# Healthcare Recommendations from the Personalised ICT Supported Service for Independent Living and Active Ageing (PERSSILAA) Study

Rónán O'Caoimh[1,2,3], D. William Molloy[1,2], Carol Fitzgerald[1], Lex Van Velsen[4,5], Miriam Cabrita[4,5], Mohammad Hossein Nassabi[5], Frederiek de Vette[5], Marit Dekker-van Weering[4], Stephanie Jansen-Kosterink[4], Wander Kenter[4], Sanne Frazer[4], Amélia P. Rauter[6], Antónia Turkman[6], Marília Antunes[6], Feridun Turkman[6], Marta S. Silva[6], Alice Martins[6], Helena S. Costa[7,8], Tânia Gonçalves Albuquerque[7,8], António Ferreira[6], Mario Scherillo[9], Vincenzo De Luca[10], Maddalena Illario[10], Alejandro García-Rudolph[11], Rocío Sanchez-Carrion[11], Javier Solana Sánchez[12,13], Enrique J. Gomez Aguilera[12,13], Hermie Hermens[4,5] and Miriam Vollenbroek-Hutten [4,5]

[1]*Centre for Gerontology and Rehabilitation, University College Cork, St Finbarrs Hospital, Cork City, Ireland*
[2]*COLLaboration on AGEing, University College Cork, Cork City, Ireland*
[3]*Health Research Board, Clinical Research Facility Galway, National University of Ireland, Galway, Ireland*
[4]*Roessingh Research and Development, Enschede, Netherlands*
[5]*University of Twente, Enschede, Netherlands*
[6]*Fundação da Faculdade de Ciências da Universidade de Lisboa, Lisboa, Portugal*
[7]*Instituto Nacional de Saúde Doutor Ricardo Jorge, IP, Lisboa, Portugal*
[8]*REQUIMTE/LAQV, Faculdade de Farmácia da Universidade do Porto, Porto, Portugal*
[9]*Nexera Centro Direzionale Isola, Napoli, Italy*
[10]*Federico II University Hospital, Napoli, Italy*
[11]*Institut Guttmann, Institut Universitari de Neurorehabilitació adscrit a la UAB, Badalona, Barcelona, Spain*
[12]*Biomedical Engineering and Telemedicine Center. ETSI Telecomunicacion. Centre for Biomedical Technology, Universidad Politécnica de Madrid, Madrid, Spain*
[13]*Centro de Investigación Biomédica en Red, Biomateriales y Nanomedicina (CIBER-BBN), Zaragoza, Spain*

SCIENCE AND TECHNOLOGY PUBLICATIONS

Keywords: Frailty, Pre-frailty, Information and Communication Technology, Clinical, Healthcare Recommendations, Guidelines.

Abstract: In the face of demographic ageing European healthcare providers and policy makers are recognising an increasing prevalence of frail, community-dwelling older adults, prone to adverse healthcare outcomes. Pre-frailty, before onset of functional decline, is suggested to be reversible but interventions targeting this risk syndrome are limited. No consensus on the definition, diagnosis or management of pre-frailty exists. The PERsonalised ICT Supported Service for Independent Living and Active Ageing (PERSSILAA) project (2013-2016 under Framework Programme 7, grant #610359) developed a comprehensive Information and Communication Technologies (ICT) supported platform to screen, assess, manage and monitor pre-frail community-dwelling older adults in order to address pre-frailty and promote active and healthy ageing. PERSSILAA, a multi-domain ICT service, targets three pre-frailty: nutrition, cognition and physical function. The project produced 42 recommendations across clinical (screening, monitoring and managing of pre-frail older adults) technical (ICT-based innovations) and societal (health literacy in older adults, guidance to healthcare professional, patients, caregivers and policy makers) areas. This paper describes the 25 healthcare related recommendations of PERSSILAA, exploring how they could be used in the development of future European guidelines on the screening and prevention of frailty.



O'Caoimh, R., Molloy, D., Fitzgerald, C., Velsen, L., Cabrita, M., Nassabi, M., Vette, F., Weering, M., Jansen-Kosterink, S., Kenter, W., Frazer, S., Rauter, A., Turkman, A., Antunes, M., Turkman, F., Silva, M., Martins, A., Costa, H., Albuquerque, T., Ferreira, A., Scherillo, M., Luca, V., Illario, M., García-Rudolph, A., Sanchez-Carrion, R., Sánchez, J., Aguilera, E., Hermens, H. and Vollenbroek-Hutten, M.
Healthcare Recommendations from the Personalised ICT Supported Service for Independent Living and Active Ageing (PERSSILAA) Study.
DOI: 10.5220/0006331800910103
In *Proceedings of the 3rd International Conference on Information and Communication Technologies for Ageing Well and e-Health (ICT4AWE 2017)*, pages 91-103
ISBN: 978-989-758-251-6
Copyright © 2017 by SCITEPRESS – Science and Technology Publications, Lda. All rights reserved

# 1 BACKGROUND

With demographic ageing the number of older Europeans, aged over 65 years, has increased (Rechel, 2013), resulting in a higher prevalence of frailty (Collard, 2012). Despite the lack of an accepted definition most experts consider frailty to be an age-associated loss of physiological reserve, characterised by an increased vulnerability to adverse healthcare outcomes (Sternberg, 2011), (Borges, 2011), (Rodríguez-Mañas, 2013), (Morley, 2013).

Pre-frailty, is a prodromal 'risk' state before the onset of frailty. However, no definition of pre-frailty is yet available. Instead, a cut-off score on a frailty screen or frailty assessment scale defines it as an intermediate level before the development of functional decline. The proportion of frail, community dwelling older adults is variable depending on the sample and setting surveyed but can be as high as half (Collard, 2012). A greater percentage, up to 60% of those aged over 65, can be classified as pre-frail (Santos-Eggimann, 2009), although again this depends on the approach used to categorise pre-frailty (Roe, 2016).

While the development of frailty is often considered permanent, some patients may convert from frail to pre-frail and even become robust again (Gill, 2006). Nevertheless, once established, frailty is challenging or near impossible to reverse (Lang, 2009) with less than 1% of patients transitioning back over five years of follow-up (Gill, 2006). Given that the onset of frailty is associated with an increased incidence of chronic medical conditions (Gray, 2013), (Sergi, 2015), hospitalisation (O'Caoimh, 2012a), (O'Caoimh, 2014a), (O'Caoimh, 2015a), hospital readmission (Kahlon, 2015), healthcare costs (Robinson, 2011), institutionalisation (Sternberg, 2013), and death (Song, 2010), there is a need to promote active and healthy ageing and instigate measures to prevent frailty (Morley, 2013), (Bousquet, 2014), (O'Caoimh, 2015b), (Fairhill, 2015), (Michel, 2016). From a practical perspective targeting pre-frailty is a reasonable approach. Specifically, the use of multi-factorial interventions to screen, monitor and manage prodromal states related to pre-frailty such as subjective or mild cognitive impairment (Fiatarone, 2014), (Ngandu, 2015), (O'Caoimh, 2015c), and reduced physical activity (Bherer, 2013), (Pahor, 2014) may be the best approach. Likewise combinations of proactive, coordinated and targeted interventions, delivered in the community, can reduce adverse healthcare outcomes among older adults (Beswick, 2008).

