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Abstract

This document presents Task 3.4, summarising the lessons learned from the PERsonalised ICT Supported Service for Independent Living and Active Ageing (PERSSILAA) project and how these may contribute to the development of European guidelines relating to the screening and prevention of frailty. The deliverable describes the initial results of PERSSILAA and provides recommendations based on these that incorporate the important clinical (screening, monitoring and managing pre-frail older adults), technical (Information and Communication Technology [ICT] based innovations) and societal (health literacy in older adults) outcomes obtained to different stakeholders and agencies including but not limited to health and social care providers, governmental organisations, business organisations and the general public (patients and caregivers). This deliverable also seeks out appropriate and relevant local, regional, European and international guidelines that currently exist and how the results of PERSSILAA could be incorporated into these, while linking closely with the deliverable concerning dissemination (i.e. WP 6, D6.2). The results presented include recommendations that could be used towards the generation of European guidelines for the identification, monitoring and multi-faceted management of pre-frailty (the precursor of frailty) in order to prevent onset of frailty and functional decline. These are grouped by theme into 43 recommendations and are grouped under the following headings: (A) Healthcare related recommendations, (B) ICT related recommendations and (C) Organisational (institutional) related recommendations.

Keyword list: Frailty, Pre-frailty, Information and Communication Technology (ICT), Clinical, Recommendations, Guidelines
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1 Executive Summary

The “PERsonalised ICT Supported Services for Independent Living and Active Ageing” (PERSSILAA) project set out to develop a comprehensive Information and Communication Technologies (ICT) supported platform to screen, assess, manage and monitor pre-frail community-dwelling older adults in order to ultimately prevent the onset of frailty and functional decline. PERSSILAA’s main focus was to address pre-frailty as a multi-domain disorder looking specifically at three main aspects that contribute to the development of this syndrome: nutrition, cognition and physical function.

This deliverable examines the three main overarching outcomes arising from the project as determined by the PERSSILAA investigators: healthcare, ICT and organisation (institutional) related outcomes, providing recommendations based on these that could be used to contribute to European (and other) guidelines on the management of frailty and functional decline. This deliverable summarises the findings of PERSSILAA based on all of these three categories and makes recommendations that will inform older adults, their families and carers, healthcare professionals, researchers, politicians and policy makers as well as business leaders on how to address a growing and important public health challenge, the development of pre-fraility, which is now recognised as a prodromal state leading to the onset of established frailty and functional decline. As ‘prevention is better than cure’, this goal is an important and timely one in the setting of a rapidly ageing European Union.

The PERSSILAA project is one of the first projects to address this topic. It uses state-of-art design and technology to build a new ICT supported training service to remotely (in so much as was possible given technological, clinical and personal preference limitations) address the management of these pre-frail older people, evaluating its utility (both accessibility –acceptability/adoptability and its ability) to tackle this difficult to define pre-frailty that as yet lacks a consensus definition. Based on the results of the project the PERSSILAA investigators have produced a set of balanced and informative recommendations to guide its target audience (as described above) in how to further refine and enhance the development of personalised, ICT supported services to address pre-frailty. These recommendations are grouped into three core areas mirroring the overarching outcomes of PERSSILAA.
In total, this deliverable presents 43 key recommendations, presented in Appendix 1, across the following areas:

A. Healthcare related recommendations:
- How to define pre-frailty for a study designed to manage pre-frailty that uses an ICT supported platform?
- How to screen for pre-frailty using an ICT supported platform?
- How to monitor for the development of frailty and functional decline using an ICT supported platform with pre-frail older adults?
- How to use multi-domain (nutrition, cognition and physical function) training modules on an ICT supported platform to Manage Pre-frailty?

B. ICT related recommendations:
- Insights gained from the project into the development of ICT supported platforms to manage pre-frailty.
- Measures to improve accessibility of ICT supported training platforms for pre-frail older adults to manage pre-frailty.
- Insights gained from the evaluation of an ICT supported platform to manage pre-frailty.
- Insights gained into the use of gamification techniques as a way to engage older adults to use ICT supported platforms to manage pre-frailty.

C. Institutional (organisational) related recommendations:
- Recommendation for multistakeholder collaboration to address together and proactively frailty and functional decline in community dwelling older adults.
- Insights gained into development and testing of business modeling for multistakeholder ICT supportive preventive services for community dwelling older adults.
- Recommendations for health economic assessments for innovative ICT supported services like PERSSILAA.
2 About this document

2.1 Overview
This document provides a brief overview of the PERSSILAA project, describes the core results to date and explains how the specific outcomes of the study can be used in future to develop recommendations for both the identification (screening) and management (prevention) of frailty, with a view that these might provide guidance to the public, carers and health professional bodies across the EU on how to identify and manage pre-frail older people living in the community. These will be the first guidelines to do this and will provide a valuable resource for the general public, researchers, policy makers and healthcare professionals.

Ultimately, it is envisaged that each of these core results could either be combined together into a single recommendation i.e. that this document itself would serve as a working document on how to identify and manage pre-frail older adults or that each of the recommendations arising from PERSSILAA would be harmonized with existing local, regional, national and international recommendations where they exist. This document also acts a precursor for including guidelines on the PERSSILAA website, where they will be made available for the general public and healthcare professionals in English and ultimately, in time, translated into the core languages of the study i.e. Dutch and Italian as well as the other languages of the EU.

