycho–social domains of frailty (133). The study aims to assess the impact of early, integrated and simultaneous "taking care" by health systems on the quality of life of community-dwelling older adults through the SUNFRAIL+ platform. In addition, the study aims to verify the effect of SUNFRAIL+ on the appropriateness of care by the healthcare system and the impact of IT solutions on the organization of services and the workload of professionals.

3.3.1. Centers

It is a multicentric study, promoted by ProMIS, which includes the following centers and regions (**Figure 11**):

- Department of Public Health of the University of Naples Federico II (Campania Region), as coordinator;
- Azienda Sociosanitaria Ligure 4 (Liguria Region);
- Azienda Provinciale per i Servizi Sanitari (Autonomous Province of Trento);
- "Res Omnia" Social Cooperative (Calabria Region);
- Azienda Sanitaria Locale Cuneo 1 (Piedmont Region);
- Azienda Unità Sanitaria Locale Nord-Ovest (Tuscany Region);
- Department of Biomedicine and Prevention of the University of Rome Tor Vergata (Lazio Region)
- Azienda Socio-Sanitaria Territoriale della Valle Olona (Lombardy Region).

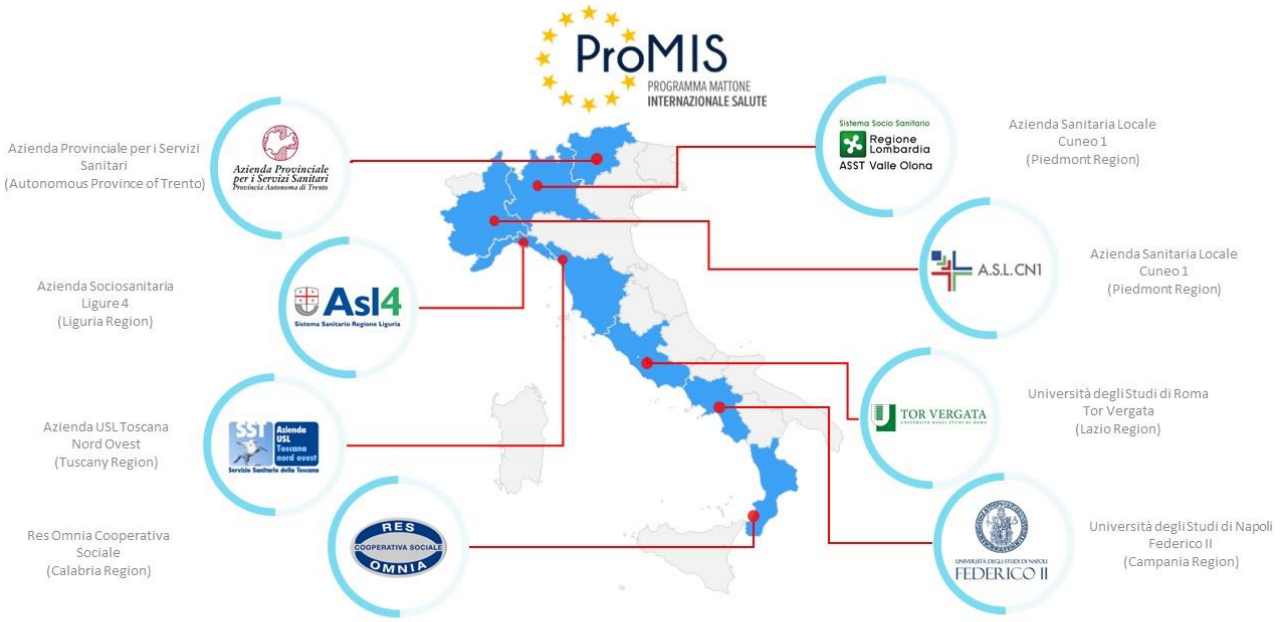

Figure 11 *The Map of the centers of SUNFRAIL+ Study*

3.3.2. Participants

Each center will independently recruit 100 ambisexuals, randomly selected older adults. Subjects who meet inclusion criteria summarized in the **Table 3**, are eligible to participate.

Inclusion criteria	**Exclusion criteria**
• age ≥ 65 years; • living at home; • accessing participating centers for social and healthcare services other than those covered by this study; • ability to sign the informed consent	• age <65 years; • residents in care facilities (hospital and nursing home); • overt frailty or disability; • already enrolled in home care; • unable to understand the study aims and sign the informed consent

Table 3 *Inclusion and exclusion criteria*

3.3.3. Intervention

The study will have a duration of 14 months: 6 months for the first multidimensional assessment (enrolment), 6 months "taking charge" (observation) and 2 months of data analysis and evaluation (follow-up) (**Figure 12**).

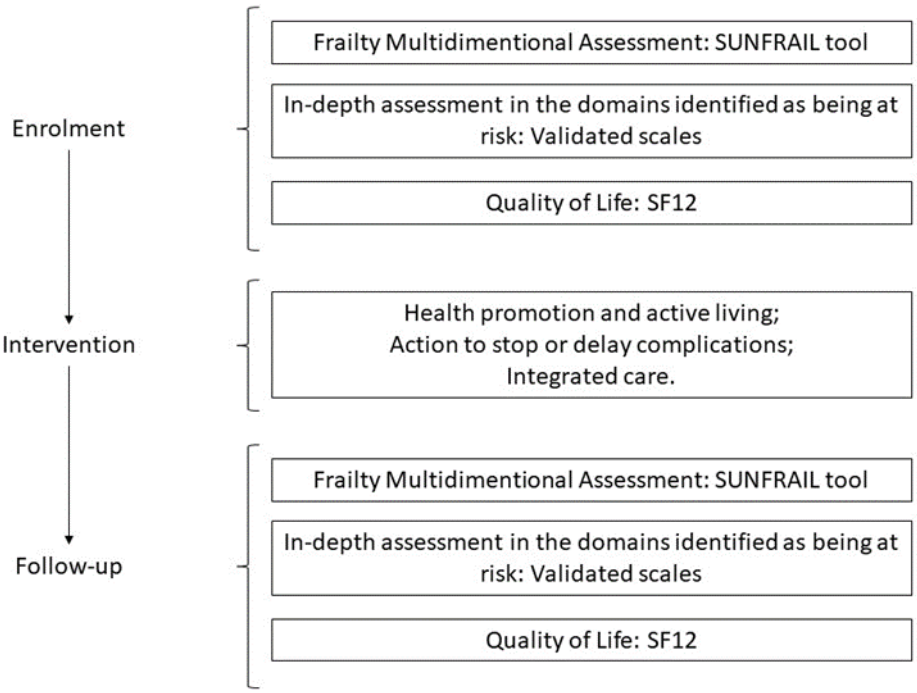

Figure 12 *SUNFRAIL+ study design and planned intervention*

Each center will administer the SUNFRAIL tool to the enrolled older adults and, according to the specific frailty risk factors identified by the answers provided, they will be subjected (at the same time or subsequently) to one or more validated scales (already included in the SUNFRAIL+ platform) in order to perform further diagnostic or dimensional evaluations in the domains identified as being at risk.

In addition, demographic, anamnestic and anthropometric variables will be acquired. The multidimensional assessment through the platform will be carried out by trained personnel.

During the observation phase, older adults will be offered different health promotion activities, depending on the multidimensional assessment. Healthy older adults will be offered collective physical exercise programs and nutritional recommendations. In addition, services will be provided to promote socialization and educational modules dedicated to fall prevention. For subjects with chronic diseases, in addition to health promotion, services for patient empowerment and improved adherence to treatment goals will be provided.

During the follow-up phase, 6 months after enrolment, the SUNFRAIL tool and in-depth tests will be administered again. In addition, during the follow-up, the extent to which the exposure to the interventions has influenced the quality of life of older adults will be measured, and the number of users enrolled by the territorial services based on us-er care needs will be documented. In addition, the level of satisfaction and usability of the SUNFRAIL+ solution by health and social care professionals will be measured.

3.3.4. Outcomes

The data from the study will be collected through the instruments and self-assessment questionnaires reported in the **Table 5**.

Outcome	Mean of measurement
Multidimensional Frailty	• SUNFRAIL tool (108)
Prescription adherence	• Therapeutic adherence scale (SAT);
Nutrition	• assessment of adherence to the Mediterranean diet (PREDIMED) (140) • Mini-Nutritional Assessment (MNA) (141)
Physical activity	• Short Physical Performance Battery (SPPB) (142)
Adherence to Medical Visit	• Checklist
Fall risk	• age-friendly environment assessment tool (AFEAT) (143) • Time up and go test (144)
Cognitive decline	• Quick mild cognitive impairment (QMCI) (145) • General practitioner assessment of cognition (GPCOG) (146)
Loneliness	• Geriatric depression scale (GDS) (147);
Support network	• Social provisions scale (SPS) (148);
Socioeconomic conditions	• Self-assessment questionnaire (MUSE) (149)
Quality of life	• SF-12 health survey (150)
Usability	• System usability scale (SUS) (151)

Table 5 *The SUNFRAIL+ outcomes and means of measurement.*

The adherence to medical visits will be measured by means of a questionnaire in which older adults will be asked how many times in the last 3 months they visited the GP, received home nursing visits, went to hospital, went to the emergency room, and had specialist examinations, blood tests or other diagnostic examinations. In addition, older adults will be asked whether they have difficulties in making an appointment with the GP or in getting to the GP's clinic.

3.3.5. Statistical Analysis

All complete questionnaires will be analyzed. The statistical analysis will be:

- Descriptive and exploratory (ADE) with respect to the study population, bringing to light any "features" present in the data;
- Confirmatory (ADC), focusing on confirming or falsifying the appropriateness of ear-ly, integrated and simultaneous care.

For the descriptive analysis, the absolute and relative frequency distributions of all qualitative variables will be calculated, while for the quantitative or semiquantitative variables (e.g., scales from 1 to 10), the main

summary and variability indices (mean, median, minimum, maximum, standard deviation, range and interquartile difference) will be calculated.

The main statistical tests will be used for confirmatory analyses, depending on the types of variables: chi-square test, McNemar test for dichotomous data, parametric t-test and Wilcoxon's nonparametric test for paired data (before–after). All tests will be two-sided, with a 5% significance level. The multiple linear regression model will be used to examine the contribution of the parameters measured during the study (explanatory variables) on the quality of life (score measured by the SF-12 questionnaire, dependent variable).

The analyses will be performed using IBM SPSS Statistics software for Windows, version 26, Armonk, NY, IBM Corp.

With a type 1 error of 5% and a study power of 80%, accepting a 95% confidence level and targeting an improvement of 10% in the SF12 score, the requested sample size will be composed of 195 subjects. The number of 700 clients exceeds the needed number of participants, which can be useful to perform nested analysis.

3.3.6. Ethics Statement

Each center is responsible for conducting the study in accordance with good clinical practice and international quality standards for the design, conduct and dissemination of studies involving human subjects (152). The study protocol, informed consent and any ac-companying material provided to the patient have been approved by the local Ethics Committee of Università "Federico II"–Azienda Ospedaliera di Rilievo Nazionale "A. Cardarelli" (record number: 284/22). The research protocol was registered at ClinicalTri-als.gov on 9 December 2022 (registration number: NCT05646472) (153).