To date, few clinical trials have used frailty as an outcome measure (Lee, 2012), examined whether frailty can be prevented or studied whether directing interventions towards pre-frail community-dwelling older adults delays onset of frailty and functional decline. Specifically, no study has examined the use of a multi-domain, information and communications technology (ICT) platform. Although several national and international Geriatric Medicine societies have provided best practice recommendations for addressing frailty (Morley, 2013), (Turner, 2014), given the paucity of studies, no guidelines exist for the management of pre-frailty.

# 2 OVERVIEW OF THE PERSSILAA PROJECT

The PERsonalised ICT Supported Services for Independent Living and Active Ageing (PERSSILAA) project is a small or medium-scale focused research project, funded under the European Commissions' Framework Programme 7 (FP7) (2013-2016, grant #610359). It consists of a consortium of eight partners from five European Union countries from across the social, medical and technological sciences as well as industry, academia and end-user organisations. The primary objective of PERSSILAA was to develop an ICT-based platform to identify and manage community dwelling older adults at risk of functional decline and frailty. This multimodal service model focuses on important pre-frailty domains, namely: nutrition, cognition and physical function. It is supported by an interoperable ICT service infrastructure, using an intelligent decision support system and gamification strategies to encourage end-users to engage with the platform. PERSSILAA was designed specifically for community-dwelling older adults (aged >65 years) who as part of the project were (1) screened using continuous trained rater and or self-assessment strategies to identify and stratify their "frailty level", (2) triaged to the appropriate ICT based solution to meet their needs (targeting one, more or all three frailty domains), (3) monitored (unobtrusively) and (4) managed with ICT supported services through local community services.

In summary, the intervention consisted of both face-to-face and remote ICT components. Suitable participants identified in one of the two evaluation sites, Enschede, the Netherlands (older adults aged 65-75 recruited through primary care, selected by their family doctor) and Campania, Italy (older adults >65 recruited through local church communities), were screened for frailty using a two-

step screening process. Once identified, PERSSILAA services were used first to deliver specific trainings modules for health and ICT literacy and where appropriate, based on the screening and triage component, to physical training, cognitive training (Guttmann NeuroPersonalTrainer®) and nutritional advice (NUTRIAGEING™ website). The PERSSILAA services are accessible and offered online via personal or tablet computers so older adults can use them independently. In addition to a standard version there is also a gamified version which wile designed to be fun and interactive, encourages participation and compliance with the intervention, something referred to as 'serious gaming'. For example in one version subjects are challenged to build a boat to escape from a virtual island but can only gather the pieces required by using the trainings modules. Gamification encourages older people to use telemedicine (de Vette, 2015) with a recent systematic review showing that it generates more engaging assessment strategies for cognition (brain training), (Lumsden, 2016).

The PERSSILAA study investigated the extent to which this ICT platform was first acceptable to older adults, then efficacious and ultimately effective in a real world setting, in preventing pre-frail older adults from becoming frail. As this was an evaluation rather than a validation study, the priority was on demonstrating acceptability and proof of concept. PERSSILAA services were studied in two different communities of older adults in Italy and the Netherlands. Two different evaluation studies were performed. In Campania, a prospective cohort study was conducted to examine the uptake, acceptability and usability of the platform among older Italians. In Enschede, a multiple cohort randomised controlled trial (mcRCT) design was used recruiting 82 participants from several Dutch sites across the region (46 of whom received the intervention). Cost effectiveness was assessed with the Monitoring and Assessment Framework for the European Innovation Partnership on Active and Healthy Ageing tool (Boehler, 2015) developed under the European Innovation Partnership on Active and Healthy Ageing (EIP on AHA). The PERSSILAA study was funded for three years with the evaluation component conducted over the last two years. Subjects were consented and assessed at baseline, scheduled intervals and the end-point. More details of the project including a full list of publications are available at www.perssilaa.eu.

# 3 RECOMMENDATIONS FROM THE PERSSILAA PROJECT

Given the interdisciplinary nature of the PERSSILAA project, the results derived from it are multi-dimensional and can be broadly categorised into three thematic areas: Healthcare related recommendations, ICT-related recommendations and Organisational (institutional) related recommendations. This review summarises the healthcare findings relating to the project.

To compile these, partners were grouped according to their relevant specialty to develop recommendations based on the work completed in the preparation of the project including an expert external review and the results emerging from the project. Each component was evaluated separately and once complete all partners provided feedback and the recommendations were grouped as described above.

There are several recommendations within each theme. The results presented in this paper describe the clinically relevant outcomes of the study and how these could be used to contribute to the development of European guidelines for the screening of and prevention of frailty in older adults.

## 3.1 Definition of Pre-frailty

Although pre-frailty may be characterised as a prodromal state before onset of frailty and subsequent functional decline, no clear definition of pre-frailty exists. Instead it is most often characterised only as a transitional stage between robust and frail states, measured by several short frailty screens and defined by a cut-off score above a robust level but below that for frailty. It is acknowledged that there is a need to identify this prodrome so that measures to effectively target frailty can be developed (Fairhall, 2015). In order to select a sample, the PERSSILAA investigators produced a definition of pre-frailty following a detailed state of the art literature review. After reviewing several possible definitions, the investigators developed a multi-domain definition targeting the key frailty domains (nutrition, cognition and physical function) of the project. As several of the partners were involved in the EIP on AHA A3 Action Group on frailty prevention (Illario 2016), the definition of pre-frailty was based upon the A3 groups' definition of frailty. This describes pre-frail older adults those *at increased risk for future poor clinical outcomes, such as the development of disability, dementia, falls, hospitalisation, institutionalisation or increased mortality* as evidenced by the presence of one or

more prodromal frailty states (e.g. mild cognitive impairment, sarcopenia, physical and functional impairment, dysthymia and social isolation).

Recommendation: *The EIP on AHA definition of frailty could be adapted to define pre-frailty*.

Recommendation: *The EIP on AHA action group A3 should take the lead in developing a definition of pre-frailty, which could support and stimulate debate on a consensus definition of this important condition and public health priority.*

## 3.2 Screening for Pre-frailty

Multiple short frailty screening instruments are currently available (de Vries, 2011), though no single instrument is recommended (Morley, 2013). Further, only a few scales are able to discriminate the pre-frail. PERSSILAA was predicated on a two-step screening and assessment approach in an attempt to correctly categorise subjects as frail. Staged screening followed by more comprehensive assessment is recommended given the high prevalence of pre-frailty in community samples and the resources involved to screen in this setting (van Kempen, 2015). Instruments were selected following a literature review. This two-stage selection involved (1) the screening of people aged 65 years and older by trained volunteers/self-screening either by email or postal questionnaire to exclude robust subjects and those with established frailty and (2) a second-level face-to-face assessment by multidisciplinary staff of those classified as pre-frail in order to confirm if they were pre-frail. Each of the three domains included in PERSSILAA were screened using this approach i.e. physical, nutritional and cognitive pre-frailty. The specific instruments used at each stage of the process are presented in Figure 1. During the first iteration (the first round) the scales were rationalised resulting in a more streamlined version (final version).