2.2 Structure
The outcomes of the PERSSILAA project, which will be discussed and incorporated into the recommendations to address the identification and management of frailty, fall roughly under the following three headings: (1) health related (clinical and health literacy), (2) Information and Communication Technologies (ICT)-related and (3) organisational (institutional) aspects. Each will be addressed separately and published on the PERSSILAA website (www.perssilaa.com).

For each of the three outcomes described the same structure (a to e: background, objective, what was done/how?, results and recommendations) was applied with an emphasis on how the results could help define recommendations for the screening and the prevention of frailty among older adults using ICT supported services:
a. Background
What is the background of the outcome including what is known about the area that the results of PERSSILAA feed into.

b. Objective
What was the objective or aim of this component of the study i.e. why was this outcome targeted or considered important and hence why was this selected as important as a recommendation?

c. What was done? How?
This will provide an overview of how this result was achieved by the PERSSILAA investigators.

d. Results
This heading describes what the i.e. What were the results? It may also include some personal experiences and insights from the PERSSILAA investigators that could contribute to the generation of guidelines relating to that parameter if relevant.

e. Recommendation(s)
Each section will provide clearly described recommendations based on PERSSILAA outcomes/results that could be used to contribute to European guidelines including the target audience (i.e. who specifically will benefit from such recommendation). This will also include future recommendations i.e. how future studies could be designed or performed in order to build on the results of PERSSILAA.

f. Target audience
Finally, this last section will explore the target audience for the recommendations made, examining which group or groups are likely to benefit or be interested in the results and findings of PERSSILAA. These are the groupings that would be expected to utilize the finding of PERSSILAA into the development of European guidelines relating to the screening and prevention of frailty.
3 Introduction

3.1 Demographics of frailty in the European Union
The number and proportion of older adults is increasing internationally, particularly within the European Union (EU) (Rechel et al., 2013). With this has come an increase in the prevalence of frailty (Collard et al., 2012) and a recognition by the EU that early intervention at local, regional and international levels is required to promote active and healthy ageing (Bousquet et al., 2014), (O’Caoimh et al., 2015a), (Michel et al., 2016). Although no clear consensus on a definition exists (Sternberg et al., 2011), (Borges et al 2011), (Rodríguez-Mañas et al., 2013), (Morley et al., 2013), frailty can be defined as a multi-factorial state, correlating with vulnerability, disability, co-morbidity and self-reported health status (Rockwood et al., 2005). In addition to the growing numbers of frail older adults, there has been an increase in those perceived to be at risk of developing frailty and subsequent functional decline, the pre-frail. While the prevalence of frailty in community-dwelling Europeans aged over 65 years varies between 5.8% and 27.3%, a much larger number, approaching 60%, are considered to be pre-frail (Santos-Eggimann et al., 2009).

3.2 Concept of frailty and approaches to address the frailty syndrome - in order to better define pre-frailty.
Currently there is no established definition of pre-frailty. Likewise, no consensus on a definition of frailty exists (Morley et al 2013), although there is growing data supporting the concept of frailty as a syndrome predisposing to the risk of adverse healthcare outcomes that is now beginning to build towards an agreed definition. Much of what is understood about pre-frailty relates to our understanding of frailty itself. Frailty is not considered a fixed state and patients make transitions between robust, pre-frail and frail (Gill et al., 2006), (Lang et al., 2009), though this trajectory is poorly understood and once established frailty may be more difficult to reverse. As frailty is associated with the development of adverse healthcare outcomes including increased cost (Robinson et al., 2011), death (Song et al., 2010), hospitalisation, disability and institutionalisation (O’Caoimh et al., 2012a), (O’Caoimh et al., 2014a), (O’Caoimh et al 2015b), (Sternberg et al., 2013), there is interest in targeting those who are pre-frail to prevent or delay frailty in the first instance (Morley et al 2013), (Fairhill et al., 2015), particularly as pre-frailty itself is associated with the development of several medical conditions including heart disease (Sergi et al., JACC 2015) and dementia (Gray et al., 2013). This proactive approach recognises that prodromal states such as subjective memory complaints (Ngandu et al., 2015) and reducing mobility (Pahor et al., 2014), relating to cognitive and physical frailty domains respectively, if targeted, may prevent or delay onset of disease, particularly if multi-factorial interventions are introduced early. To date, the strongest evidence is
for interventions targeting the physical domain but there is also evidence for nutritional and cognitive strategies (Morley et al., 2013).

To date, few studies have investigated whether frailty can be prevented and whether targeting pre-frail individuals in particular, will delay onset of frailty and functional decline. Few trials have used frailty as an outcome measure (Lee et al., 2012) and most have targeted individual risk factors such as cognition and or physical inactivity (Bherer et al., 2013), (Fiatarone et al., 2014), (O’Caomh et al., 2015). However, combinations of complex interventions, delivered in the community, can reduce adverse healthcare outcomes (Beswick et al., 2008). To our knowledge, no study before this has investigated whether a multi-focal, information and communications technology (ICT) based intervention, targeting specific frailty domains including cognition, nutrition and physical function can prevent frailty in pre-frail individuals.