4. Results

4.1 Narrative review

4.1.1. Polypharmacy

The process of review papers selection has been summarized in the flowchart of **Figure 13**.

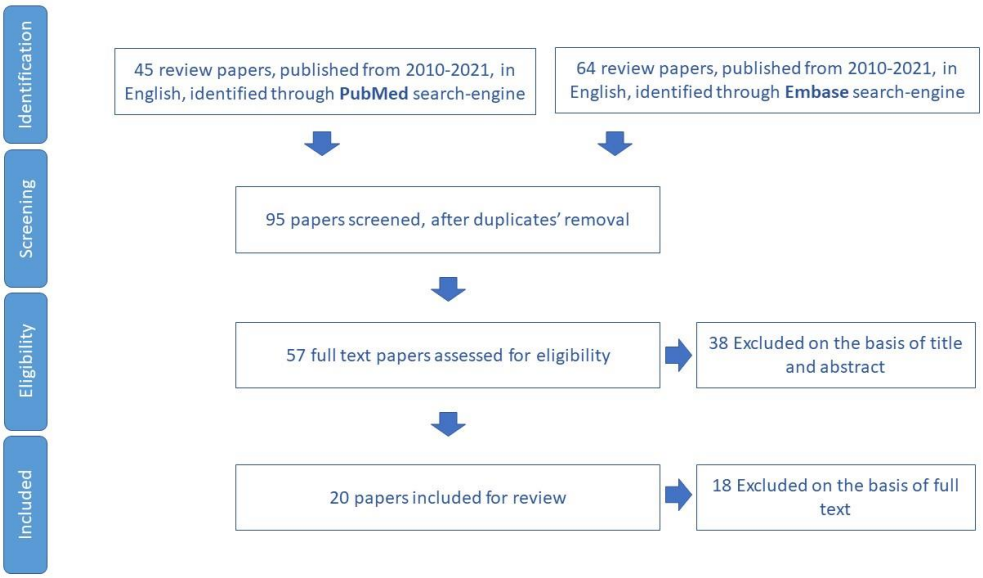

Figure 13 *Process of study selection for polypharmacy domain*

In total, we extracted 15 tools for the assessment of prescription appropriateness and adherence in older adults' population (**Supplementary Materials - Table S1**).

The tools we most common found were Screening tool of older people's prescriptions and Screening tool to alert to right treatment and (STOPP/START) (154) (n = 17 review papers), followed by Beers Criteria (155) (n = 12), Medication Appropriateness Index (MAI) (156) (n = 4), and Fit fOR The Aged list (FORTA) (157) (n = 4). These tools, as well as STOPPFrail (158), Norwegian General Practice criteria (NORGEP) (159), the (EU)(7)-PIM list (160), the PRISCUS list (161), Systematic Tool to Reduce Inappropriate Prescribing (STRIP) (162), Good Palliative-Geriatric Practice (GP-GP) (163), Individualised Medication Assessment and Planning program (IMAP) (164) and Zhan Criteria (165) are mainly criteria used to review drug therapy in the light of identified iterations. They are used by professionals, mainly physicians and pharmacists, to identify potential drug interactions, which may have a negative im-pact on the health of the patient. Other tools, such as Drug Regimen Unassisted Grading Scale (DRUGS) (166), Medication Management Ability Assessment (MMAA) (167), Self-Efficacy for Appropriate Medication Use Scale (SEAMS) (168), are used to assess the older adult's ability to adhere to prescriptions and to independently take care of themselves. **Table 6** shows the Prescription appropriateness and adherence assessment tools scores.

	use on older adults living at home	validation	number of items	specificity	ease of use	usability by different professionals
STOPP/START	2	3	2	3	1	1
Beers criteria	2	3	2	3	1	1
Medication Appropriateness Index (MAI)	2	3	3	3	3	1
Fit fOR The Aged list (FORTA)	2	3	1	3	1	1
STOPPFrail	2	3	2	3	1	1
Norwegian General Practice criteria (NORGEP)	2	3	2	3	1	1
(EU)(7)-PIM list	2	3	2	3	1	1
PRISCUS list	2	3	2	3	1	1
Systematic Tool to Reduce Inappropriate Prescribing (STRIP)	3	2	3	1	3	2
Good Palliative-Geriatric Practice (GP-GP)	1	1	2	1	2	1
Individualised Medication Assessment and Planning program (IMAP)	3	3	2	2	1	1
Zhan Criteria	2	3	2	3	1	1
Drug Regimen Unassisted Grading Scale (DRUGS)	1	3	2	2	2	2
Medication Management Ability Assessment (MMAA)	2	3	2	2	2	2
Self-Efficacy for Appropriate Medication Use Scale (SEAMS)	1	3	2	2	2	2

Table 6 *Prescription appropriateness and adherence assessment tools scores*

4.1.2. Weight loss

We included for review 13 papers (Figure 14) and we extracted 15 tools aimed to assess malnutrition in older adults (**Supplementary Materials – Table S2**).

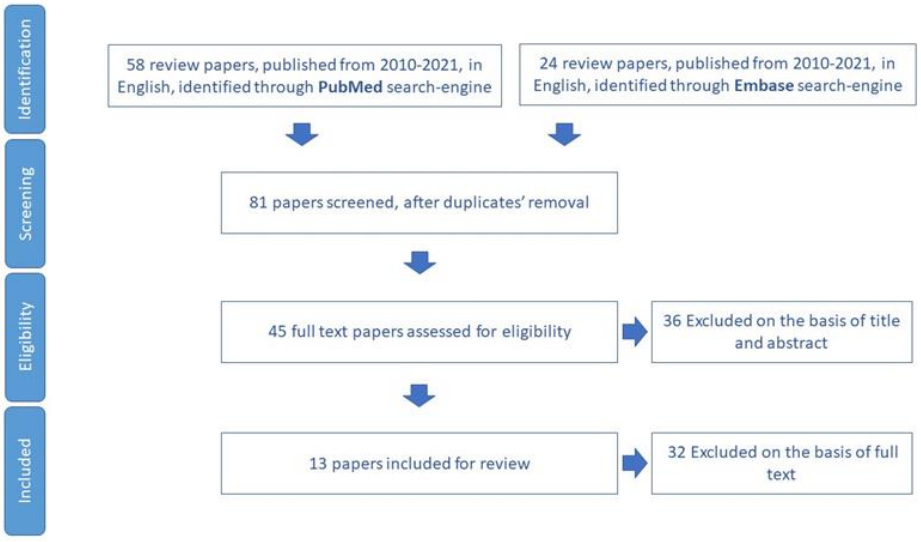

Figure 14 *Process of study selection for nutrition domain*

The best-rated nutrition screening tools are the PREDIMED (140) and the 10-point Mediterranean diet scale (169). They are easy to use and measure adherence to the Mediterranean diet. The Mini Nutritional Assessment (MNA) (141), including the Mini Nutrition Assessment Short Form (MNA-SF) (170), is a more reliable tool for nutritional screening, but needs assessments that cannot be performed by not-medical professionals. The Nutritional Form for the Elderly (NUFFE) (171) is a self-assessment questionnaire developed for the hospital setting, but it takes into account all aspects considered important for nutritional assessment. The Malnutrition Universal Screening Tool (MUST) (172) is a very thorough and com-plex tool to submit. The Canadian Nutrition Screening Tool (CNST) (173), the Chapman Nutritional screening (174), the Malnutrition Screening Tool (MST) (175), measure the nutritional status of the patient in the hospital setting. The DETERMINE Checklist (176) is not specific. The Seniors in the Community Risk Evaluation for Eating and Nutrition (SCREEN I) or (SCREEN II) questionnaire (177) places more emphasis on clinical judgement.

The Council on Nutrition Appetite Questionnaire (CNAQ) (178) and the Simplified Nutritional Appetite Questionnaire (SNAQ) (179) are not specific, as they measure appetite level. The SNAQ65+ (180) combines self-rated questions and anthropometric measurements. The SCALES (Sadness, Cholesterol, Albumin, Loss of weight, Eating, Shopping) questionnaire (181) measures weight loss associated with other risk factors and requires specific clinical expertise. **Table 7** shows malnutrition assessment tools scores.

	used on older adults living at home	validation	number of items	specificity	ease of use	usability by different professionals
PREDIMED	3	3	3	3	3	3
Mini Nutritional Assessment (MNA)	3	3	3	3	3	2
Mini Nutrition Assessment Short Form (MNA-SF)	3	3	3	3	3	2
Malnutrition Universal Screening Tool (MUST)	3	3	2	3	1	1
10-point Mediterranean-diet scale	3	3	3	3	3	3
Canadian Nutrition Screening Tool (CNST)	1	3	2	3	3	3
Chapman Screening tool	1	2	2	1	2	2
Malnutrition Screening Tool (MST)	1	3	2	2	3	3
DETERMINE Checklist	2	3	1	1	1	1
Seniors in the Community Risk Evaluation for Eating and Nutrition questionnaire (SCREEN I) or (SCREEN II)	3	3	3	3	1	1
Council on Nutrition Appetite Questionnaire (CNAQ)	3	3	3	1	3	3
Nutritional Form for the Elderly (NUFFE)	3	3	3	3	3	2
Simplified Nutritional Appetite Questionnaire (SNAQ)	3	3	3	1	3	2
Short Nutritional Assessment Questionnaire (SNAQ65+)	3	3	1	1	3	3
SCALES (Sadness, Cholesterol, Albumin, Loss of weight, Eating, Shopping) questionnaire	3	2	2	1	1	1

***Table** 7 Malnutrition assessment tools scores*

4.1.3. Physical activity

The study selected 74 papers for review (**Figure 15**).