In summary, in the first step subjects were divided into robust, pre-frail and frail using a 'global' frailty scale and individual measures of nutrition, cognition and physical function. Two 'global' instruments were initially selected (1) the Groningen Frailty Indicator (GFI), a 15-point yes-no questionnaire exploring physical, cognitive, social and psychological components of frailty taking a cut-off of ≥4/15 for moderate-severe frailty (Steverink, 2001) and (2) the INTERMED (self-rated version) screen, a reliable, self-administered 20-question survey covering biological, psychological, social factors and the extent of recent healthcare usage (Peters, 2013). As the INTERMED did not provide sufficient additional information, only the GFI was used in the final version, as it was shorter, validated in the languages of the project and easier to use. Participants were further screened using instruments specific to the selected pre-frailty domains using appropriate cut-off scores. The final instruments selected were the Mini-Nutritional Assessment (MNA) short form for nutrition, the 8-item Alzheimer's disease 8 questionnaire (AD8) for cognitive impairment (Galvin, 2005) and the Short-form 36 questionnaire (SF-36) for physical impairment. The KATZ activities of daily living (ADL) scale and Quick Memory Check (QMC) were initially trialled in the 'first round' (see Figure 1) but were felt to be impractical for self-screening.

In the second step (face-to-face assessment), older adults were assessed to confirm if they were pre-frail. Nutritional deficits were identified using the remainder of the MNA (G-R), mild cognitive impairment was identified with the brief Quick Mild Cognitive Impairment (Q*mci*) cognitive screen (O'Caoimh, 2012), (O'Caoimh, 2013), (O'Caoimh, 2014a), (Bunt, 2015), (O'Caoimh, 2016), using age and education adjusted cut-offs, (O'Caoimh, 2017), and a short physical performance battery (using the Timed Up-and-Go Test, the Two-Minute Step Test, the Chair-Stand Test, and the Chair-Sit-and-Reach Test) were used for physical function.

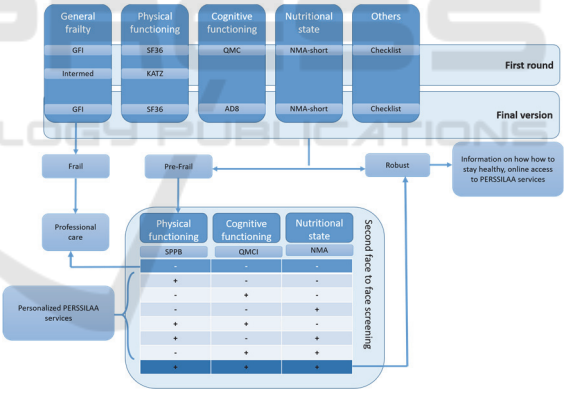


Figure 1: Two-step screening protocol for the PERSSILAA project showing the first and final version of the first screening step.

The results showed that the two-step PERSSILAA screening-service, when combined with additional demographic data seems a good method to quickly and accurately classify community-dwelling older adults into robust, pre-frail and frail. In all, 4071 participants were pre-screened (step one). The majority of these participants were classified as robust (60%) at first step screening. A further 916 (23%) were characterised as having a high probability of being pre-frail and suitable for further assessment (step

two). The second face-to-face screening confirmed that of these 90% were pre-frail.

Receiver operating characteristic curve analysis showed that the marker of nutrition, the MNA, was the most accurate predictor of pre-frailty (area under the curve of 0.80). Logistic regression was used to confirm whether those screening positive were truly pre-frail and showed that the first-step screening process had an overall good to excellent accuracy (area under the curve of 0.87 with a sensitivity of 77% and specificity of 84%). Further analysis of the second level assessment showed a good agreement among the classifications of pre-frail and robust individuals. Thus, the results suggest that the two-step screening approach developed as part of the PERSILLAA is able to correctly categorise pre-frail community-dwelling older adults.

Recommendation: *Pre-frailty should be considered a multi-domain, multi-factorial syndrome.*

Recommendation: *Several, different pre-frailty sub-domains should be addressed when screening for and assessing pre-frailty among older adults and should include cognitive, physical, nutritional and social domains*.

Recommendation: *More research is required in this area and future studies should capture multiple pre-frailty domains along with global measures of frailty*.

Recommendation: *A two-step screening approach is an acceptable and accurate means to identify pre-frailty in a community setting, though more research to confirm this approach is required.*

## 3.3 ICT Training Modules to Manage Pre-frailty

Three training modules were developed as part of PERSSILAA, one for each of the three domains targeted by the project: nutrition, cognition and physical function. This section outlines how each module was developed, the results of their implementation, the conclusions drawn by the PERSSILAA researchers and the recommendations made. This section also puts a special emphasis on health literacy, an important and often overlooked element in the care of older adults. It also includes a preliminary analysis of the effects of the training platform on quality of life.

### 3.3.1 Nutrition Training Module

Nutrition plays an important role across the life span but especially for older adults. Among community-dwelling older people between 10-35% are undernourished i.e. at risk of malnutrition (Schilp, 2012) or malnourished (Shakersain, 2016). The prevalence can reach 45% in hospital (O'Shea, 2016) and between 30%-65% for those in institutionalised care (Pauly, 2007) though figures vary by setting and sample characteristics. The cause is often inappropriate food consumption (van Staveren, 2011), manifest by a gap between actual nutrient consumption and recommended dietary intakes. Education on healthy eating and nutrition is important to provide adequate and reliable information to consumers to promote healthy diets. The NUTRIAGEING website (http://nutriageing.fc.ul.pt/) is an easy-to-use, "app-like" interface with minimal menus or other clutter designed to promote translate scientific knowledge into usable person-centred nutritional advice for the general public. It's three areas are: (1) Healthy eating, (2) Recipes and videos, and (3) Vegetable gardens. The "Recipes and videos" subsection includes 15 videos of recipes developed by the famous Portuguese Chef Hélio Loureiro. The functionality of the website was tested in two day care centres in Portugal with 45 older adults and their caregivers. In free text feedback sessions, participants rated the site as excellent but noted that ICT bridging science and public knowledge such as the NUTRIAGEING™ website should be: (1) easy to use, (2) evidence based and evaluated by experts and (3) have their contents presented in an appealing and enjoyable format to encourage access and learning.

Recommendation: *Nutritional education, required to promote healthier eating habits among the general population and in particular pre-frail older adults, can be delivered successfully online*.

Recommendation: *Educating caregivers on the benefits of nutrition using ICT-supported platforms such as the* NUTRIAGEING™ website *is important and may benefit older adults directly – more research is required to confirm this*.

Recommendation: *Educating cooks and professionals involved in food preparation on the benefits of healthy foods and nutrition using ICT supported platforms such as the* NUTRIAGEING™ website *is important and may benefit older adults directly – again research is required to confirm this*.