3.3. Current Guidelines to Address Frailty:
Screening instruments for pre-frailty
Given the lack of consensus on a definition, screening for pre-frailty, like frailty itself, is challenging. The concept of pre-frailty, while intuitive is ill defined. Pre-frailty can be identified by several short frailty screens and is usually defined by cut-off scores below that of frailty itself. While multiple instruments exist to screen for frailty (de Vries et al., 2011), few are available that specifically target to identify those who are pre-frail. Those that specifically identify pre-frailty include the FRAIL scale (Morley et al., 2012). Two-step approaches to frailty screening among community dwelling older adults have proven successful (Woo et al., 2015). Suggested and validated instruments include the FRAIL scale at baseline followed by comprehensive geriatric assessment (CGA) (Woo et al., 2015).

At present no specific recommendations for screening for pre-frailty are available. The evidence to date comes from guidelines on screening to identify established frailty, presented and summarised in Table 1. Likewise, there are no accepted guidelines for frailty approved by the EU though several European organisations representing specialists with an interest in the care of older people have issue recommendations. In the United Kingdom, the British Geriatrics Society and the Royal College of Physicians in London in their ‘Fit for Frailty’ document recommend that a frailty assessment is conducted at each interaction between older persons and healthcare professionals but do not advocate population based screening approaches or routine screening in general practice as there is insufficient evidence for benefit (Fit for frailty 2014), (Turner et al., 2014). In France, the French Society of Geriatrics and Gerontology also advocate screening for frailty (Rolland et al., 2011). Internationally, a consensus panel of experts from the International Association of Gerontology and Geriatrics (IAGG), Society on sacropaenia, cachexia and wasting diseases, European Union Geriatric Medicine Society (EUGMS), American Medical Directors Association and the American Federation for Ageing Research met in 2013
but could not agree a single operational definition of frailty (Morley et al., 2013). The lack of consensus on this has led to the recent funding of a Joint Action on Frailty Prevention by the European Commission through the 3rd Health Programme. This initiative (called ADVANTAGE), involves 36 partners in 23 European countries, aims to identify factors that promote disability-free ageing in Europe and will be launched in 2017. ADVANTAGE will make recommendations based on existing data including existing local, national and EU guidelines on identifying, monitoring and managing frailty and its precursors (and by implication factors contributing to pre-frailty). However, without a consensus definition of frailty, it is challenging to begin working towards a definition of its prodrome, pre-frailty.

Table 1. Existing recommendations and guidelines for the screening and management of frailty (as a surrogate for of pre-frailty).

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<td>Turner &amp; Clegg 2014</td>
<td>British Geriatrics Society, Age UK and Royal College of General Practitioners</td>
<td>All encounters between health and social care staff and older people in community and outpatient settings should include an assessment for frailty. No recommendation for population based screening.</td>
</tr>
<tr>
<td>Morley et al., 2013</td>
<td>International consensus panel of experts from the International Association of Gerontology and Geriatrics, Society on Sacropaenia, cachexia and wasting diseases, European Union Geriatric Medicine Society, American Medical Directors Association, American Federation for Ageing Research.</td>
<td>Emphasis on case-finding should target those who are ‘pre-disabled’ rather than dependent. Simple, rapid screening tests have been developed and validated. Those over 70 years or losing &gt;5% body weight should be screened. Physical frailty is particularly important as it may be prevented or treated with specific modalities such as exercise.</td>
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<tr>
<td>Cesari et al., 2013</td>
<td>European Union Geriatric Medicine Society working group on frailty</td>
<td>No clear guidance yet published. Physical impairment and sarcopenia are targets for interventions against disability. The choice of screening instruments should be driven by their characteristics and aims of the assessment.</td>
</tr>
<tr>
<td>Rolland et al., 2011</td>
<td>French Society of Geriatrics and Gerontology</td>
<td>Advocate screening for frailty. Frailty can be modulated by physical, psychological and social factors. Frailty can be defined by its effects on functional status (decline) and adverse outcomes.</td>
</tr>
<tr>
<td>Cruz-Jentoft et al., 2010</td>
<td>European Working Group on Sarcopenia in Older People</td>
<td>Sacropenia leads to the development of frailty. No accepted definition of sacropenia, working definition only. Consensus diagnostic criteria presented.</td>
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3.4 PERSSILAA general overview - concept

The “PERsonalised ICT Supported Services for Independent Living and Active Ageing” project or PERSSILAA (www.perssilaa.eu) is a FP7 funded European project (grant number 610359), combining a consortium (eight partners from five countries) from social, medical and technological sciences with industry, academia and end user organisations, with the primary objective of developing an ICT based platform to identify and manage community dwelling older adults at risk of functional decline and frailty. PERSSILAA aims to encourage a move away from the current model of fragmented, reactive disease management towards a preventive, personalised model offered through local community services which is both supported by a proactive team of caregivers and health professionals, and integrated into existing healthcare services. This multimodal service model focuses on three main pre-frailty domains, namely: nutrition, physical and cognitive function. It is supported by an interoperable ICT service infrastructure, which uses an intelligent decision support system and gamification strategies to encourage end users. PERSSILAA is designed for older adults (> 65 years) who are screened (using both rater and continuous self-assessment to identify and stratify their “frailty level”), triaged (to the appropriate ICT based solution to meet their needs), monitored (unobtrusively) and managed (with ICT supported services) through local community services.