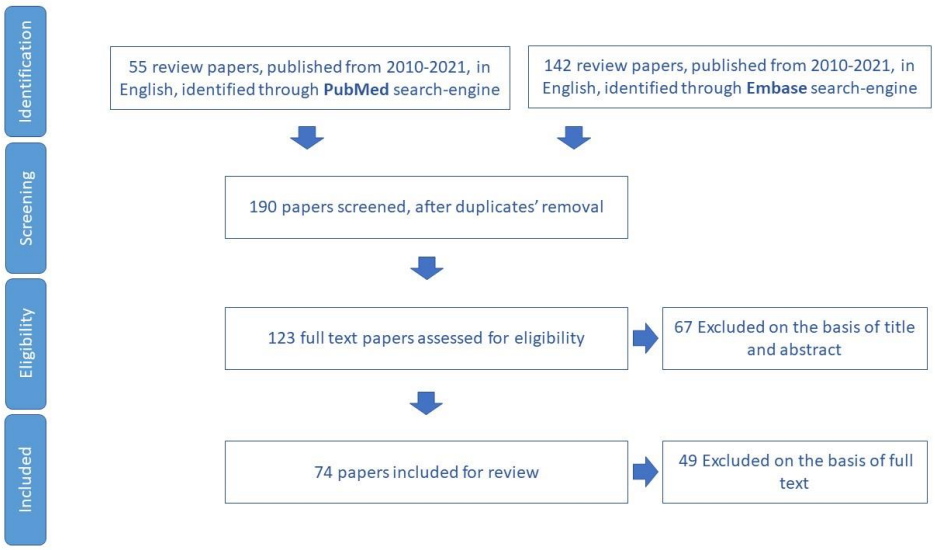

***Figure 15** Process of study selection for physical activity domain*

25 tools aimed to assess physical activity in older adults have been identified (**Supplementary Materials – Table S3**)

The tool that was found most often was the Short Physical Performance Battery (SPPB) (n=40) (142). It assesses the older adult's ability to walk, get up from the chair and remain balanced. Other instruments, such as the 5-chair stand test (182), Timed-Up & Go Test (144) (n=30), the 4-Square Step test (183) and Alternate-step test (ATS) (184) measure sever-al aspects of physical function individually. The SPPB is also used to assess fall risk. The 6-Minute Walking Test (6MWT) (n=33) (185) and 5-Meter Walking Test (5MWT) (186) instruments are easy to use in both hospital and community settings to assess the older adult's ability to walk. The incremental shuttle walk test (ISWT) (187) aims to simulate a cardiopulmonary exercise test using a field walking test. There have been several self-report questionnaires found to quantify the amount of daily physical activity of older adults. The widely used measures are the Physical Activity Scale for the Elderly (PASE) (n=8) (188). Community Healthy Activities Model Program for Seniors (CHAMPS) questionnaire (189), Zutphen Physical Activity Questionnaire (190), Physical Activity and Sedentary Behavior Questionnaire (PASB-Q) (191), EPIC Physical Activity Questionnaire (EPAQ2) (192), International Physical Activity Questionnaire (IPAQ) (193), General Practice Physical Activity Questionnaire (GPPAQ) (194), and Longitudinal Aging Study Amsterdam Physical Activity Questionnaire (LAPAQ) (195) aim to assess the duration, frequency, exertion level, and amount of physical activity undertaken over a seven day period by individuals 65 years and older. Stanford Brief Activity Survey (196), Women's Health Initiative physical activity questionnaire (WHI-PAQ) (197), Physical Activity Scale for Individuals with Physical Disabilities (PASIPD) (198) Duke Activity Status Index (199) assess recreational activities or exercises (mild, moderate, and strenuous), household and yard activities.

The SF-36 (physical component scale) (200) measures self-perceived physical function, role limitations-physical, bodily pain. The WOMAC physical function subscale (201) is a widely employed patient reported measurement instrument for difficulty in physical function due to pain, discomfort in knee osteoarthritis patients. The Tinetti Performance-Oriented Mobility Assessment (POMA) (202), Mini Motor Test (MMT) (203), and Elderly Mobility Scale (204) evaluate physical performance by means of gait, balance, and stand-up tasks.

Table 8 shows physical activity assessment tools scores.

	used on older adults living at home	validation	number of items	specificity	ease of use	usability by different professionals
Short Physical Performance Battery (SPPB)	3	3	2	3	3	3
5CST, five-chair stand test	3	3	1	1	2	2
Timed-Up & Go Test	3	3	1	1	2	2
Four-Square Step test	2	1	3	3	3	3
Alternate-step test (ATS)	3	3	1	1	2	2
6-minute walking test (6MWT)	3	3	3	3	2	2
5-meter walking test (5MWT)	2	3	3	2	3	3
Incremental Shuttle Walk Test (ISWT)	2	2	2	1	1	1
Physical Activity Scale for the Elderly (PASE)	2	3	3	2	3	3
Community Healthy Activities Model Program for Seniors (CHAMPS)	3	3	1	3	1	1
Zutphen Physical Activity Questionnaire	3	1	1	1	3	3
Physical Activity and Sedentary Behavior Questionnaire (PASB-Q)	3	1	2	1	3	3
EPIC Physical Activity Questionnaire (EPAQ2)	3	3	2	1	2	3
International Physical Activity Questionnaire (IPAQ)	1	3	2	1	3	3
General Practice Physical Activity Questionnaire (GPPAQ)	3	2	1	1	3	3
Longitudinal Aging Study Amsterdam Physical Activity Questionnaire (LAPAQ)	3	3	3	2	2	2
Stanford Brief Activity Survey (SBAS)	2	3	1	1	3	3
Women's Health Initiative physical activity questionnaire (WHI-PAQ)	1	3	2	2	2	2
Physical Activity Scale for Individuals with Physical Disabilities (PASIPD)	2	2	1	1	2	3
Duke Activity Status Index	3	2	3	2	2	3
SF-36 (physical component scale)	1	3	1	1	1	2
WOMAC physical function sub-scale	2	1	2	2	2	2
Tinetti Performance-Oriented Mobility Assessment (POMA)	1	3	1	3	1	1
Mini Motor Test (MMT)	3	2	1	3	1	2
Elderly Mobility Scale	1	2	2	2	2	1

Table 7 *Physical activity assessment tools scores*

4.1.4. Adherence to medical visits

The scientific production on the topic of adherence to medical visits is not extensive. The search only concerned reviews and meta-analyses on this specific topic, so it did not produce any results (**Figure 16**).

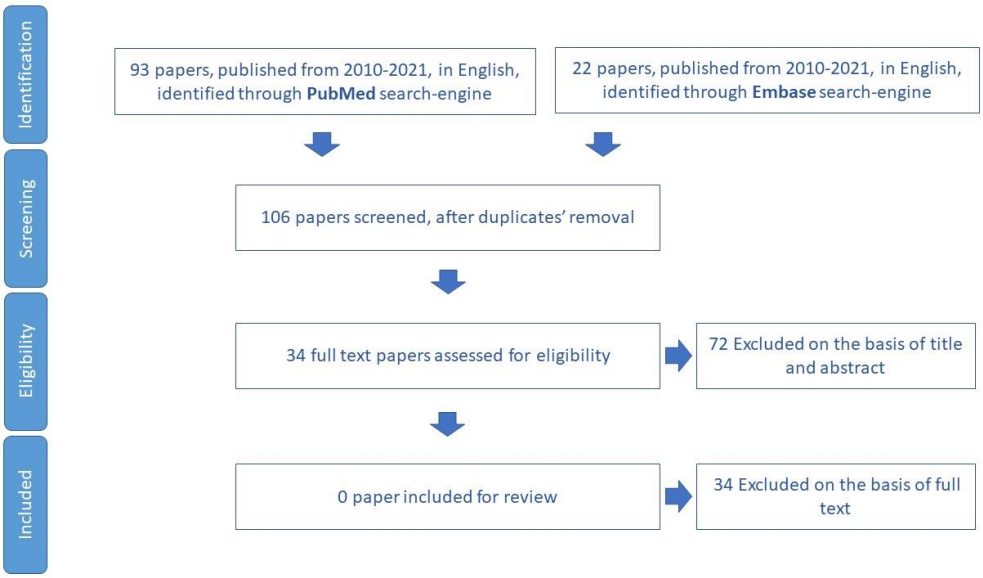

Figure 16 *Process of study selection for assessment of adherence to medical visits*

However, the analysis of the eligible papers highlighted several studies that have predominantly used checklists or single oral questions. Among the excluded papers, there is a study in which an 8-item tool was used to collect information on older adults' access to primary care, continuity and connectedness, which were considered to be enabling factors for the use of the emergency room (205).

4.1.5. Falls

The narrative review for fall item included 39 papers for review (**Figure 17**) through which 26 tools aimed to assess fall and the risk of falling in older adults have been identified (**Supplementary Materials – Table S4**).

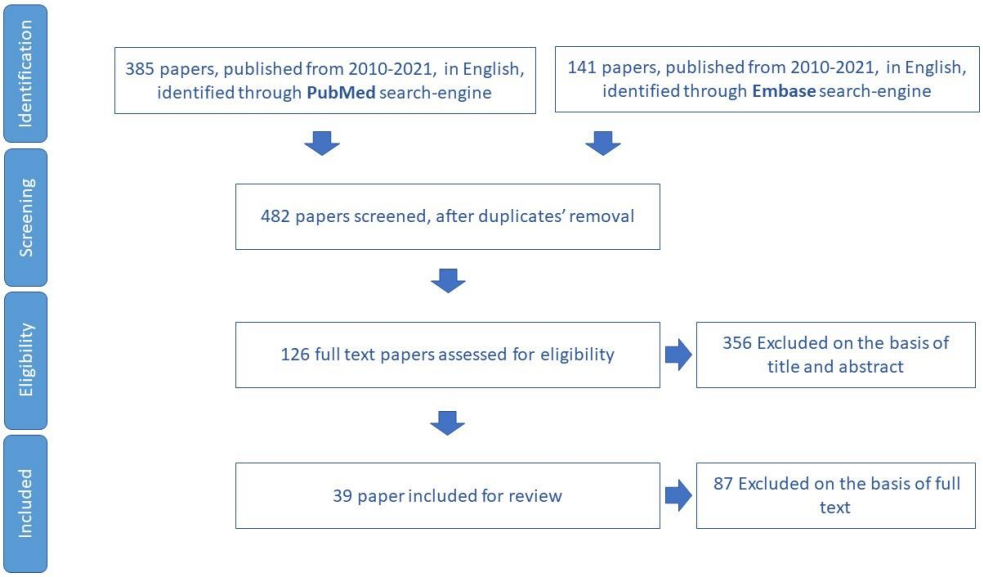

Figure 17 *Process of study selection for fall risk assessment*

The Falls Efficacy Scale (FES) (206), and its revised versions, the Modified Falls Efficacy Scale (MFES) (207) and the Short Falls Efficacy Scale-International (FES-I) (208), are the most common instruments for assessing

confidence in older adults' ability to perform Activities of Daily Living (ADL) without falling. Survey of Activities and Fear of Falling in the Elderly (SAFE) (209), Mobility Efficacy Scale (MES) (210), University of Illinois at Chicago Fear of Falling Measure (UIC FFM) (211) measure the self-reported fear of falling. Falls Risk Assessment Questionnaire (FRAQ) (212) aims to assess awareness and perception of falls risk. Fall Risk Index (FRI-21) (213) has been used to detect older adults' decline in basic activities of daily living (BADL). Fracture Risk Assessment Tool (FRAX) (214) estimates the risk of having a hip or other major fracture. Tinetti POMA (202), Berg Balance Scale (BBS) (215), Fullerton Advanced Balance (FAB) Scale (216) assess static and dynamic balance and fall risk in adults. The Activities-specific Balance confidence (ABS) scale (217) is a questionnaire developed to assess older individual's self-perceived balance confidence in performing daily activities. Fall risk assessment tool (FRAT) (218), Morse Fall Scale (219), St. Thomas Risk Assessment Tool in Falling Elderly Inpatients (STRATIFY) (220), Conley Scale (221), the Johns Hopkins Fall Risk Assessment Tool (222), Hendrich II Fall Risk Model tool (223), Austin Health Falls Risk Screening Tool (AHFRST) (224) Falls Risk For Hospitalized Older People (FRHOP) (225) identify risk factors of falls in hospitalized patients. Falls Risk for Older People in the Community (FROP-Com) (226), Downton Fall Risk Index (DFRI) (227) aim to predict post-discharge injuries, identifying people who require further assessment and management. Elderly Fall Screening Test (EFST) (228) aims to stratify community-dwelling older adults population into low and high risk of fall, based on the falls history and observations of walking speed and gait style. Home-screen scale (229) and Safety House Checklist (230) aim to identify environmental safety hazards in older adults' homes. **Table 8** shows falls assessment tools scores.