Recommendation: *ICT platforms, if user friendly and intuitively designed, can provide the general population but also older persons and healthcare professionals with reliable information and easy-to-use tools, which may increase their knowledge of nutrition and healthy eating*.

### 3.3.2 Cognition Training Module

Demographic ageing is associated with an increased prevalence of cognitive impairment including mild cognitive impairment (Plassman, 2008) and dementia (Prince, 2013). Recent data suggest that the incidence (Satizabal, 2016) and prevalence (Matthews, 2013), (Langa, 2016) of dementia may be falling in developed countries, possibly reflecting improved education, socioeconomic factors and cardiovascular brain health, all of which may contribute to cognitive reserve (Norton, 2014). Further, studies trialling multi-domain interventions targeting at risk populations show that cognitive stimulation when deployed with other lifestyle measures and cardiovascular risk-factor assessment and treatment may reduce progression to dementia (Ngandu, 2015), Cognitive training, often called 'brain training' typically involves guided practice on a set of standardised tasks designed to reflect particular cognitive functions.

In PERSSILAA the mean AD8 score for the total sample of 4,071 participants screened at step one was 0.66±1.22 compared to 1.03±1.28 for pre-frail older adults. A score of two or greater is suggestive of cognitive impairment (Galvin, 2005), though specificity is low at this cut-off (Larner, 2015). The mean Q*mci* score of pre-frail participants at the second step was 64.5/100 ±11.32, within the accepted range of cut-off scores for separating mild cognitive impairment from normal cognition: between 64 and 70/100 (O'Caoimh, 2017).

Over the course of the evaluation, pre-frail older adults were asked to complete the cognitive training modules over 12 weeks, 3 times per week with each session designed to last one hour. The cognitive training tasks were selected from the Guttmann NeuroPersonalTrainer® and incorporated into the platform in two blocks. The first group (Block 1) were assessment-oriented tasks and the second group (Block 2) training-oriented tasks. Block 1 was composed of 10 different tasks, Block 2 25 tasks. Both groups of tasks cover the main cognitive functions involved in ADL. The therapeutic range was set between 65%-85% and difficulty levels were adjusted up/down if the number of correct answers/responses were less or exceeded this.

Cognitive training was trialled in both evaluation sites. In Enschede (Netherlands) 18 older adults participated individually completing a total of 893 tasks during 107 sessions. In Campania (Italy) 53 participated in 15 collective (group) sessions: a total number of 223 individual log in's. Usability testing performed in both regions showed satisfactory results. In the Netherlands eight participants were tested, ten in Italy. The mean score across both sites on the system usability scale (SUS), a subjective 10-item Likert scale measuring usability (Brooke, 1996), was 64/100 suggesting that the cognitive training was usable. Based upon the results the following recommendations were made:

Recommendation: *Cognitive training tasks for use with pre-frail older adults should be easy to understand and use. Important information should be provided in a large, conspicuous, non-crowded format in the person's central visual field*.

Recommendation: *The visual display on cognitive training devices for pre-frail older adults should be simple; avoiding distracting visual stimuli (such as elaborate backgrounds and flashing or flickering lights) unless they are used judiciously to signal a specific required action or function*.

Recommendation: *Clear instructions should be provided to pre-frail older adults before each cognitive training task, particularly where additional effort is required on behalf of the end user (e.g. sustained attention tasks)*.

Recommendation: *Immediate feedback should always be provided to pre-frail older adults after completing individual cognitive training activities. Aggregated information should also be provided to show trends or evolution in performance over time*.

Recommendation: *The difficulty of cognitive training tasks for pre-frail older adults should be tailored to each individual's level based upon normative data for these tasks*.

Recommendation: *Cognitive training modules for pre-frail older people should be adapted to mobile/smart technologies and devices. Engagement with training should be encouraged with techniques such as gamification or through the use of group work (either remotely or at centralised locations)*.

Recommendation: *Fields that represent pre-frail older adults' interests or hobbies should be used throughout cognitive tasks (in the form of images, texts, words etc.) to personalise the experience for older adults*.

### 3.3.3 Physical Training Module

Frailty and pre-frailty are associated with sarcopenia, osteopenia and osteoporosis that contribute to adverse outcomes such as falls and hip fractures (Liu, 2015). Regular physical activity, particularly resistance exercises, may prevent onset of frailty (Liu, 2011). Data also suggests that exercise interventions can improve ADL function among frail older adults and delay progression of functional impairment or disability (Giné-Garriga, 2014). The Otago Exercise Programme (OEP), an established, validated, cost-effective home-based tailored falls prevention programme (Robertson, 2001), reduces the risk of falls and mortality among community-dwelling older adults (Thomas, 2010), though it is unknown whether it can be used remotely by pre-frail older patients.

A technology-supported self-management, physical training module platform, based on the OEP, was developed for use on the PERSSILAA platform. This was structure around an existing platform called the Condition Coach (CoCo) for patients with Chronic Obstructive Pulmonary Disease (Tabak, 2014), containing advice and instructional videos, which was reconditioned for use with pre-frail older through a iterative design approach until a final version was released. A more extensive description of the development of the physical module is presented elsewhere (Vollenbroek-Hutten, 2015).

Participants using the physical training module were requested to train online three times a week for three months. Few participants dropped out mainly due to their own health problems, which prevented them from exercising. Initial technical problems e.g. with browsers were resolved by setting up a helpdesk. Of the participants finishing the complete protocol (i.e. 12 weeks of training), the majority continued using the service for up to one year. Most who used the module were very satisfied and evaluated the module as excellent, scoring a mean of 84/100 on the SUS. In the mcRCT the mean values of the Chair Stand Test and Two minutes step test increased for those using the physical training model compared to controls.

Recommendation: *Strategies to motivate pre-frail older adults to begin and to continue using physical training modules on ICT supported platforms should be included as part of the implementation process.*

Recommendation: *A 'home' online physical training module provided on an ICT supported platform is feasible for pre-frail older adults, though professional support seems useful and should be provided as back up.*

Recommendation: The provision of *physical training modules on ICT supported platforms to pre-frail older adults, at risk of frailty or functional decline may enable them to improve their physical fitness.*

### 3.3.4 Health and ICT literacy

As older adults represent the fastest growing section of our population and the biggest users of healthcare, insufficient attention is paid to their understanding of health literature. It is known that simple measures can rapidly improve older person's understanding (Manafo, 2012). This also applies to eHealth literacy skills (Norman, 2006). In PERSSILAA health and ICT literacy programmes were developed in Italy. This worked on a train the trainer model with healthcare experts teaching local volunteers. In all 2,560 older adults attended classes, with a mean attendance of 13.5 older adults per lesson. Feedback was excellent and older adults reported in subsequent surveys that they required this education in order to interact with the training and monitoring modules (see Section 3.5)

## 3.4 Effects on Quality of Life

Frailty has a negative impact upon quality of life (Strawbridge, 1998). At the beginning of the project a survey conducted with participants suggested high levels of loneliness and depressive symptoms. In all, 73% reported feeling empty and 74% mow mood or depressive symptoms. Thus, in addition to the pre-frailty screening and assessment scales, the European Quality of Life–5 Dimensions questionnaire or EQ-5D (Euroqol), scored from 0 (worst imaginable health state) to 100 (best imaginable health state), was used to measure the effects of the PERSSILAA training modules on quality of life. This was also included to facilitate an economic analysis of the cost effectiveness of the project. The EQ-5D was measured at baseline and end-point for those participating in the mcRCT. The final mean score increased compared with the initial assessment by a mean of 10 points suggesting that those using PERSSILAA reported a higher quality of life after using the platform. The Short-Form 12 (SF-12), which includes physical and mental domains taken from the SF-36 was used to measure perceived health. Higher scores were found on the Mental Component Survey of the SF-12 for those using PERSSILAA training services compared to the control group, suggesting that better mental health is associated with the used of the platform.