This ICT intervention consisted of screening services to identify suitable subjects and specific trainings modules for health and ICT literacy, physical training, cognitive training and/or nutritional advice. The PERSSILAA services are offered online via personal or tablet computers in such a way that older adults can use them independently. In addition to a standard version there is also a gamified version. Gamified features encourage participation and compliance with the intervention and are designed to be fun and interactive. Participants are challenged to build a boat to escape from a virtual island but can only gather the pieces needed to do this by using the trainings modules. To investigate whether these ICT tools are agreeable to and effective for older adults, the PERSSILAA services were implemented in two different communities and two evaluation studies were performed. A prospective cohort study to investigate the adoption rate and usability in Italy and a multiple cohort randomized controlled trial (mRCT) in the Netherlands were conducted. A mRCT is a state of the art study design used to measure the effectiveness of new and rapidly emerging technologies. Cost effectiveness was investigated using the MAFEIP tool developed under the EIP on AHA framework. The PERSSILAA evaluation ran for a total of two years and participants were assessed at baseline and monitored at intervals.
4. PERSSILAA recommendations

PERSSILAA results overview
The results and recommendations derived from the PERSSILAA project are multi-dimensional based upon health related (including health literacy), ICT-related and organisational/institutional aspects of the project.

4.1. Health related recommendations
The first PERSSILAA results presented here describe the clinically relevant outcomes of the study and how these could be used to contribute to European guidelines for the screening of and prevention of frailty and functional decline in older adults. The main clinical areas that PERSSILAA feeds into relate to the following healthcare domains/areas:

a) Definitions of Pre-frailty and General Frailty
b) Physical Frailty
c) Nutritional Frailty
d) Cognitive Frailty

This first section outlines the three main healthcare related outcomes of the study that will contribute to the clinical and healthcare recommendations i.e. 4.1.1 recommendations relating to the definition of pre-frailty; 4.1.2, recommendations relating to the screening procedure to identify pre-frailty; 4.1.3, recommendations relating to monitoring of pre-frailty and 4.1.4 recommendations relating to integrated training modules for health and ICT literacy to manage pre-frailty.

4.1.1 Definition of Pre-frailty - recommendations relating to the study definitions of pre-frailty

a. Background
Although pre-frailty is characterised by a vulnerability to frailty and subsequent functional decline, no clear definition of pre-frailty exists. Instead it can be identified as an intermediate stage between robust and frail, which can be measured by several short frailty screens and defined by a cut-off score below that for frailty. It is acknowledged that there is a need to identify this pre-frail older adults, as pre-frailty is the target for effective and low cost interventions to prevent frailty.

b. Objective
The objective of this outcome was the selection of a shared vision of pre-frailty following a review of suitable definitions.

c. What was done? How?
As part of D2.1, the PERSSILAA investigators selected a definition of pre-frailty following a detailed state of the art literature review. After reviewing several possible definitions, the investigators met, debated, deliberated and decided upon a multi-factorial definition, in recognition of the multi-domain view of the investigators and the proposed PERSSILAA study.

d. Results
The consortium adopted the definition of frailty defined by the A3 action group of the European Innovation Partnership on Active and Healthy Ageing (EIP on AHA). Thus, to identify what is pre-frail, the PERSSILAA investigators used a clear definition of established frailty and adopted a mechanism to identify patients that fell short of this definition as a definition of pre-frailty. Overall, the PERSSILAA investigators felt that the shared vision of frailty selected in D2.1 is an acceptable definition of frailty, which could easily and practically be used to build a template for a working definition of pre-frailty.

e. Recommendation(s)
The result of the PERSSILAA project support the EIP on AHA definition of frailty i.e. “[Frail elderly are] older adults who are at increased risk for future poor clinical outcomes, such as development of disability, dementia, falls, hospitalisation, institutionalisation or increased mortality” and the development of a definition of pre-frailty based upon this.

Recommendation 1: The EIP on AHA definition of frailty could be adapted to define pre-frailty.

Recommendation 2: 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.

f. Target audience
The target audience for the development of an evidenced based definition of pre-frailty includes healthcare researchers and healthcare professionals, particularly those working actively in the community with older adults including those researching or implementing integrated care pathways for frailty. Public health professionals will especially require such a definition if interventions to prevent frailty are proven in order to rapidly identify and manage pre-frailty.
4.1.2 Screening Pathway for Pre-frailty - for risk of developing frailty i.e. Pre-frailty

a. Background – (i.e. approach to develop a screening pathway for pre-frailty):
There are currently no accepted guidelines on how to screen for and identify pre-frailty. The current evidence for this is weak as described above. The screening component of PERSSILAA was conducted using a two-phase approach. This involved the screening of people aged 65 years and older by trained volunteers/self-screening by email or postal questionnaire to exclude robust subjects and those established, followed by a second-level assessment by multidisciplinary staff of those classified as pre-frail in order to more clearly and specifically identify pre-frail older adults (i.e. to confirm this status with more detailed face-to-face assessment). Each of the three domains included in PERSSILAA were screened using this approach i.e. overall (generalized) pre-frailty and physical, nutritional and cognitive pre-frailty. No scientific paper was available that specifically reviewed instruments that can be used to screen for pre-frailty.