	used on older adults living at home	validation	number of items	specificity	ease of use	usability by different professionals
Falls Efficacy Scale (FES)	3	3	3	3	3	3
Modified Falls Efficacy Scale (MFES)	3	3	3	3	3	3
Short Falls Efficacy Scale-International (FES-I)	3	3	3	3	3	3
Survey of Activities and Fear of Falling in the Elderly (SAFE)	3	3	2	3	3	3
Mobility Efficacy Scale (MES)	3	2	3	2	3	3
University of Illinois at Chicago Fear of Falling Measure (UIC FFM)	3	3	2	2	2	3
Fall Risk Index (FRI-21)	3	3	3	3	3	3
Falls Risk Awareness Questionnaire (FRAQ)	3	3	3	3	2	2
Fracture Risk Assessment Tool (FRAX)	2	3	2	3	1	1
Berg Balance Scale	3	3	2	3	1	1
Fullerton Advanced Balance (FAB) Scale	3	3	2	3	1	1
Activities-specific Balance Confidence scale (ABC)	3	3	3	2	3	3
Fall risk assessment tool (FRAT)	2	3	2	3	1	1
Morse Fall Scale	1	3	2	2	2	1
St. Thomas Risk Assessment Tool in Falling in Elderly Inpatients (STRATIFY)	1	3	2	1	1	1
Conley Scale	2	3	2	1	3	3
Johns Hopkins Fall Risk Assessment Tool (JHFRAT)	3	3	3	2	3	3
Hendrich II Fall Risk Model	2	3	1	2	1	1
Austin Health Falls Risk Screening Tool (AHFRST)	2	2	1	2	2	1
Falls Risk for Hospitalized Older People (FRHOP)	1	2	1	2	1	1
Falls Risk for Older Persons-Community Setting Screening Tool (FROP Com)	3	3	2	1	3	3
Downton Fall Risk Index	1	3	2	2	1	1
Elderly Fall Screening Test (EFST) Tool	3	2	2	1	3	3
Home-Screen Scale	3	2	2	2	3	3
Safety House Checklist	3	1	2	2	3	3
Tinetti Performance-Oriented Mobility Assessment (POMA)	2	3	2	3	1	1

Table 8 *Falls assessment tools scores.*

4.1.6. Memory loss

In memory loss item, the study selected 12 papers for review (**Figure 18**). 18 tools aimed to assess cognitive function in older adults have been identified (**Supplementary Materials – Table S5**).

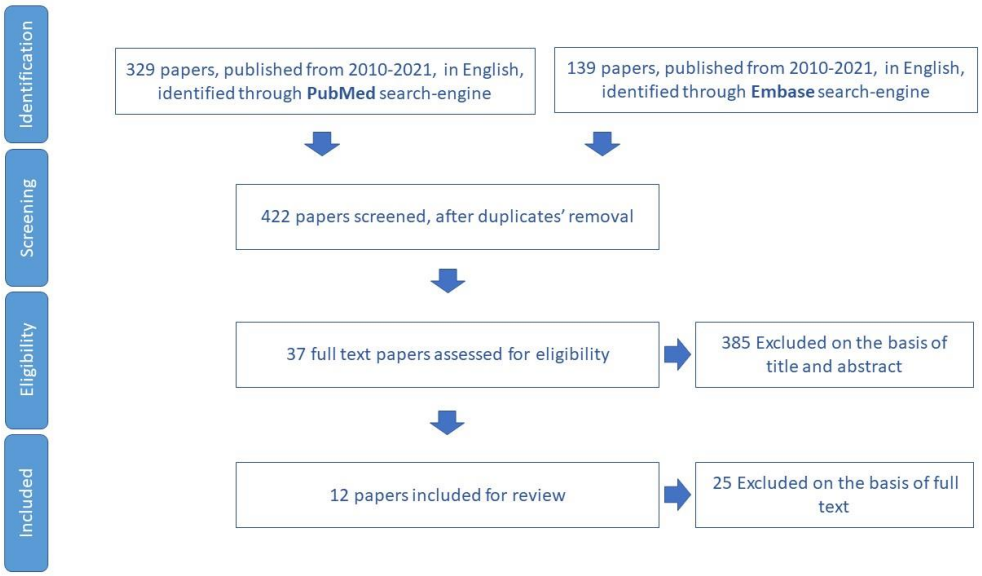

Figure 18 *Process of study selection for the assessment of cognitive decline*

Our research showed that the most used tool is Mini Mental State Examination (MMSE) (231) and its modified version (3MS) (232) are questionnaires that healthcare professionals commonly use to check for problems with thinking, communication, understanding and memory. The Montreal Cognitive Assessment (MoCA) (233) was designed as a tool for rapid screening of mild cognitive impairment. Cognitive Abilities Screening Instrument (CASI) (234), with a 0 to 100 score range, assesses several cognitive domains: attention and concentration, executive functions, memory, language, visual-constructive skills, abstraction, calculation and orientation. Short portable mental status questionnaire (SPMSQ or Pfeiffer) (235) aims to define the presence and intensity (mild, moderate and severe) of cognitive disturbances of organic origin in elderly patients. Abbreviated Mental Test (AMT) (236) is a quick to use screening test in general hospital usage. The 6-item cognitive impairment test (6-CIT) (237) is a useful dementia screening tool in Primary Care. The Clifton Assessment Procedures for the Elderly (CAPE) (238) evaluates the presence and severity of impairment in mental and behavioural functioning in long-term psychiatric patients. The Clinical Dementia Rating (CDR) (239) is used to quantify the severity of dementia, using a semi-structured interview. Controlled Oral Word Association Test (COWAT) (240) and Isaacs Set Test (IST) (241) are neuropsychological measures of verbal fluency. The Trail Making Test A & B (TMT) (242) assesses spatial planning ability in a visual-motor task. Rey Auditory Verbal Learning Test (RAVLT) (243) measures the immediate memory span and provides an assessment of learning. The clock drawing test (CDT) (244) is a quick screening test for cognitive dysfunction, but it lacks sensitivity for the diagnosis of early or mild dementia. The Brief Cognitive Screening Battery (BCSB) (245) includes MMSE, Verbal Fluency, Clock Drawing and Figure Memory Tests. The Mini-Cog (246) consists of a 3-item recall test for memory and a simply scored clock drawing test. The Telephone Interview for Cognitive Status (TICS) (247) is designed to be administered over the telephone. The Community Screening Interview for Dementia (CSID) (248) consists of a cognitive test and an interview on performance in everyday living. **Table 9** shows cognitive decline assessment tools scores.

	used on older adults living at home	validation	number of items	specificity	ease of use	usability by different professionals
Mini Mental State Examination (MMSE)	3	3	3	3	2	2
Modified Mini Mental State Examination (3MS)	3	3	3	3	2	2
Montreal Cognitive Assessment (MoCA)	3	3	3	3	2	2
Cognitive Abilities Screening Instrument (CASI)	3	3	2	3	2	2
Short portable mental status questionnaire (SPMSQ or Pfeiffer)	3	3	3	2	3	3
Abbreviated Mental Test (AMT)	3	3	3	2	3	3
6-item cognitive impairment test (6-CIT)	3	3	2	2	3	3
Clifton Assessment Procedures for the Elderly (CAPE)	3	3	2	3	2	2
Clinical Dementia Rating scale (CDR)	3	3	2	2	3	2
Controlled Oral Word Association Test (COWAT)	3	3	2	2	1	2
Isaac Set Test (IST)	3	3	2	2	1	2
Trail Making Test A & B (TMT)	2	3	2	1	1	1
Rey Auditory Verbal Learning Test (RAVLT)	2	3	2	1	1	1
Clock drawing test (CDT)	3	3	2	3	3	3
Brief Cognitive Screening Battery (BCSB)	2	3	2	3	2	1
Mini-cog	3	3	3	2	3	3
Telephone Interview for Cognitive status (TICS)	3	3	2	3	3	3
Cognitive screening instrument for dementia (CSID)	3	3	2	3	3	3

Table 9 *Cognitive decline assessment tools scores.*

4.1.7. Loneliness

We included for review 15 papers (**Figure 19**) and we extracted 9 tools aimed to assess loneliness in older adults (**Supplementary Materials – Table S6**).

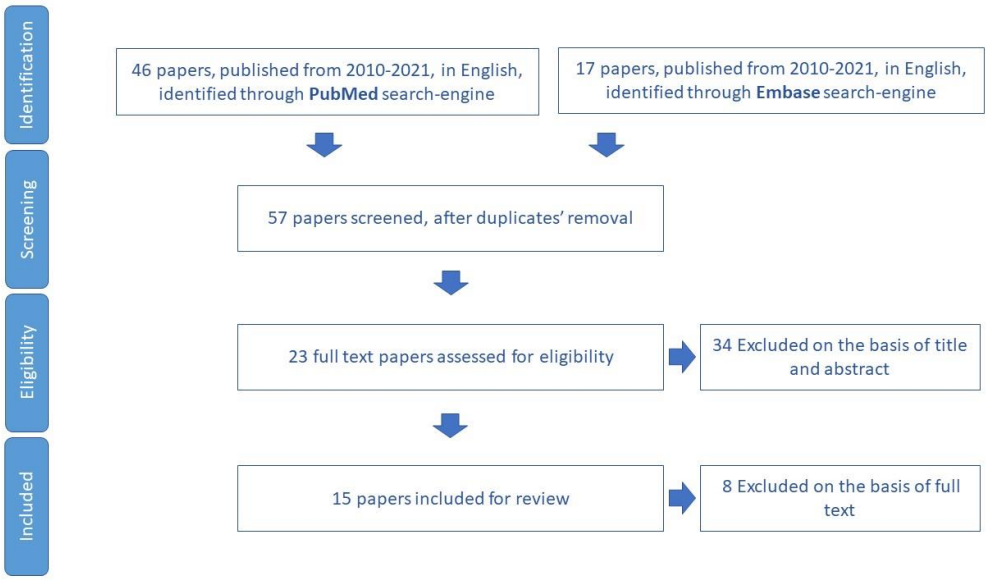

Figure 19 *Process of study selection for the assessment of loneliness*

The UCLA Loneliness Scale (249) and the De Jong Gierveld scale (250) are the most common tools to measure subjective feelings of loneliness as well as feelings of social isolation in older adults. Three-Item Loneliness Scale (251) is an interviewer-administered questionnaire developed from the Revised UCLA Loneliness Scale. The Questionnaire to define Social Frailty Status (QSFS) (252) aims to evaluate the state of social frailty through simple questions on daily social activity, social role and social relationships. The Social Frailty Index (SFI) (253) assesses through self-reported survey questionnaires living alone, no education, absence of a confident, infrequent contact, infrequent social activities, financial difficulty and socioeconomic depravation. The Steptoe Social Isolation Index (254) measures family status, monthly contacts with children, family and friends and participation in social groups. The 11-items Duke Social Support Index (255) includes subscales for social interaction and subjective support. **Table 10** shows loneliness assessment tools scores.

	use on older adults living at home	validation	number of items	specificity	ease of use	usability by different professionals
The UCLA Loneliness Scale	3	3	3	3	2	2
The De Jong Gierveld scale	3	3	3	3	2	2
Three-Item Loneliness Scale	3	3	3	3	3	2
The Questionnaire to define Social Frailty Status (QSFS)	3	1	3	2	3	3
The Social Frailty Index (SFI)	3	1	3	2	2	3
The Steptoe Social Isolation Index	3	3	3	3	2	3
The 11-items Duke Social Support Index	3	3	3	3	2	2

Table 10 *Loneliness assessment tools scores.*

4.1.8. Social support

We included for review 5 papers (**Figure 20**) and we extracted 15 tools to assess social support network (**Supplementary Materials – Table S7**).