Recommendation: *Engaging in online mulit-domain training modules to manage pre-frailty may improve the perceived quality of life of older adults*.

### 3.5 Monitoring for the Development of Frailty – Frailty Transitions

Studies of frailty trajectories show that few older adults can transition from frail to pre-frail or robust (Gill, 2006). These have been limited by the type of data available, which relies on face-to-face assessment. While technology is suggested to allow for unobtrusive monitoring, it may distract end-users and lead to 'attention theft', necessitating a more non-invasive approach in the home environment, particularly when daily activities are being measured (Bitterman, 2011). Further, while useful with younger adults, it is unclear if such models are applicable to community-dwelling older adults. While older adults do engage with ICT, its uptake is low (Selwyn, 2003). Older people perceive ICT to be of little utility and frequently rank their technology skills as low (Scanlon, 2015). Further, it is challenging to combine all the information collected in a meaningful way in order to obtain an overview of the everyday functioning of pre-frail older adults.

Different approaches to monitoring were used in PERSSILAA depending on the pre-frailty domain assessed. To facilitate monitoring software was provided on the portal and on mobile and home sensing devises. All data were collected automatically and uploaded into the PERSSILAA database for analysis. Transitions between different frailty states (robust, pre-frail and frail) were examined using the GFI data at baseline and end-point. To monitor nutrition two questionnaires were placed on the PERSSILAA portal to evaluate eating habits: the 24-hour dietary recall and an additional 'general' questionnaire developed by the PERSSILAA investigators. To supplement this, a 'smart scale' (weighing scale connected wirelessly to a computer application) was chosen to monitor weight on a daily basis. For cognition a shorter version of the full Guttmann NeuroPersonalTrainer® was developed to enable monitoring of cognitive function over time in short sessions of less than 15 minutes comparing each score with baseline and the previous results. For physical function a step counter was chosen to monitor daily physical activity and obtain an overview of physical functioning, all collected by means of a smartphone application. Wellbeing was also measured daily using a smartphone application recorded. The acceptability of the monitoring module was evaluated through semi-structured interviews and by measuring how frequently the technology was used over one month.

In all, 169 participants had completed the GFI at baseline and end-point at the last follow-up. Of these, 78% remained robust, while half remained pre-frail or frail. One quarter transitioned from frail to pre-frail and from pre-frail to robust. One fifth converted from pre-frailty to established frailty. These data are presented in Figure 2. The proportion transitioning is higher than that reported previously and likely represents differences in the way that data is collected and a shorter period of follow-up. There was no difference in overall 'global' frailty status as measured by the GFI between those included in the mcRCT as cases utilising the PERSSILAA training modules and pre-frail controls, $p<0.05$. Twelve community-dwelling older adults participated in the monitoring feasibility sub-study. At baseline each was surveyed to determine their self-reported familiarity, comfort and level of daily use of ICT. Over the following month their daily weight and physical activity were measured and monitored using the 'smart scale' and pedometer provided. At the end a semi-structured interview was conducted. Overall, compliance was modest with participants stressing that ICT monitoring devices should be designed with their needs in mind. Participants stated that they were knew that maintaining a healthy weight has benefits and enjoyed access to healthy recipes.

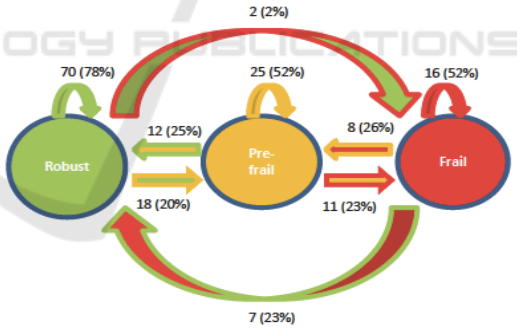


Figure 2: Frailty transitions (n=169) for participants with baseline & end-point Groningen Frailty Indicator scores.

Examining the cognitive domain, it was found that older adults also enjoyed the 'brain training' games but do not want to be confronted or compared with the results of peers. Likewise, older adults stated that physical activity is important for overall health.

These approaches to continuous ICT monitoring showed mixed results and confirmed that older adults while keen to engage technology for the betterment of their health will only do so when it is acceptable to them. Future studies should be designed to study the effects and ultimately

incorporate health and ICT literacy in their designs. Striking the balance between non-invasive monitoring that is non-obtrusive and avoids 'attention theft' and more obvious strategies that increase awareness of the need to engage with ICT to prevent frailty and subsequent functional decline will be the challenge.

Recommendation: *There is likely to be no 'one-size-fits-all' approach to monitoring older community dwellers for pre-frailty. However, ICT training is required for older adults in order for them to engage with monitoring, particularly where end-user feedback is required.*

Recommendation: *Monitoring of everyday function must be complemented by meaningful (older adult-specific) information to support the adoption of healthier behaviours.*

Recommendation: *Technology to support the prevention of functional decline must go beyond the disease oriented-perspective and focus, instead, on strategies to maintain independence in daily activities.*

Recommendation: *When remotely monitoring older adults health (pre-frailty) status using ICT technologies, systems should provide feedback on the data collected.*

# 4 CONCLUSIONS

The results of the three-year, FP7 funded, PERSSILAA project show the potential to use an ICT-based, multi-domain service module to target pre-frail older adults at risk of becoming frail and developing functional decline. These results discuss the healthcare recommendations that can be drawn from the project and which could form the basis of a European guideline on managing pre-frailty. Specifically, PERSSILAA demonstrated the acceptability and usability of this approach with older adults, who may not find the use of such technology easy (Scanlon, 2015), especially where there is coexisting disability (Gell, 2015). To our knowledge, this is the first paper to explore the use of ICT with pre-frail, community-dwelling older adults and the results showed that they rated the three training modules (nutritional, cognitive and physical) high for usability. This was similar for the two distinct populations sampled: older Dutch citizens attending primary care and older Italians living in communities centred around their local church. Only Portuguese citizens rated the NUTRIAGEING$^{TM}$ website though it unlikely that these differ considerably from other participants. Another key finding of PERSSILAA is that health literacy and ICT literacy are both important in allowing older adults access such services. Older Italians felt they benefited from the social environment created by the classrooms provided. Dutch participants however, preferred to train alone and not compare results with their compatriots. This may reflect different cultural backgrounds and suggests that a one size fits all approach is unlikely to be successful when integrating ICT into the every day lives of older Europeans to improve their health status. PERSSILAA is also one of the first studies to study the effects of gamification (de Vette, 2015) on older adults and how it may help engage them with ICT training modules.