b. Objective
The objective was to identify suitable, short screening instruments and then to develop a reliable approach to quickly screen participants for pre-frailty, starting by excluding clearly robust individuals and then by separating those with established frailty from those with pre-frailty. This would need to be done for the general pre-frailty state or syndrome and for each of the three domains included: physical, nutritional and cognitive pre-frailty. The number of steps required to do this also needed to be decided upon/evidence based.

c. What was done? How?
A key component of this was the identification of suitable screening tools for pre-frailty including each of the three pre-frailty domains selected: physical, nutritional and cognitive pre-frailty. This was a key step in reaching consensus and consisted of a state of the art literature review based upon a search of multiple data repositories/scholarly libraries including MEDLINE, Web of Science, EMBASE, PsycINFO, Picarta, Google Scholar, and the Cochrane Controlled Trial Register. The following criteria were considered necessary:
1. The instrument should be reliable and valid,
2. The instrument should be suitable (validated) for an older population,
3. The instrument should have been used previously in a European setting;
4. The instrument should be sensitive and specific (i.e. with a high level of accuracy),
5. The instrument should be accompanied by an overview of outcome scores and cut-off points that specify the likelihood of an individual having a condition (in terms
of general frailty, or in terms of one of the three domains), i.e. separating normal from impaired.

6. The instrument should also be easy and quick to administer (and if possible self-administered).

The following were considered desirable:
1. The instrument was available in one or more of the validation country languages (i.e. Dutch and Italian).
2. The instrument should be quick to administer/short.
3. The instrument should be valid when self-administered
4. The instrument should be valid if administered by post or online (i.e. not face to face) as this was in-keeping with the ethos of the project and would be most feasible/practical.

This was followed by a review of different screening approaches. One-step or two-step screening strategies were reviewed. An external review was also conducted to ensure that the selected screening pathway along with the selected instruments was appropriate.

d. Results

From a clinical perspective PERSSILAA developed and employed a focused evidence-based strategy to identify pre-frail community-dwelling older adults. This involved the adoption and then creation of a novel two-step screening approach to identify suitable subjects that could benefit from PERSSILAA. In order to show that the PERSSILAA model and intervention could prevent onset of functional decline and subsequent frailty, pre-frail i.e. “vulnerable” community-dwelling older adults on the cusp of becoming frail were selected using this two-step approach: self-screening (postal/online questionnaires). Once the PERSSILAA platform was operational patients were selected randomly to participate in the clinical evaluation of PERSSILAA, described in Deliverable 2.1

Aspects of the three pre-frailty domains, selected a priori (i.e. nutritional, cognitive and physical frailty), were incorporated into the screening process and helped inform the selection of the screening instruments. This approach was chosen as it maximises the number of patients that could benefit from a platform such as PERSSILAA i.e. some patients might be cognitively pre-frail (e.g. those with mild cognitive impairment) but not physically or nutritionally frail. The screening and assessment (stratification) process was based on a ‘state of the art literature’ review with respect to the methods (strategy and instruments used). This utilised and combined novel techniques (email-based self-screening and ICT-based application monitoring) with established clinical practice (screening and monitoring in primary care under direct supervision by trained healthcare professionals). This hybrid model was necessitated and represents a step-forward in the implementation of a personalised healthcare.
Global measures of frailty were also used in order to provide an overall frailty construct allowing patients to be divided into robust, pre-frail and frail. Step one consisted of self-reported screening (using posted paper-based or emailed online questionnaires); step two consisted of a rater-observed assessment in a face-to-face interview to confirm the true frailty status of each subject. The agreed screening instruments were already translated into the local languages of the implementation sites in the Netherlands and Italy facilitating rapid initiation of the screening protocol. Instruments used in step one included the Mini-Nutritional Assessment-short form (MNA-SF) for nutrition, the AD8 for cognitive impairment and the SF36 for physical impairment. The Groningen Frailty Indicator (GFI) with a cut-off of ≥4/15 for moderate to severe frailty and demographic data were also collected at step one. Fried criteria were not used, as they focus mainly on clinical and physical frailty. The reference definition of frailty (that of the EIP on AHA) considers frailty to be a multidimensional multi-domain condition.

During step 2, the face-to-face assessment, specific frailty domains were evaluated using more detailed instruments to stratify participants according to their deficits and needs. This allowed a tailored ‘personalised’ approach to the implementation of PERSSILAA. Older adults were assessed for cognitive deficits using the validated Quick Mild Cognitive Impairment (Qmci) screen (O’Caoimh., et al 2012-2016), (Bunt et al., 2015), for nutritional deficits using remainder of the Mini-Nutritional Assessment (MNA G-R) and for physical function with specific functional tests (timed up and go test, chair stand test, chair sit and reach test, two minute step test) to confirm that they were pre-frail.