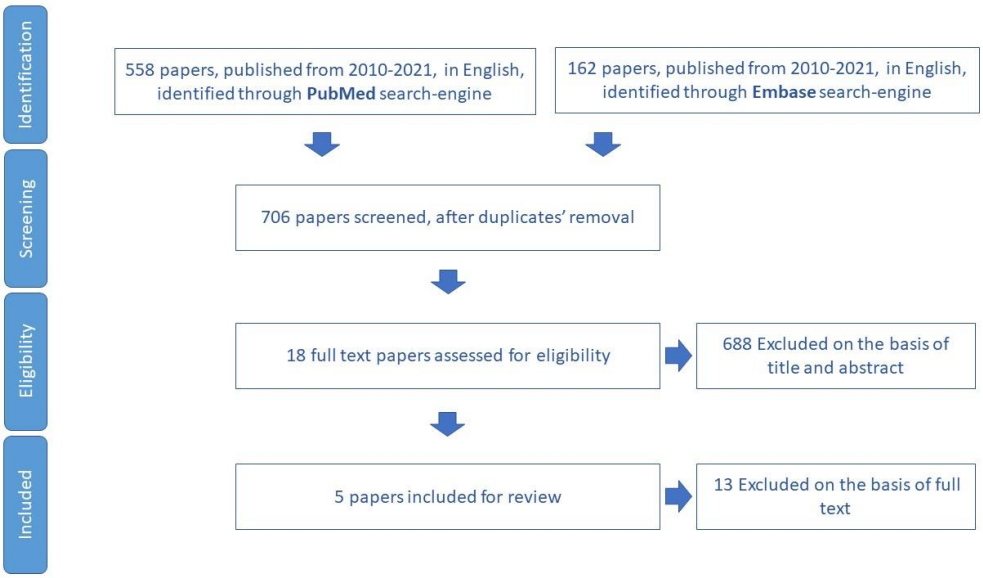

Figure 20 *Process of study selection for social support domain*

The UCLA Loneliness Scale (249) and the De Jong Gierveld scale (250) are also very much used to assess the older adult's support network and the presence of people who can take care of him/her in case of need. The Older Americans Resources and Services Program (OARS) Multidimensional Functional Assessment of Older Adults (MFAQ) (256) allows to stratify older adults population in area of social resources. The Inventory of Social Supportive Behaviors (ISSB) (257) assesses how often individuals received various forms of assistance during the preceding month. The Social Provision Scale (148) contains four subscales for each of the four social dispositions: attachment, social integration, material help and value reassurance. The social support behaviors (SS-B) scale (258) and Medical Outcome Study Social Support Survey (MOS-SSS) (259) assess supportive behavior available from family and from friends in terms of emotional support, socializing, practical assistance, financial assistance, and advice/guidance. The Duke Social Support Index (255) assesses older adult's social interaction and his/her satisfaction. The Multidimensional Scale of Perceived Social Support (260) and the Lubben Social Network Scale (261) measure the perceived adequacy of social support from three sources: family, friends, and significant other. The Berkman-Syme Social Network Index (262) allows researchers to categorize individuals into four levels of social connection: socially isolated, moderately isolated, moderately integrated, and socially integrated. The Personal Resource Questionnaire (PRQ) (263) provides descriptive information about the person's resources and measures the respondent's level of perceived social support. The Six social support deficits (264) is a checklist including living alone, seeing a relative less often than once a week, lack of reciprocity with neighbors, lack of reciprocity between extended family members, relationship difficulty with one or more relatives, and dissatisfaction with support from family. 2-Way Social Support Scale (265) assesses emotional support and instrumental support, given and received. Philadelphia Geriatric Center Morale Scale (PGCMS) (266) lonely dissatisfaction subscale represents the older person's acceptance or dissatisfaction with the amount of social interaction they are presently experiencing. **Table 11** shows support network assessment tools scores.

	use on older adults living at home	validation	number of items	specificity	ease of use	usability by different professionals
UCLA Loneliness Scale	3	3	3	3	2	2
De Jong Gierveld scale	3	3	3	3	2	2
Older Americans Resources and Services Program (OARS) Multidimensional Functional Assessment of Older Adults (MFAQ)	3	3	2	3	3	3
Inventory of Social Supportive Behaviors (ISSB)	3	2	1	3	3	3
Social Provision Scale	3	3	3	3	3	3
social support behaviors (SS-B) scale	2	3	1	2	2	3
Medical Outcome Study Social Support Survey (MOS-SSS)	3	3	3	3	3	3
Duke Social Support Index	3	3	3	3	2	2
Multidimensional Scale of Perceived Social Support	3	2	3	2	3	3
Lubben Social Network Scale	3	2	3	3	3	3
Berkman-Syme Social Network Index	3	3	3	3	3	3
Personal Resource Questionnaire (PRQ)	2	3	3	3	3	3
Six social support deficits	3	3	3	2	3	3
2-Way Social Support Scale	1	3	2	3	3	3
Philadelphia Geriatric Center Morale Scale (PGCMS)	2	3	2	3	2	3

Table 11 *Support network assessment tools scores*

4.1.9. Economic conditions

The search for reviews, systematic reviews and meta-analyses on the assessment of the economic conditions of community-dwelling older people did not yield any results. The reason is that this domain belongs to a research field more related to the social sciences than to medicine and healthcare service organization.

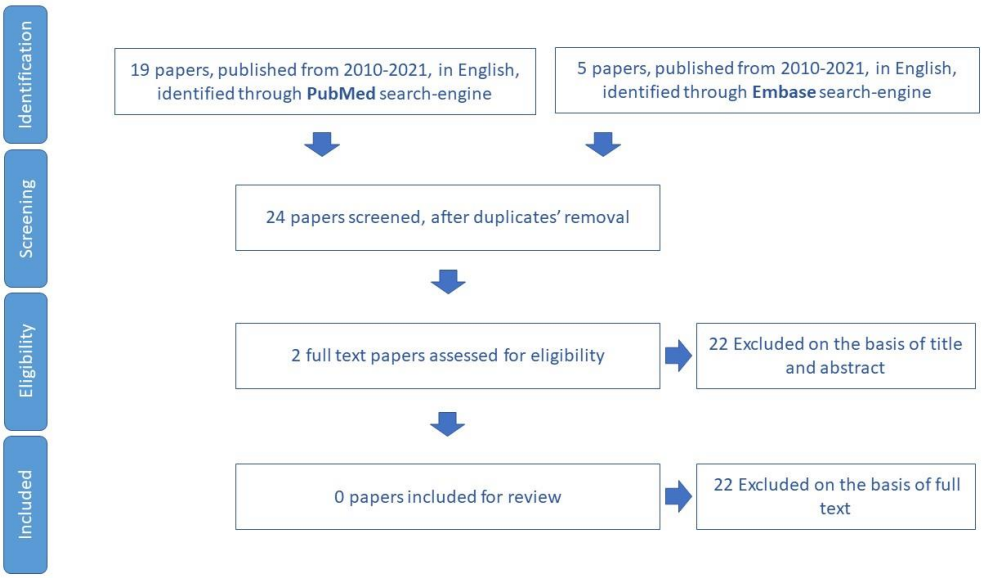

Figure 21 *Process of study selection for assessment of economic constraints*

The side-search allowed to identify two tools that can be used to assess economic conditions of older adults. Tarasenko & Schoenberg, 2017 (149) adopted a self-perceived income sufficiency questionnaire to assess resources in an underserved population. The Subjective Status Scale of Adler et al., 2000 (267) measures self-rated socio-economic status by means of a 10-step scale whose extremes represent people who are better off - those who have more money, more education and the most respected jobs - and those who are worse off - people who have less money, less education and fewer or no respected jobs.

4.2.SUNFRAIL+ Study preliminary results

A pilot study was conducted to evaluate how the technology can support professionals in screening for frailty in community-dwelling older adults. The study aims to assess the impact of early, integrated and simultaneous "taking care" by health systems on the quality of life of community-dwelling older adults through the SUNFRAIL+ platform. The study is still underway in 8 centers coordinated by the Department of Public Health of Federico II University. A total of 113 older adults were enrolled in the study at the Federico II University Hospital (FIIUH) (**Table 12**).

N.	**<75**	**76-85**	**>85**
113 **(F=68; 60.2%)**	73 (64.6%) (F=45; 61.6%)	38 (33.6%) (F=22; 57.9%)	3 (2.6%) (F=1; 33.3%)

Table 12 *FIIUH Enrolled older adults distribution by age and sex*

Approximately 90% of the enrolled subjects have at least one frailty risk factor collected through the SUNFRAIL tool (**Table 13**).

SUNFRAIL alerts	Older adults	%
0	12	10.6%
1	25	22.1%
2	31	27.4%
3	26	23.0%
4	8	7.1%
5	8	7.1%
6	3	2.6%
7	0	0%
8	0	0%

Table 13 *FIIUH enrolled older adults distribution by number of alerts at baseline*

The preliminary results of the study showed that the most frequent risk factor is polypharmacy (47.8%), followed by a sedentary lifestyle (37.1%) and memory loss (32.7%) (**Table 14**).

SUNFRAIL alert	Older Adults	%
No risk factors	12	10.6%
Polypharmacy	54	47.8%
Weight loss	9	7.9%
Reduction in physical activity	42	37.1%
Adherence to medical visits	32	28.3%
Falls	25	22.1%
Memory loss	37	32.7%
Loneliness	28	24.7%
Support network	12	10.6%
Socio-economic conditions	16	14.1%

Table 14 *FIIUH enrolled older adults distribution by type of alerts at baseline*

4.2.1. Polypharmacy

Out of n=29 subjects who presented a risk factor for polypharmacy, only n=7 older adults (24.1%) confirmed that they were not adhering to pharmacological therapies through the SAT scale (**Table 15**)

N. older adults	Adhering to therapies	Not adhering to therapies
29	7 (24.1%)	22 (75.9%)

Table 15 *FIIUH older adults SAT score at baseline*

4.2.2. Nutrition

N=7 subjects who presented a risk factor for malnutrition through SUNFRAIL underwent nutritional screening (MNA) and Mediterranean diet adherence questionnaire (PREDIMED). It was confirmed that n=4 (57.1%) were at risk of malnutrition through MNA and n=1 (14.2%) was found to be malnourished. Results on adherence to the Mediterranean diet showed that n=6 (87.7%) older adults were moderately adherent and n=1 poorly adherent. No one presents good adherence to Mediterranean diet (**Table 16**).