The results also highlight many of the challenges of undertaking a study like this with a difficult population to sample: pre-frail, older adults, who while at risk for subsequent frailty and functional decline may not be aware of this or motivated enough to engage with screening processes. The two-stage process enhanced the screening pathway developed to recruit suitable participants. Several of screens have excellent sensitivity though relatively poor specificity meaning that a face-to-face assessment was required to ensure that participants were pre-frail. The results suggested that this strategy was accurate. Due to resource limitations not all those screening positive for pre-frailty had a repeat assessment at the end-point of the study and only a small number were monitored. The study was also able to demonstrate frailty transitions during the evaluation period but these may not be representative of the true trajectory of frailty in this population. Such proportionally high (approx. 20%) transitions from one frailty state to another over a short period are in contrast with data presented elsewhere in larger samples over longer periods (Gill, 2006). Therefore, it is likely that this reflects the limitations of the screening and assessment process itself, delivered both remotely and face-to-face using validated instruments but not senior physician/geriatrician assessment. However, this project aimed to show the potential for lay or self-screening, something that is likely to become more widely accepted as healthcare becomes more proactive and less reactive, stepping away from the traditional medical model. Another limitation is that only a small sample trialled the full platform, released in stages as it was developed, which meant that no significant impact upon GFI scores were

seen. This limits the project to the development and evaluation of a service platform, which was the main focus of the research. Thus, as a proof of concept PERSSILAA shows the potential to use a multi-domain ICT-based platform with older, pre-frail adults. This, however, reduces the generalisability of the results, which nevertheless present useful lessons from both the development and implementation of the platform

Overall, the 25 healthcare-related recommendations presented provide guidance on how to address the development and evaluation of ICT supported services to tackle the emerging public health challenge that an increasingly ageing and frail older population represents. To our knowledge, this is the first study to show the potential for an ICT platform targeting key pre-frailty areas (i.e. nutritional, cognitive and physical domains) in the screening, monitoring and managing of pre-frailty. The results of the evaluation are being analysed further and future research is being planned to validate the PERSSILAA platform with a suitably powered RCT to determine if ICT-supported services can truly prevent or delay onset of frailty and functional decline in pre-frail community-dwelling older adults.

## ACKNOWLEDGEMENTS

The authors wish to thank all the PERSSILAA participants throughout the three years of the project. Specifically , the authors thank - all older adults who joined the project: for Italy this includes residents from the Confalone, Pilar, Rogazionisti and Santa Maria della Salute communities; for the Netherlands this includes those in the municipalities of Enschede, Hengelo, Tubbergen and Twenterand. The researchers would also like to acknowledge the not for profit organizations in Italy who collaborated (Progetto Alfa, Saluta in Collina), the healthcare professionals from Campania (Local Health Agency Naples 1, CRIUV) and the health systems including General Practitioners who supported the project in the Netherlands.

## REFERENCES

Beswick, A.D., Rees, K., Dieppe, P., Ayis, S., Gooberman-Hill, R., Horwood, J., Ebrahim, S. 2008. Complex interventions to improve physical function and maintain independent living in elderly people: a systematic review and meta-analysis. *The Lancet*, 371, 725-735.

Bherer, L., Erickson, K.I., Liu-Ambrose, T. 2013. A review of the effects of physical activity and exercise on cognitive and brain functions in older adults. *Journal of aging research*, 11;2013.

Bitterman, N., 2011. Design of medical devices—A home perspective. *European journal of internal medicine*, *22*(1), pp.39-42.

Boehler, C.E., de Graaf, G., Steuten, L., Yang, Y., Abadie, F. 2015. "Development of a web-based tool for the assessment of health and economic outcomes of the European Innovation Partnership on Active and Healthy Ageing (EIP on AHA)," *BMC Med. Inform. Decis. Mak* 15 (S3), p. S4.

Borges, L.L. and Menezes, R.L., 2011. Definitions and markers of frailty: a systematic review of literature. *Reviews in Clinical Gerontology*, 21(01), pp.67-77.

Bousquet, J., Michel, J.P., Strandberg, T., Crooks, D., Iakovidis, I., Iglesia, M. 2014. The European innovation partnership on active and healthy ageing: the European geriatric medicine introduces the EIP on AHA column. *Eur Geriatr Med* 5:361–362.

Brooke, J. 1996. "SUS: a "quick and dirty" usability scale". In P. W. Jordan, B. Thomas, B. A. Weerdmeester, & A. L. McClelland. *Usability Evaluation in Industry*. London: Taylor and Francis.

Bunt, S., O'Caoimh, R., Krijnen, W.P., Molloy, D.W., Goodijk, G.P., van der Schans, C.P., Hobbelen, J.S.M. 2015. Validation of the Dutch version of the Quick Mild Cognitive Impairment Screen (Qmci-D). *BMC Geriatrics* 15:115 DOI 10.1186/s12877-015-0113-1.

de Vette, F., Tabak, M., Dekker-van Weering, M., Vollenbroek-Hutten, M. 2015. Engaging Elderly People in Telemedicine Through Gamification. *JMIR Serious Games*, 3(2):e9.

de Vries, N.,M., Staal, J.,B., van Ravensberg, C.,D., Hobbelen, J.,S.,M., Olde Rikkerte, M.,G.,M., Nijhuis-van der Sanden, M.,W.,G. 2011. Outcome instruments to measure frailty: A systematic review. *Ageing Research Reviews*, 10: 104–114.

Fairhall, N., Kurrle, S.E., Sherrington, C., Lord, S.,R., Lockwood, K., John, B., Monaghan, N., Howard, K., Cameron, I,.D. 2015. Effectiveness of a multifactorial intervention on preventing development of frailty in pre-frail older people: study protocol for a randomised controlled trial. *BMJ Open*. 5(2):e007091.

Fiatarone Singh, M.A., Gates, N., Saigal, N., et al. 2014. The Study of Mental and Resistance Training (SMART) study-resistance training and/or cognitive training in mild cognitive impairment: a randomized, double-blind, double-sham controlled trial. *J Am Med Dir Assoc*, 15(12): 873–80.

Galvin, J.E., Roe, C.M., Powlishta, K.K., Coats, M.A., Muich, S.J., Grant, E., Miller, J.P., Storandt, M. and Morris, J.C., 2005. The AD8 A brief informant interview to detect dementia. *Neurology*, 65(4); pp.559-564.

Gell, N.,M., Rosenberg, D.,E., Demiris, G., LaCroix, A.,Z., Patel, K.,V. 2015. Patterns of technology use among older adults with and without disabilities. *Gerontologist*, 55(3):pp412-21.

Gill, T.M., Gahbauer, E.A., Allore, H.G, Han, L. 2006. Transitions between frailty states among community-living older persons. *Arch Intern Med*, 166(4):418-23.