The results of this stratification process are presented in detail in WP3, D3.1. Screening included an assessment of all three pre-frailty domains as well as a general frailty measure to exclude robust subjects and those with already established frailty. The results showed that the two-step PERSSILAA screening-service seems a good method to quickly and accurately classify community-dwelling older adults into robust, pre-frail and frail. Specifically, statistical analysis revealed that the first screening was able to separate those who were classified as frail or robust. However the separation was less clear for those who were classified as pre-frail, in particular when their scores approached the cut-off points, a recognised challenge of using cut-off scores in clinical practice, which often require adjustment for patient specific features such as age or education (O’Caoimh et al., 2014b). Statistical analysis of the second level face-to-face screening showed a good agreement among the classifications of pre-frail and robust individuals. Hence, a two-step screening approach appears to be important to correctly identify pre-frail individuals.

e. Recommendation(s)
The results of the PERSSILAA project suggest that no one single domain will accurately or adequately reflect pre-frailty on its own. Thus, the results of PERSSILAA support the need to address several different pre-frailty sub-domains when screening for and assessing pre-frailty. This is particularly important given that currently there is no accepted definition of pre-frailty in use or accepted by recognised agencies in the EU or worldwide. The PERSSILAA investigators suggest that the domains selected in PERSSILAA are important but that other domains should also be included in future studies. The results also support the use of a two-step screening approach to identify pre-frailty in a community setting, which appears from this project to be an acceptable and accurate means to measure and identify pre-frail community dwelling older adults.

Recommendation 1: Pre-frailty should be considered a multi-domain, multi-factorial syndrome.

Recommendation 2: Several, different pre-frailty sub-domains should be addressed when screening for and assessing pre-frailty among older adults and should include cognitive, physical and nutritional pre-frailty domains.

Recommendation 3: More research is required in this area and future studies should capture multiple pre-frailty domains along with global measures of frailty.

Recommendation 4: 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.

f. Target audience
These results could be useful for healthcare practitioners particularly public health specialists and policy makers, as well as those working with older adults in the community such as those implementing and managing integrated care pathways for pre-frailty and frailty. Patients (community dwelling older adults) and their families could also benefit from this guidance, particularly those concerned about the development of frailty, those keen to discover if they or others are pre-frail and those determined to adopt proactive healthcare and lifestyle strategies to prevent onset of frailty and functional decline.
4.1.3 Monitoring for Development of Frailty - Technology-based tools to monitor everyday function of older adults to prevent functional decline

a. Background
Recent technology developments allow unobtrusive and continuous monitoring of health parameters in daily life. However, it remains a challenge to combine all the information collected in a meaningful way in order to obtain an overview of the everyday functioning of older adults. Furthermore, there are still well-known barriers hindering the adoption and acceptance of technology in daily life, such as low perceived usefulness of technology and poor self-rated technology skills (Scanlon et al., 2015).

b. Objective
To develop and evaluate a set of technology-based tools to monitor everyday function of older adults and support prevention of functional decline. Within the PERSSILAA project three health domains are concerned: nutrition, cognitive function and physical function.

c. What was done? How?
The PERSSILAA consortium, based on each partner’s expertise, worked together to choose health parameters and technological tools that were available at the time of the project to monitor everyday functioning. The final selection of monitoring tools consisted of a combination of questionnaires provided on the PERSSILAA portal, as well as, mobile and home sensing, delivered as follows:

- Nutritional domain – two questionnaires were selected to evaluate eating habits on the PERSSILAA portal: the 24-hour dietary recall and general questionnaires developed by the PERSSILAA team. Additionally, a ‘smart scale’ (weighing scale connected wirelessly to an computer application) was chosen to monitor weight on a daily basis and automatically upload the information into the PERSSILAA database.

- Cognitive domain – the domain experts met and discussed currently available instruments including computerised neuropsychological batteries but considered that, at the moment, no sensing tool was available that could fully meet the requirements of the PERSSILAA project (brief, validated, freely available, available in the languages of the study). Therefore, a shorter version of the Neuropersonal Trainer 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.

- Physical domain – a step counter was chosen to unobtrusively monitor daily physical activity and obtain an overview of physical functioning. These data were collected on a smartphone and then made available in the monitoring database. Given the growing evidence relating wellbeing to the everyday functioning of older people,
wellbeing was added to the parameters monitored in PERSSILAA. For convenience, the validated questionnaires were included under the umbrella of the physical domain. A smartphone application applying experience sampling was chosen to assess wellbeing on a daily basis.

The usability and feasibility of the monitoring module was evaluated through semi-structured interviews (perceived usefulness and intention to use) and through an assessment of the frequency of use of the technology during a period of approximately 4 weeks (actual use of technology).

d. Results
Twelve community-dwelling older adults participated in the monitoring module feasibility study over one month. At the beginning of the study participants were interviewed to assess current practices in the self-management of health and to evaluate expectations and intention to use of technology-based monitoring tools in their everyday lives. Additionally, during this four weeks, the same group of older adults monitored their physical activity, weight and wellbeing using a smartphone, a pedometer and a smart scale.