N. older adults	Mini Nutritional Assessment Score			PREDIMED score		
	12-14 points: normal nutritional status	8-11 points: at risk of malnutrition	0-7 points: malnourished	≥10 Good adherence	6–9 medium adherence	≤5 Poor adherence
7	2 (28.5%)	4 (57.1%)	1 (14.2%)	0 (0%)	6 (87.7%)	1 (14.2%)

Table 16 *MNA and PREDIMED score at baseline*

4.2.3. Adherence to medical visits

N=21 older adults completed the questionnaire on adherence to medical visits. N=5 older adults (23.8%) have difficulty making an appointment with their GP. N=8 older adults (38%) have transport difficulties to reach their GP's office. Only n=6 older adults (28.5%) in the last three months went to their GP at least once. Only n=2 older adults (9%) have had hospital admissions or emergency room access in the last 3 months. Both did not contact their GP following hospitalization. N=17 older adults (80%) have had specialist visits, blood tests or other diagnostic tests in the last 3 months. Of these, only n=7 (41.1%) contacted their GP following specialist visits and/or diagnostic tests (**Table 17**).

N. Older adults	Older adult has difficulty making an appointment with his GP	Older adult has transport difficulties to reach his/her GP's office	In the last three months, older adult has visited his/her GP at least once	In the last three months, older adult has gone to the nursing clinic or received home nursing visits	In the last 3 months, older adult has undergone hospital admissions	Following hospital admission, older adult contacted his/her GP	Older adult has visited the emergency room in the last 3 months	Following access to the emergency room, older adult contacted his/her GP	Older adult had specialist visits, blood tests or other diagnostic tests in the last 3 months	Following specialist visits and/or diagnostic tests, older adult contacted his/her GP
N=21	5 (23.8%)	8 (38%)	6 (28.5%)	0 (0%)	2 (9.5%)	0 (0%)	1 (4.7%)	0 (0%)	17 (80.9 %)	7 (41.1%)

Table 17 *Questionnaire on adherence to medical visit score at baseline*

4.2.4. Fall risk

N=21 older adults took the Timed Up and Go (TUG) Test. According to the interpretation of Podsiadlo & Richardson (268), n=3 have normal mobility. N=18 have good mobility which allows them to go out alone and move without walking aid. N=4, despite having good mobility, are at high risk of falling.

N. older adults	**≤10 seconds=normal**	**>10 - ≤20 seconds = good mobility**	**>20 - ≤30 seconds = mobility problems**	**>30 seconds = high risk of falls**
N=21	3 (14.2%)	18 (85.8%)	0 (0%)	4 (19%)

Table 18 *Timed Up and Go Test score at baseline*

Older adults also completed the AFEAT questionnaire. The tool does not have a final score but provides qualitative information on the older adult's living environment. Further analyses are underway to verify any correlations between the TUG and specific characteristics of the older adult's living environment.

4.2.5. Physical activity

SPPB scores range from zero to 12 possible points. The lower score corresponds to a worse physical performance of the older adult. N=37 older adults performed the SPPB in the SUNFRAIL+ Study. Of these, n=3 have very low physical performance. N=8 have low physical performance. N=23 present good physical performance. N=3 have a high physical performance.

N. older adults	very low physical performance (score 0–3)	low physical performance (score 4–6)	intermediate physical performance (score 7–9)	high physical performance (score 10–12)
N=37	3 (8.1%)	8 (21.6%)	23 (62.1%)	3 (8.1%)

Table 19 *SPPB score at baseline*

4.2.6. Loneliness

N=23 older adults completed the Geriatric Depression Scale (GDS) questionnaire. N=10 older adults presented a probable depression.

N. older adults	10–15 Points: Probable depression	6–9 Points: Possible Depression	0–5 Points: Improbable Depression
N=23	10 (43.4%)	7 (30.4%)	6 (26.0%)

Table 20 *GDS score at baseline*

4.2.7. Cognitive Decline

The tools identified by the SUNFRAIL+ study for the assessment of cognitive decline are GPCog and QMCI. In the GPCog scale, if patient scores 9 no significant cognitive impairment and further testing are not necessary. If patient scores 5-8, more information are required. If patient scores 0-4, cognitive impairment is indicated. N=31 older adults completed GPCog scale. N=7 older adults presents no significant cognitive impairment. N=18 older adults request further investigation. N=6 older adults present cognitive impairment.

N. older adults	9 Points: no significant cognitive impairment	5-8 Points: more information required	0-4 Points: cognitive impairment
N=31	7 (22.5%)	18 (58%)	6 (19.3%)

Table 21 *GPCog score at baseline*

In the QMCI scale, mild cognitive impairment is suggested if the score is <62/100 but requires adjustment for age and education. N=24 older adults present mild cognitive impairment. Further analysis of data are requested to adjust the score for age and education.

N. older adults	<62/100	≥62/100
N=31	24 (77.4%)	7 (22.6%)

Table 22 *QMCI score at baseline*

4.2.8. Social support

N=9 older adults completed the Social Provision Scale (SPS) questionnaire. The tool does not have a final score but provides qualitative information on the older adult's social network. Further analyses are underway to verify any correlations between the SPS and specific characteristics of the older adult's social network.

4.2.9. Economic conditions

N=11 older adults completed the modified self-perceived income sufficiency questionnaire (MUSE). The tool does not have a final score but provides qualitative information on the older adult's economic conditions. Further analyses are underway to verify any correlations between the MUSE and specific characteristics of the older adult's socio-economic conditions.

5. Discussion

The study aims to contribute to the implementation and validation of a multi-professional and multi-stakeholder service model for the screening of frailty in community-dwelling older adults, using an IT tool to support the healthcare system and/or social care professional at evaluating the domains of compromised bio-psycho-social frailty and allowing the development of integrated intervention strategies.

5.1 Implications for practice

The approach responds to the consolidated need to early identify risk conditions that lead to the progressive loss of autonomy in order to reduce the impact of health conditions that require a strong commitment of socioeconomic resources to guarantee adequate care and cure. In the general evolution of health care system, that are undergoing a paradigmatic shift from reactive disease management towards a proactive, person-centred approach to health service provision, the knowledge emerging around the tools dedicated to the early identification of frailty play a key role.

The study has an expected impact on the quality of life of older adults and on the improvement of health outcomes in frailty risk factors, deriving from participation in collective and individual prevention and health promotion services, such as adapted physical activity programmes, primary services and secondary nutritional interventions, fall prevention, adherence to pharmacological therapies and medical visits, socialization and psychological support. The adoption of digital solutions is crucial for the continuous improvement of diagnosis, treatment, and personalization of care (69, 269).

The preliminary results of the SUNFRAIL+ study showed that the most frequent risk factors are polypharmacy (47.8%), sedentary lifestyle (37.1%) and memory loss (32.7%). These results confirm a situation found globally, where 31% of the population is not sufficiently active (270) and insufficient physical activity is one of the main risk factors for death worldwide (271). Physical activity has significant health benefits and helps prevent and manage non-communicable diseases (272). Regular exercise can improve physical performance

and quality of life, but also reduce the risks of falls and depressive symptoms and reduce the likelihood of cognitive decline in older adults (273, 274). Hence the growing need for effective and sustainable interventions capable of providing opportunities for physical, psychological and cognitive stimulation, as well as motivation for older adults (275). Using SUNFRAIL+, social and healthcare workers are supported and motivated to incentivize and/or activate care interventions, aimed mainly at improve NCDs self-management and medication adherence, preventing falls and cognitive decline and combating social and psychological distress. A promising digital tool to improve physical and cognitive functioning is immersive virtual reality (VR), an user-computer interface involving real-time stimulation and interactions of an embedded subject through multiple sensorial channels, based on a synthetic environment in which the subject feels his presence (276). Serious games (SG) are interactive, entertaining and engaging form of exercise, providing therapeutic applications of VR for balance recovery and functional mobility (277). Evidence suggests VR and SG are an efficacious rehabilitation method of persons post-stroke and in persons with other neurological disorders, such as Multiple Sclerosis patients (278). SG can improve cognitive and physical functions on the basis of increased sensorial flow physical effort (279).

A potential intervention in the frailty risk domains prevalent in the SUNFRAIL+ study population could be provided by solutions from the "VR2Care - 3D Community Aware Virtual Spaces as Smart Living Environments for Physical Activity and Rehabilitation" project, co-financed by the European Union's Horizon 2020 framework programme, which aims to develop and test VR solutions enabling immersive multi-user experiences for physical activity and rehabilitation service provision for older adults (280). The project consortium developed a system of systems that combines 4 existing solutions, into a single integrated one:

- REHABILITY system combines physical with cognitive stimulation offering a range of serious games for functional exercises that patients can easily lead back to realistic tasks, so that also older people and fragile patients understand the usefulness of what they are doing while enjoying the gamified setting (281,282).
- 3D Multiuser Environment (MUE) provides immersive environments for physical exercise that can be scheduled One-to-one, for private and more controlled physical exercise between the patient and the trainer, or One-to-many for groups to practice physical exercise with the support of a coach/trainer (283);
- SmartAL is a telemonitoring system that allows healthcare providers and patients to define and execute daily monitoring plans, including sending notifications for taking medications (284);
- cogvisAI is a Motion Capture and Metrics tool that detects falls, obstacles, movement and position while preserving patient privacy (285,286).

SUNFRAIL+ will improve the availability of data on the target population for health and social workers, allowing them to develop targeted prevention and health promotion interventions in the sectors identified as at risk, using the resources of the community in which the older adults lives, use mobile health tools (and

platforms), environmental sensors and other technologies to extend independent living and improve the quality of life of people and their families (287).

In many EU Member States, public health data on frailty are collected in national or regional databases and some of these are based on self-assessments by citizens (288) rather than quantitative data collected during structured screening programmes. The main focus of the available national epidemiological data concerns deficit and disability. In Italy, the “Passi d'Argento” surveillance system takes into consideration some aspects of health and disease, collecting information, through a questionnaire, directly from people selected with random sampling (289). This low rate of screening programs in Europe, leaves Member States and the European Commission (EC) with little understanding of the clinical characteristics and functional capabilities of older citizens, before they incur disability. This hinders the development of a solid concept of prevention of frailty and monitoring of functionality and its dynamics which represents the main obstacle to the development of holistic, permanent and integrated approaches for the management of frailty in public health in Europe. Approaches such as SUNFRAIL+ improve the availability of health data on older adults, allowing citizens to be followed longitudinally across care settings (hospital, local social and healthcare services and the community) and will therefore allow the identification of the dynamics of medical, functional and social needs in a very early stage of deterioration. Consequently, an informed and integrated intervention will improve the independent living of older adults, helping them to play an active role in society (69, 109).

5.2 Limitations

The SUNFRAIL+ approach aims to connect additional scales to the SUNFRAIL multidimensional frailty screening tool for a more in-depth assessment in the frailty domain recognized as at risk. To be effectively used for frailty screening and implementation of prevention interventions in community-dwelling older adults, the assessment tools to be linked to SUNFRAIL should be aimed at identifying risk factors that may lead to the impairment of one or more than the domains of frailty. The SUNFRAIL+ study did not perform a comparative analysis on the specificity and sensitivity of the assessment tools used in each of the domains. Rather, the research group focused on the validity of the general approach, which does not preclude the replacement of individual tools with more performing ones in the future.