Giné-Garriga, M., Roqué-Fíguls, M., Coll-Planas, L., Sitjà-Rabert, M., Salvà, A. 2014. Physical Exercise Interventions for Improving Performance-Based Measures of Physical Function in Community-Dwelling, Frail Older Adults: A Systematic Review and Meta-Analysis. *Archives of physical medicine and rehabilitation*, 95 (4):pp 753–769.e3.

Gray, S.L, Anderson, M.L, Hubbard, R.A., LaCroix, A., Crane, P.K., McCormick, W., Bowen, J.D, McCurry, S.M., Larson, E.B. 2013. Frailty and incident dementia. *J Gerontol A Biol Sci Med Sci*, 68(9):1083-90.

Illario, M., Iaccarino, G., Piazza, O., Menditto, E., Coscioni, E. 2016. Proceedings of the EIP on AHA: A3 Action Group on Frailty. *Transl Med UniSa*. 31;13:1-3.

Kahlon, S., Pederson, J., Majumdar, S.R., Belga, S., Lau, D., Fradette, M., Boyko, D., Bakal, J.A., Johnston, C., Padwal, R.S. and McAlister, F.A., 2015. Association between frailty and 30-day outcomes after discharge from hospital. *Canadian Medical Association Journal*, 187(11): pp.799-804.

Lang, P.O., Michel, J.P., Zekry, D. 2009. Frailty syndrome: a transitional state in a dynamic process. *Gerontology*, 55(5):539-49.

Langa, K.M., Larson, E.B., Crimmins, E.M., et al. 2016. A comparison of the prevalence of dementia in the United States in 2000 and 2012. *JAMA Intern Med* doi:10.1001 /jamainternmed.2016.6807

Larner, A.J., 2015. AD8 Informant Questionnaire for Cognitive Impairment Pragmatic Diagnostic Test Accuracy Study. *Journal of geriatric psychiatry and neurology*, 28(3): pp.198-202.

Lee, P.H., Lee, Y.S., Chan, D.C. 2012. Interventions targeting geriatric frailty: a systemic review. *Journal of Clinical Gerontology and Geriatrics*, 3(2):47-52.

Liu, C.K. and Fielding, R.A., 2011. Exercise as an intervention for frailty. *Clinics in geriatric medicine*, 27(1), pp.101-110.

Liu, L.K., Lee, W.J., Chen, L.Y., Hwang, A.C., Lin, M.H., Peng, L.N. and Chen, L.K., 2015. Association between frailty, osteoporosis, falls and hip fractures among community-dwelling people aged 50 years and older in Taiwan: results from I-Lan longitudinal aging study. *PLoS one*, 10(9), p.e0136968.

Lumsden, J., Edwards, E.A., Lawrence, N.S., Coyle, D. and Munafò, M.R., 2016. Gamification of cognitive assessment and cognitive training: a systematic review of applications and efficacy. *JMIR Serious Games*, 4(2).

Manafo, E., Wong., S. 2012. Health literacy programs for older adults: a systematic literature review. *Health Educ Res*. 27(6):947-60.

Matthews, F.E., Arthur, A., Barnes, L.E., et al. 2013. Medical Research Council Cognitive Function and Ageing Collaboration. A two-decade comparison of prevalence of dementia in individuals aged 65 years and older from three geographical areas of England: results of the Cognitive Function and Ageing Study I and II. *The Lancet*, 382(9902):1405-1412.

Michel, J.P., Dreux, C., Vacheron, A. 2016. Healthy ageing: evidence that improvement is possible at every age. *European Geriatric Medicine*, 7(4), pp.298-305.

Morley, J.E., Vellas, B., van Kan, G.A., et al. 2013. Frailty consensus: a call to action. *Journal of the American Medical Directors Association* 14:392–7.

Ngandu, T., Lehtisalo, J., Solomon, A., Levälahti, E., Ahtiluoto, S., Antikainen, R., Bäckman, L., Hänninen, T., Jula, A., Laatikainen, T. and Lindström, J., 2015. A 2 year multidomain intervention of diet, exercise, cognitive training, and vascular risk monitoring versus control to prevent cognitive decline in at-risk elderly people (FINGER): a randomised controlled trial. *The Lancet*, 385(9984), pp.2255-2263.

Norman, C., Skinner, H. 2006. eHealth literacy: Essential skills for consumer health in a networked world. *J Med Internet Res*, 8:e9.

O'Caoimh, R., Gao, Y., McGlade, C., Healy, L., Gallagher, P., Timmons, S., Molloy, D.W. 2012. Comparison of the Quick Mild Cognitive Impairment (Qmci) screen and the SMMSE in Screening for Mild Cognitive Impairment. *Age and Ageing* 41(5):624-9.

O'Caoimh, R., Gao, Y., Gallagher, P., Eustace, J., McGlade, C., Molloy, D.W. 2013. Which Part of the Quick Mild Cognitive Impairment Screen (Qmci) Discriminates Between Normal Cognition, Mild Cognitive Impairment and Dementia? *Age and Ageing* 42: 324-330.

O'Caoimh, R., Svendrovski, A., Johnston, B., Gao, Y., McGlade, C., Timmons, S., Eustace, J., Guyatt, G., Molloy, D.W. 2014a. The Quick Mild Cognitive Impairment Screen correlated with the Standardised Alzheimer`s Disease Assessment Scale-cognitive section in clinical trials. *Journal of Clinical Epidemiology* 67, 87-92.

O'Caoimh, R., Gao, Y., Svendrovski, A., Healy, E., O'Connell, E., O'Keeffe, G., Leahy-Warren, P., Cronin, U., O'Herlihy, E., Cornally, N., Molloy, D.W. 2015a. The Risk Instrument for Screening in the Community (RISC): A New Instrument for Predicting Risk of Adverse Outcomes in Community Dwelling Older Adults. *BMC Geriatrics* 15:92. doi: 10.1186/s12877-015-0095-z.

O'Caoimh, R., Sweeney, C., Hynes, H. et al. 2015b. COLLaboration on AGEing – COLLAGE: Ireland's three star reference site for the European Innovation Partnership on Active and Healthy Ageing (EIP on AHA). *Eur Geriatr Med* 6:505–511.

O'Caoimh, R., Sato, S., Wall, J., Igras, E., Foley, M.J., Timmons, S., Molloy, D.W. 2015c. Potential for a "Memory Gym" Intervention to Delay Conversion of Mild Cognitive Impairment to Dementia. *Journal of the American Medical Directors Association* 16 (11), pp.998-999.

O'Caoimh, R., Timmons, S., Molloy, D.W. 2016. Screening for Mild Cognitive Impairment:

Comparison of "MCI Specific" Screening Instruments. *Journal of Alzheimer's disease* 51(2):619-29.

O'Caoimh, R., Gao, Y., Gallagher, P., Eustace, J., Molloy, W. 2017. Comparing Approaches to Optimize Cut-off Scores for Short Cognitive Screening Instruments in Mild Cognitive Impairment and Dementia. *Journal Of Alzheimer's Disease*, in press.