The results show that if health-monitoring tools are to be used in everyday life they must be designed with and for older adults. Older adults want to use technology that is designed for them, taking into account their personal health conditions, especially when multi-morbidity is present. Older adults look not only for feedback and guidance in their health behaviors, but also for the reasons underpinning why such behaviors or values are important. Older adults stated that they were aware of the importance of keeping a healthy weight and would like to have access to healthy recipes. Examining the cognitive domain, it was found that older adults like to play cognitive training games but do not want to be confronted or compared with the results of peers. Finally, it was found from the results of the semi-structured interviews that older adults regard being physically active as very important for both body and mind.

Thus, monitoring tools aiming to prevent functional decline must be tailored, provide meaningful feedback and include health literacy. Independent of their familiarity and comfort using technology at the beginning of the study, older adults were able to use the system during the 4-weeks period. In general, participants were satisfied with the monitoring tools and, especially the least active participants, referred that they became more aware of their lack of daily activity.

e. Recommendations
Based on the results of the monitoring module the PERSSILAA investigators suggest that there is no one-size-fits-all approach to monitoring older community dwellers for pre-frailty (i.e. its reversal or the subsequent development of frailty). Instead, means
to monitor subjects should be tailored to meet the needs and preferences of the users. To ensure that adherence does not drop and users keep engaged with the technology, users need to perceive an added value of using the technology in their daily lives. A possible solution is to give users the possibility to lock and unlock the functionalities they want, or do not want, to use. It may also be that monitoring needs to be unobtrusive to increase acceptability and reduce attention theft.

Recommendation 1: There is likely to be no ‘one-size-fits-all’ approach to monitoring older community dwellers for pre-frailty.

The PERSSILAA investigators found that older adults are willing to use technology in their daily life to monitor their health and support the adoption of healthier lifestyles. However, recommendations for behavior change should be complemented with the reasoning why certain behavior is, or is not, healthy. This also means that technology should always aim to improve the health literacy.

Recommendation 2: Monitoring of everyday function must be complemented by meaningful (older adult-specific) information to support the adoption of healthier behaviors.

As people grow old, they tend to adopt a functional perspective of health in a way that “being able to do daily activities independently” surpasses “avoidance of disease”. Therefore, it is of utmost importance to design tools aiming at keep this functional independence, instead of targeting specific health symptoms.

Recommendation 3: 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.

The study suggests that when input is required from the user, it is important to provide feedback, for example, in the form of an overview of the information collected.

Recommendation 4: When remotely monitoring older adults health (pre-frailty) status using ICT technologies, systems should provide feedback on the data collected.

f. Target audience
All stakeholders involved in the design, development and implementation of mobile technology to support prevention and early detection of pre-frailty and functional decline.
4.1.4 Training Modules to Manage Pre-frailty (to enhance active and healthy ageing)

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.

As of the 4th of November 2016, 3802 participants were pre-screened (step one of screening) of which 895 (24%) 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 568 of the 632 (90%) were pre-frail among 632 participants making 90% of the participants.

4.1.4.1 Nutrition Module

a. Background

Nutrition plays an important role across the life span, especially for older adults. Among community dwelling older people (> 65 years old), 5-10% are undernourished, and for those in institutionalised care, the prevalence can reach 30%-65%. The cause is often inappropriate food consumption (van Staveren et al., 2011), manifest by a gap between actual nutrient consumption and recommended dietary intakes. Hence, the importance of nutritional education to negate the impact of consumer misinformation about the benefits of food choices become clear with the recognition that nutritional status influences the rate of physiological and functional decline with age.

b. Objective

To develop an easy-to-use website with nutritional information, scientifically based and delivered by experts to educate, not only older adults, but also the general population. Concepts bridging nutrition with related scientific areas such as chemistry, biochemistry, statistics, landscape architecture and organic agriculture were offered aiming to provide education on what you should eat, how and why.

c. What was done and How

The Portuguese team within PERSSILAA developed the NUTRIAGEING website (http://nutriageing.fc.ul.pt/) as a platform for the transfer of scientific knowledge into usable person-centred advice to the general public. The NUTRIAGEING website is an informative website with a clean, easy-to-use, “app-like” interface with minimal menus or other clutter. The responsive layout ensures device-independent accessibility and a good viewing experience to the user, since it automatically adjusts to fit the screen of a desktop computer, a laptop, a tablet or a mobile phone, either horizontally or vertically oriented. The NUTRIAGEING website offers several modules to promote healthier nutrition, educate people how to improve their eating habits.
habits and how to grow vegetables. It is structured around three major themes: (1) Healthy eating, (2) Recipes and videos, and (3) Vegetable gardens. The “Healthy eating” section, developed by nutritionists, chemists and biochemists, is mainly focused on nutrition literacy, with general information on healthy eating habits, clinical nutrition and understanding nutritional labelling. This section was developed aiming to cover specific subjects dealing with nutritional eating habits that are responsible for several chronic diseases in older people, such as diabetes, obesity, hypertension, among others. The included 11 topics, in the sub-section “How much should I eat?”, were planned to cover general information that can be useful not only for older people, but also for other persons interested in this subject. The topic of functional ingredients also reports on findings that are the outcome of lab work, shown to illustrate how to discover new ingredients, and to highlight the importance of innovative work in the area, with citation of the publications thereof for further reading, if required.