The present study limited the literature review on frailty risk factor assessment tools to reviews, systematic reviews and meta-analyses. This did not allow the most recent tools to be included in the results. As in the case of the Quick Mild Cognitive Impairment (QMCI) Screen for the evaluation of mild cognitive decline, it is particularly useful for dementia prevention interventions (145), which was then included in the SUNFRAIL+ protocol. In the polypharmacy domain, the most often used medication review support tools for the older adults require specialized skills and therefore cannot be managed by non-medical personnel. Therefore, in a community-based frailty screening and prevention model, such as SUNFRAIL, interventions should focus on adherence to drug therapies, and assessment tools should measure the older adult 's ability to self-care and

manage chronic diseases. For this reason, the SAT scale was included in the SUNFRAIL+ study protocol. It is a very simple 4-question instrument that allows to verify adherence to therapies.

The participation of several centres in the pilot study, providing different services but all interacting with the target population along the SUNFRAIL specific domains, will make it possible to demonstrate that the identification of frailty risk factors in older adults and their enrolment in prevention and health promotion services should not only take place in a dedicated healthcare facility but in different settings (community, social and health service facilities) and at different levels of care.

Although the different intervention strategies of the centres involved in SUNFRAIL+ do not allow the study to be able to investigate the effectiveness of prevention and health promotion interventions in addressing frailty risk factors, the impact expected from the validation of the SUNFRAIL+ approach derives by deploying a preventive intervention following a multidimensional evaluation on a target population, which is currently taken care of by the NHS only following an adverse event. The exploitation of the study outcomes depends very much on the ability of the centres to link the screening of frailty's risk factors with the services currently available in the participating centres for prevention and health promotion.

6. Conclusion

The study aimed to design and validate a digitally supported frailty screening and prevention intervention in community-dwelling older adults, to integrate the biomedical paradigm of frailty (88) with the "bio-psycho-social" paradigm (89), in order to take into account all the different factors that influence the individual's health towards frailty: environmental, physical, educational, socio-economic and psychological. The study took in consideration SUNFRAIL multidimensional frailty screening tool, which consists of only nine items, to screen for bio-psycho-social frailty risk factors, to generate alerts orienting subsequent diagnostic assessments for health promotion, disease prevention and targeted interventions (125-128). A literature review has been developed to identify further evaluation tools of bio-psycho-social frailty domains. The study selected 178 reviews, published between January 2010 and December 2021. Within the selected articles, 123 assessment tools were identified (polypharmacy 15; malnutrition 15; physical activity 25; medical visits 0; falls 26; cognitive decline 18; loneliness 9; social support 15; economic conditions 0) (133). A new service model for frailty screening of community-dwelling older adults has been developed through the SUNFRAIL+ platform, an IT tool that supports healthcare professionals by linking the items of the SUNFRAIL tool to additional scales aimed at assessing frailty domains and enabling the development of adequate intervention strategies. A national multi-centre observational study protocol has been designed to validate the approach by assessing the impact of early, integrated and multi-professional care on the quality of life of the community-dwelling older adult population and the professional's satisfaction (153). The study is still underway in 8 centers coordinated by the Department of Public Health of Federico II University. 113 older adults were enrolled in the study at the Federico II University Hospital. Approximately 90% of the enrolled subjects have at least one frailty risk factor collected through the SUNFRAIL tool. The study showed that the most frequent risk factor is

polypharmacy (47.8%), followed by a sedentary lifestyle (37.1%) and memory loss (32.7%). The preliminary data from the pilot study revealed that SUNFRAIL+ is able to describe in details an existing frailty; it is simple to use and characterized by a low expenditure of resources which would allow its widespread use throughout the territory, in order to intercept people at risk of frailty. The planned six-month follow-up will provide information on the impact of the model in terms of preventing negative outcomes. This would allow the patient to be guaranteed a better quality of life and at the same time reduce the demand for services paid by the National Health System.

The SUNFRAIL Model and the SUNFRAIL+ digital solution respond to the need to support health professionals in the creation of integrated health and care services through multidisciplinary paths at home or in common aggregation points. The study aspires to provide a model that integrates different health ecosystem services to maximize health and well-being, empowering individuals, families and communities, motivating them to take responsibility for their own health. The study addresses the fragmentation of care services for the older adults (general practitioners, geriatricians, local specialists, rehabilitators, Family and Community Nurses, etc.). Frailty screening by means of the SUNFRAIL+ tool will enable the activation of any subsequent diagnostic tests at the relevant healthcare facilities. Knowledge gaps persist on the business models that can sustain in the medium and long term these approaches: more cost studies evaluating avoided expenses, direct and indirect cost drivers and the like are needed, involving interdisciplinary teams. The ongoing progressive integration of digital technologies into diagnostic-therapeutic pathways is a good starting point and has been driving innovative education and training routes that promise to contribute to open new opportunities for sustainable development. A long way to go still, especially in relation to the use of AI for risk stratification to allow personalized interventions, and to the environmental elements hindering active and healthy ageing. SUNFRAIL+ tool represents a milestone in the evolution of our approach towards frailty and is well suited to drive further research in the framework of the innovation ecosystems at local, national and international levels.

7. Supplementary Materials

	START/STOPP	STOPPFrail	Beers criteria	Norwegian General Practice criteria (NORGEP)	(EU) (7)-PIM list	PRISCUS list	FORTA (Fit fOR The Aged) list	MAI (Medication Appropriateness Index)	STRIP method (Systematic Tool to Reduce Inappropriate Prescribing)	GP-GP (good palliative-geriatric practice)	IMAP (individualised medication assessment and planning program)	Zhan Criteria	Drug Regimen Unassisted Grading Scale (DRUGS)	Medication Management Ability Assessment (MMAA)	Self-Efficacy for Appropriate Medication Use Scale (SEAMS)
Sadowski C.A., et al. 2021 (290)	X														
Saeed D., et al. 2021 (291)	X	X													
Amorim W.W., et al. 2021 (292)	X		X	X	X	X									
Loste C., et al. 2021 (293)	X		X												
Pazan F., et al. 2021 (294)	X		X				X								
De Oliveira L.M., et al. 2021 (295)			X												
Williams S., et al. 2019 (296)	X		X				X								
Muth C., et al. 2019 (297)	X		X		X		X	X	X						
Kok R.M., et al. 2017 (298)	X														
Huiskes V.J., et al. 2017 (299)	X							X							
Ulley J., et al. 2019 (300)	X		X								X				
Storms H., et al. 2017 (301)	X		X			X		X							
Mohamed M.R., et al. 2020 (302)	X							X				X			
Cross A.J., et al. 2020 (303)													X	X	X
Palmer K., et al. 2019 (304)	X						X								
Muhlack D.C., et al. 2017 (305)			X												
Hasan Ibrahim A.S., et al. 2021 (306)	X									X					
Kua C.H., et al. 2019 (307)	X		X												
Ibrahim K., et al. 2021 (308)	X	X	X												
Chang C.T., et al. 2021 (309)	X		X												
	17	**2**	**12**	**1**	**2**	**2**	**4**	**4**	**1**	**1**	**1**	**1**	**1**	**1**	**1**

Table S1 *Assessment tools of prescription appropriateness and adherence in older adults' population*

	PREDIMED	10-point Mediterranean-diet scale	Mini Nutritional Assessment (MNA)	Mini Nutrition Assessment Short Form (MNA-SF)	Canadian Nutrition Screening Tool (CNST)	Council on Nutrition Appetite Questionnaire (CNAQ)	DETERMINE Checklist	Malnutrition Screening Tool (MST)	Malnutrition Universal Screening Tool (MUST)	SCALES (Sadness, Cholesterol, Albumin, Loss of weight, Eating, Shopping) questionnaire	Seniors in the Community Risk Evaluation for Eating and Nutrition questionnaire (SCREEN I) or (SCREEN II)	Simplified Nutritional Appetie Questionnaire (SNAQ)	Nutritional Form for the Elderly (NUFFE)	Chapman Screening tool	Short Nutritional Assessment Questionnaire (SNAQ65+)
Suárez M et al. 2017 (310)	X	X													
Laur CV et al. 2017 (311)			X		X										
Dwyer JT et al. 2020 (312)			X	X		X	X	X	X	X	X	X			
Marshall S. 2016 (313)				X				X	X				X	X	X
Zupo R et al. 2020 (314)				X											
Barchitta M et al. 2020 (315)	X														
Oktaviana J et al. 2020 (316)			X												
Robertson DA et al. 2013 (317)	X														
Cox et al. 2020 (318)												X			
Jadczak AD & Visvanathan R. 2019 (319)															
Fernández-Pombo A et al. 2021 (320)			X						X			X			
Ruiz M & Kamerman LA, 2010 (321)			X				X		X						
Kuzuya M, 2021 (322)			X												
	3	1	6	3	1	1	2	2	4	1	1	3	1	1	1

Table S2*: assessment tools of nutritional habits*

	Giannitsi S. et al. 2019 (323)	Vadalà G. et al. 2020 (324)	Tamulevi ciute-Prasciene E et al. 2018 (325)	Lynch EA et al. 2018 (326)	McGettig an M et al. 2020 (327)	Gordt K et al. 2018 (328)	Jian-Yu E et al. 2020 (329)	Schwenk M et al. 2014 (330)	Albrecht M et al. 2018 (331)	Satler MC et al.
6-minute walking test (6MWT)	X			X						
SF-36 (physical component scale)		X			X	X				
5-meter walking test (5MWT)			X							
Short Physical Performance Battery (SPPB)					X	X		X		
Physical Activity Scale for the Elderly (PASE)						X	X			X
Community Healthy Activities Model Program for Seniors CHAMPS							X			
Zutphen Physical Activity Questionnaire									X	
Physical Activity and Sedentary Behavior Questionnaire (PASB-Q)										X
EPIC Physical Activity Questionnaire (EPAQ2)										X
International Physical Activity Questionnaire (IPAQ)										X
Stanford Brief Activity Survey (SBAS)										X
Women’s Health Initiative Physical Activity Questionnaire (WHI-PAQ)										X
GPPAQ General Practice Physical Activity Questionnaire										X
Longitudinal Aging Study Amsterdam Physical Activity Questionnaire (LAPAQ)										X
PASIPD, Physical Activity Scale for Individuals with Physical Disabilities										
Duke’s activity status index (DASI)										
Incremental Shuttle Walk Test (ISWT)										
WOMAC physical function sub-scale										
5CST, five-chair stand test										
Timed-Up & Go Test										
Four-Square Step test.										
Tinetti Performance Oriented Mobility Assessment (POMA)										
Alternate-step test (ATS)										
Mini Motor Test (MMT)										
Elderly Mobility Scale										