O'Shea, E., Trawley, S., Manning, E. et al. 2016. Malnutrition in hospitalised older adults: A multicentre observational study of prevalence, associations and outcomes *J Nutr Health Aging* doi:10.1007/s12603-016-0831-x

Pahor, M., Guralnik, J.M., Ambrosius, W.T., Blair, S., Bonds, D.E., Church, T.S., Espeland, M.A., Fielding, R.A., Gill, T.M., Groessl, E.J. and King, A.C. 2014. Effect of structured physical activity on prevention of major mobility disability in older adults: the LIFE study randomized clinical trial. *Jama*, 311(23), pp.2387-2396.

Pauly, L., Stehle, P., Volkert, D. 2007. Nutritional situation of elderly nursing home residents. *Z Gerontol Geriatr* 40(1):3-12.

Peters, L.L., Boter, H., Slaets, J.P., Buskens, E. 2013. Development and measurement properties of the self assessment version of the INTERMED for the elderly to assess case complexity. *Journal of Psychosom Res* ;74(6):518-522.

Plassman, B.L., Langa, K.M., Fisher, G.G., Heeringa, S.G., Weir, D.R., Ofstedal, M.B., Burke, J.R., Hurd, M.D., Potter, G.G., Rodgers, W.L. and Steffens, D.C., 2008. Prevalence of cognitive impairment without dementia in the United States. *Annals of internal medicine*, 148(6), pp.427-434.

Prince, M., Bryce, R., Albanese, E., Wimo, A., Ribeiro, W., Ferri, C.P. 2013. The global prevalence of dementia: a systematic review and meta-analysis. *Alzheimers Dementia*, 9(1):63-75.

Rechel, B., Grundy, E., Robine, J.M., Cylus, J., Mackenbach, J.P., Knai, C., et al. 2013. Ageing in the European Union. *The Lancet,* 381(9874):1312–22.

Robertson, M.C., Devlin, N., Scuffham, P., Gardner, M.M., Buchner, D.M., Campbell, A.J. 2001. Economic evaluation of a community based exercise programme to prevent falls. *J Epidemiol Community Health* 55:600-606.

Rodríguez-Mañas, L., Féart, C., Mann, G., Viña, J., Chatterji, S., Chodzko-Zajko, W., Harmand, M.G., Bergman, H., Carcaillon, L., Nicholson, C., Scuteri, A. 2013. Searching for an operational definition of frailty: a Delphi method based consensus statement. The frailty operative definition-consensus conference project. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, 68(1):62-7.

Roe, L., O'Halloran, A., Normand, C., Murphy, C. 2016. The impact of frailty on public Health Nurse Service Utilisation: Findings from the Irish Longitudinal Study On Ageing (TILDA).

Santos-Eggimann, B., Cuenoud, P., Spagnoli, J., Junod, J. 2009. Prevalence of Frailty in Middle-Aged and Older Community-Dwelling Europeans Living in 10 Countries. *Journals of Gerontology Series a-Biological Sciences and Medical Sciences*, 64, 675-681.

Satizabal, C.L., Beiser, A.S., Chouraki, V., Chêne, G., Dufouil, C., Seshadri, S.2016. Incidence of dementia over three decades in the Framingham Heart Study. *N Engl J Med*, 374(6):523-532.

Scanlon, L., O'Shea, E., O'Caoimh, R., Timmons, S. 2015. Technology use, frequency and self-rated skills: A survey of community dwelling older adults. *Journal of American Geriatrics Society* 63(7):1483-4.

Schilp, J., Kruizenga, H.M., Wijnhoven, H.A., Leistra, E., Evers, A.M., van Binsbergen, J.J., Deeg, D.J. and Visser, M., 2012. High prevalence of undernutrition in Dutch community-dwelling older individuals. *Nutrition*, 28(11), pp.1151-1156.

Selwyn, N., Gorard, S., Furlong, J. and Madden, L., 2003. Older adults' use of information and communications technology in everyday life. *Ageing and society*, 23(05), pp.561-582.

Sergi, G., Veronese, N., Fontana, L., De Rui, M., Bolzetta, F., Zambon, S., Corti, M.C., Baggio, G., Toffanello, E.D., Crepaldi, G. and Perissinotto, E. 2015. Pre-frailty and risk of cardiovascular disease in elderly men and women: the Pro. VA study. *Journal of The American college of cardiology*, 65(10), pp.976-983.

Shakersain, B., Santoni, G., Faxén-Irving, G., Rizzuto, D., Fratiglioni, L., Xu, W. 2016. Nutritional status and survival among old adults: an 11-year population-based longitudinal study. *European Journal of Clinical Nutrition*, 70, 320-325.

Song, X., Mitnitski, A., Rockwood, K. 2010. Prevalence and 10-year outcomes of frailty in older adults in relation to deficit accumulation. *J Am Geriatr Soc* 58(4):681-7.

Sternberg, S.A., Schwartz, A.W., Karunananthan, S., Bergman, H., Clarfield, A.M. 2011. The Identification of Frailty: A Systematic Literature Review. *Journal of the American Geriatrics Society*, 59, 2129-2138

Steverink, N., Slaets, J.P.J., Schuurmans, H., Van Lis, M. 2001. Measuring frailty: developing and testing the GFI (Groningen Frailty Indicator). *Gerontologist*. 2001;41(Special Issue 1):236.

Strawbridge, W.,J., Shema, S.,J., Balfour, J.,L., Higby, H.,R., Kaplan, G.,A. 1998. Antecedents of frailty over three decades in an older cohort. *J Gerontology* 53b(1);ppS9-16.

Tabak, M., Brusse-Keizer, M., van der Valk, P., Hermens, H. and Vollenbroek-Hutten, M. 2014. A telehealth program for self-management of COPD exacerbations and promotion of an active lifestyle: a pilot randomized controlled trial. *International journal of chronic obstructive pulmonary disease*, 9, p.935.

Thomas, S., Mackintosh, S. and Halbert, J. 2010. Does the 'Otago exercise programme'reduce mortality and falls in older adults?: a systematic review and meta-analysis. *Age and Ageing*, 39(6):pp681-7.

Turner, G., Clegg, A; British Geriatrics Society; Age UK; Royal College of General Practioners. 2014. Best practice guidelines for the management of frailty: a

British Geriatrics Society, Age UK and Royal College of General Practitioners report. *Age and Ageing*, 43(6):pp744-7.

van Kempen, J.A., Schers, H.J., Philp, I., Rikkert, M.G.O. and Melis, R.J., 2015. Predictive validity of a two-step tool to map frailty in primary care. *BMC medicine*, *13*(1), p.1.

van Staveren, W.A. and de Groot, L.C.P. 2011. Evidence-based dietary guidance and the role of dairy products for appropriate nutrition in the elderly. *Journal of the American College of Nutrition*, 30(sup5), pp.429S-437S.

Vollenbroek-Hutten, M., Pais, S., Ponce, S., Dekker-van Weering, M., Jansen-Kosterink, S., Schena, F., Tabarini, N., Carotenuto, F., Iadicicco, V. and Illario, M. 2015. Rest Rust! Physical active for active and healthy ageing. *Translational medicine@ UniSa*, *13*, p.19.

SCITEPRESS
SCIENCE AND TECHNOLOGY PUBLICATIONS