2020 (332)																								
Karpman C & Benzo R., 2014 (333)	X																							
Vialleron T et al. 2020 (334)	X																							
Aquilani R et al. 2014 (335)	X																							
Berner K et al. 2017 (336)				X																				
You Y et al. 2021 (337)	X			X																				
Donini LM et al. 2016 (338)	X																							
Cheng DK et al. 2021 (339)	X			X										X										
Argillander TE et al. 2021 (340)	X			X																				
Qiu S et al. 2015 (341)										X														
Daami M et al. 2017 (342)	X																							
Keating CJ et al. 2021 (343)				X																				
Mehdizadeh D et al. 2021 (344)				X																				
Vavasour G et al. 2021 (345)				X																				
Pu C.Y. et al. 2021 (346)	X																							
Baritello O et al. 2021 (347)	X			X																				
Anabitarte-García F et al. 2021 (348)				X																				
Abou L et al. 2021 (349)	X			X																				
Elena P et al. 2021 (350)				X																				
Mañas A et al. 2021 (351)	X			X	X																			

Yoo J et al. 2021 (352)	X			X												X	X							
Pitsillides A et al. 2021 (353)				X														X						
van der Kruk E et al. 2021 (354)	X			X																				
Williams F.R et al. 2021 (355)	X			X																				
Bortone I et al. 2021 (356)	X			X															X	X				
Inoue T et al. 2021 (357)																				X	X			
Yang F et al. 2021 (358)				X																X				
Gielen E et al. 2021 (359)	X			X																				
Pazan F et al. 2021 (294)				X																X				
Gafner S.C et al. 2021 (360)				X																X		X		
McMillan J.M. et al. 2021 (361)																				X				
Ponciano V et al 2021 (362)																				X				
Lund C.M et al. 2020 (363)	X			X	X																			
Zheng L et al. 2020 (364)				X																X				
Guo Z et al. 2020 (365)																				X				
Byra J & Czernicki K. 2020 (366)	X																							
Zampogna B et al. 2020 (367)	X																	X						
Oktaviana J et al 2020 (316)				X																				
Wang D.X.M et al 2019 (368)	X			X																X		X		
Chen M.Y et al. 2019 (369)	X																							

Pei G et al 2019 (370)	X																							
Bet P et al 2019 (371)	X			X															X		X	X	X	
Granic A. et al. 2019 (372)				X																				
Facal D et al. 2019 (373)				X															X					
Mol A et al. 2018 (374)																			X					
Wright J. et al. 2018 (375)																			X					
Liao C et al. 2018 (376)	X			X	X																X			
Doma K et al. 2018 (377)	X																		X					
Lopez P. et al. 2018 (378)				X															X					
Dewansingh P et al. 2018 (379)	X			X															X					
Luo D et al. 2017 (380)				X															X					
Apóstolo J et al 2017 (381)																			X					
Wouters H et al. 2017 (382)				X															X					
van Deudekom F.J et al. 2017 (383)																			X					
Bahureksa L et al. 2017 (384)																			X					
McDonald V.S et al. 2016 (385)				X															X					
Bullo V et al. 2015 (386)																			X	X				
Furukawa & H., Tanemoto K. 2015 (387)	X																							
McNeely M.E et al 2015 (388)																			X		X			
Hill K.D. et al 2015 (389)					X														X					
Pamoukdjian F et				X															X					

al. 2015 (390)																									
Stehr M.D et al. 2012 (391)		X			X	X																			
Chou C.-H et al. 2012 (392)		X																	X					X	
Lee P et al. 2012 (393)				X		X																			
Den Ouden M.E.M et al. 2011 (394)																					X				
	33	5	1	40	8	3	1	1	1	2	1	1	1	1	1	1	1	2	1	30	2	6	1	1	1

Table S3*: assessment tools of physical activity*

	Choi SD et al. 2017 (395)	Kendrick D et al. 2014 (396)	Papalia GF et al. 2020 (396)	De Coninck L et al. 2017 (398)	Nunan S et al. 2018 (399)	Kumar A et al. 2016 (400)	Bullo V et al. 2020 (401)	Zhang J et al. 2020 (404)	Liau SJ et al. 2021 (403)	Strini V et al. 2021 (405)
Falls Efficacy Scale (FES)	X	X	X	X		X				
Modified Falls Efficacy Scale (MFES)		X								
Activities-specific Balance Confidence scale (ABC)		X	X	X		X				X
Survey of Activities and Fear of Falling in the Elderly (SAFE)		X				X				
Fall risk assessment tool (FRAT)					X					
Mobility Efficacy Scale (MES)						X				
Short Falls Efficacy Scale-International (FES-I)							X			X
University of Illinois at Chicago Fear of Falling Measure							X			
Fall Risk Index										
Fracture Risk Assessment Tool (FRAX)								X		
Tinetti Performance-Oriented Mobility Assessment (POMA)										X
Berg Balance Scale										X
Morse Fall Scale										X
Downton Fall Risk Index										X
St. Thomas Risk Assessment Tool in Falling in Elderly Inpatients										X
Conley Scale										X
Falls Risk for Older Persons-Community Setting Screening Tool										X
Johns Hopkins Fall Risk Assessment Tool (JHFRAT)										X
Fullerton Advanced Balance (FAB) Scale										X
Hendrich II Fall Risk Model										X
Austin Health Falls Risk Screening Tool (AHFRST)										X
Elderly Falls Screening Tool										
Home-Screen Scale										
Safety House Checklist										
Falls Risk for Hospitalized Older People (FRHOP)										
Falls Risk Awareness Questionnaire (FRAQ)										

Zheng L et al. 2020 (406)			X				X																		
Zengin A et al. 2018 (407)																						X			
Lee J et al. 2013 (408)													X		X										
Romli MH et al. 2017 (409)																							X	X	
Williams-Roberts H et al. 2020 (410)	X				X						X	X	X		X		X	X		X					X	
Omaña H et al. 2021 (411)											X	X													
Wiseman T & Betihavas V, 2019 (412)	X																								
Vilaca T et al. 2020 (413)										X															
Howcroft J et al. 2013 (414)											X				X										
Ciorba A et al. 2017 (415)			X																						
Lenouvel E et al. 2021 (416)							X																		
Anthony K et al. 2013 (417)	X																								
Aranda-Gallardo M et al 2013 (418)											X		X	X	X	X				X					
Reeve E et al. 2020 (419)							X																		
Wang J et al. 2010 (420)	X	X	X	X																					
Bahat G et al. 2021 (421)										X															
Senderovich											X														

H et al. 2021 (422)																									
Kruisbrink M et al. 2021 (423)	X		X	X			X																		
Lim SER et al. 2021 (424)							X																		
Sattar S et al 2020 (425)																			X						
Kruisbrink M et al. 2021 (426)	X		X	X			X																		
Stockwell-Smith G et al. 2020 (427)																			X						
McMahon S et al. 2012 (428)	X	X	X	X		X																			
Martins Gaspar AG & Lapão LV, 2021 (429)	X											X													
Hill A et al. 2019 (430)	X				X										X				X						X
Lopez P et al. 2018 (431)	X		X																						
Marques-Vieira CMA et al. 2016 (432)							X																		
Visschedijk J et al. 2010 (433)	X		X									X													
	16	3	13	6	3	2	9	1	1	1	6	5	4	2	6	2	2	2	1	6	1	1	1	1	1	1

Table S4*: fall and the risk of falling assessment tools*

	Mini Mental State Examination (MMSE)	Short portable mental status questionnaire (SPMSQ or Pfeiffer)	Abbreviated Mental Test (AMT)	Montreal Cognitive Assessment (MoCA)	Clinical Dementia Rating scale (CDR)	Controlled Oral Word Association Test (COWAT)	Trail Making Test A & B (TMT)	Rey Auditory Verbal Learning Test (RAVLT)	Clock drawing test (CDT)	Isaac Set Test (IST)	Cognitive Abilities Screening Instrument (CASI)	Brief Cognitive Screening Battery (BCSB)	Modified Mini Mental State Examination (3MS)	Clifton Assessment Procedures for the Elderly (CAPE)	Telephone Interview for Cognitive status (TICS)	Cognitive screening instrument for dementia (CSID)	6-item cognitive impairment test (6-CIT)	Mini-cog
Caçador C et al., 2021 (434)	X	X																
van Aalst FM et al., 2020 (435)			X	X														
Facal D et al., 2019 (436)	X			X	X	X	X	X	X									
Borges MK et al., 2019 (437)	X			X	X					X	X							
Panza F et al., 2018 (438)	X			X	X													
van Deudekom FJ et al., 2017 (439)	X																	
Panza F et al., 2014 (440)	X	X								X		X	X					
Robertson DA et al., 2013 (317)	X	X								X		X	X					
Gracie TJ et al., 2021 (441)	X			X														
Zheng L et al., 2020 (442)	X			X	X					X								
Vella Azzopardi R et al., 2018 (443)	X	X												X	X	X	X	X
van Deudekom FJ et al., 2017 (444)	X																	
	11	4	1	6	4	1	1	1	1	4	1	2	2	1	1	1	1	1

Table S5*: assessment tools for cognitive function*

	UCLA Loneliness scale	De Jong Gierveld scale	Three Item Loneliness Scale	Social Frailty Index (SFI)	Questionnaire to define Social Frailty Status (QSFS)	Chicago Social Activity Scale	Life Space Index (LSI)	Steptoe Social Isolation Index	11-items Duke Social Support Index
Courtin E, Knapp M. 2017 (445)	X	X							
Cohen-Mansfield J. et al. 2015 (446)	X	X							
Li J et al. 2018 (447)	X								
Smith KJ, & Victor C, 2021 (448)	X	X							
van der Aa H.P. et al. 2016 (449)	X								
McClelland H. et al. 2020 (450)	X	X							
Noone C. et al. 2020 (451)	X								
Chawla K et al. 2021 (452)	X	X	X						
Casanova G. et a. 2021 (453)	X	X							
Ellis S. et al. 2021 (454)	X	X							
Krzeczkowska A. et al. 2021 (455)	X								
Bessa B, et al. 2018 (456)				X	X				
Landeiro F, et al. 2017 (457)	X	X							X
Tong F. et al. 2021 (458)	X	X				X	X	X	
Dahlberg L. et al. 2020 (459)	X	X							
	16	11	1	1	1	1	1	1	

Table S6: *loneliness assessment tools*

	UCLA Loneliness Scale	OARS Multidimensional Functional Assessment of Older Adults (MFAQ)	Inventory of Socially Supportive Behaviours (ISSB)	Social support behaviors (SS-B) scale	Multidimensional Scale of Perceived Social Support	Berkman-Syme Social Network Index (SNI)	De Jong Gierveld Scale	Social Provisions Scale	Personal Resource Questionnaire (PRQ)	Lubben Social Network Scale	Duke Social Support Index (DSSI)	Medical Outcome Study Social Support Survey (MOS-SSS)	Six social support deficits	2-Way Social Support Scale	Philadelphia Geriatric Center Morale Scale (PGCMS)
Lem K et al 2021 (460)	X	X	X	X	X	X	X	X	X						
Casanova G et al 2021 (453)	X						X	X		X					
Cappelli M et al 2020 (461)	X	X				X									
Tengku Mohd TAM et al 2019 (462)		X			X				X	X	X	X	X	X	
Cohen-Mansfield J et al 2015 (446)	X	X					X								X
	4	4	1	1	2	2	3	2	2	2		1	1	1	1

Table S7*: assessment tools for social support network*

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