Regarding “Clinical nutrition”, it is expected that older people clearly understand the importance of the nutritional evaluation, and it provides tools for their self-assessment of weight, body mass index, waist circumference, among others. The sub-section “Nutritional labelling” will be very useful for older people and others to perform informed choices when they acquire their food products. Afterwards an “Enjoy” subsection with word puzzles and quizzes for people to test their knowledge and to entertain themselves. The “Recipes and videos” subsection is an innovation of this website. It includes 15 videos of recipes developed by the Chef Hélio Loureiro, the famous Portuguese Chef. While cooking a recipe, he discusses the nutritional value of the recipe, and the benefits of the herbs, vegetables, fish or meat used with three experts who have previously conducted research on the recipe components to bring this knowledge to the general public in a pleasant discussion with the Chef. The “Vegetable gardens” section is another innovative area of this website. In this section a landscape architect teaches users how to plan a vegetable garden in a variety of settings from the backyard to the balcony or even small pots on the kitchen window. All these sections are interconnected and crossed-references.

d. Results and Experiences
The functionality of the website was tested in two day care centres in the Lisbon area (Casa de Repouso dos Arcos, http://casarepousodosarcos.pt/; and Magnolia Villa, http://www.magnoliavilla.pt/). This evaluation involved a total of 45 older adults from these centres and their caregivers. Participants were informed about the PERSSILAA project and the PERSSILAA nutritional module. They were asked to navigate through a shorter version of the website with contents in Portuguese, using computers and iPads provided by the researchers. They also watched three selected videos in Portuguese on TV (seasonal and non-seasonal food, nutritional labelling and the health benefits of beer and wine). Afterwards these recipes were prepared in each institution to evaluate the ease to which these could be scaled-up and to receive comments and feedback from the older adults and their caregivers.
The overall feedback was very positive and everyone was eager to see the full version of the website (currently in the process of translation into Portuguese). Concerning the ‘vegetable gardens’ section of this module, in one of these day care centres (Casa de Repouso dos Arcos), plans were developed for two unoccupied garden areas (see projects 1 and 2 on the NUTRIAGEING website). Project 1 is an aromatic garden growing parsley, coriander, basil, rosemary, lavender, thyme and lemon thyme, which can be picked whenever they are needed. Project 2 is a vegetable garden with plants that are easy to plant and maintain, producing vegetables for use in everyday meals, including common beans, tomatoes, lettuces, carrots, onions and garlic.

e. Recommendation(s)
The PERSSILAA project found that ICT products that bridge science and society 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 promote learning. Improvement of nutritional knowledge of the population is extremely important, especially for older people. Educated people make better and healthier choices.

Recommendation 1: Education, required to promote healthier eating habits among the general population and in particular pre-frail older adults, can be delivered successfully with an online format.

Interventions based on factual nutritional guidance have proven efficacy in achieving behavioral changes. Day care centers and healthcare professionals, including dietitians, family physicians and nutrition professionals benefit from nutrition education to help them engage with patients and to provide advice and counsel to their families towards the adoption of healthier eating habits. PERSSILAA shows that the education of caregivers may also be important to encourage healthy choices among older adults.

Recommendation 2: 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.

Chefs and other professionals working with food in settings such as day care centers and hospitals may benefit from nutrition education to help them prepare healthier meals for older adults.

Recommendation 3: Educating cooks and professionals involved in food preparation on the benefits of 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.
Older adults and their caregiver found the NUTRIAGEING website interactive and easy-to-use, even if they were not experienced using ICT tools.

Recommendation 4: 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.

f. Target audience
This recommendation is important for the general population, older adults and healthcare professionals working directly with older people such as those working in day care centers, dietitians, family physicians and nutrition professionals. It is also important for those in the food industry such as Chefs, in particular those employed to provide food in day care centers and hospitals. Other important end-users include policy makers from governmental agencies, national health laboratories and city councils.

4.1.4.2 Cognition Module

a. Background
Ageing is associated with an increased prevalence of cognitive ageing and cognitive impairment. There is a need to identify quick, effective, low-cost solutions to identify and delay the onset of pathological cognitive decline. Cognitive aging is a public health concern from many perspectives. Individuals are deeply concerned about decline in memory and decision making abilities as they age and may be worried about whether these declines represent the early signs of a neurodegenerative disease, particularly those with a family history. Cognitive decline affects not only the individual but also his or her family and community, and an array of health, public health, social, and other services may be required to provide necessary assistance and support. Interest in training programs designed to improve cognitive abilities in older adults has been growing steadily in recent years. Cognitive training, often called ‘brain training’ typically involves guided practice on a set of standardised tasks designed to reflect particular cognitive functions such as memory, attention or problem-solving. This training can take many shapes. For instance, it can be conducted on the computer or delivered in person, either individually or in small groups but it typically involves using repetitive exercises designed to improve single (e.g., memory) or multiple (e.g., memory and reasoning) cognitive abilities. Growing evidence suggests that late-life cognitive activities, independent of early life experiences like education, can reduce the risk of dementia by 40-50%.
b. Objective
To adapt the Guttmann NeuroPersonalTrainer® (GNPT) platform to the PERSSILAA framework and it’s specifications. GNPT is a suite of tools designed by Guttmann for use by professionals in the area of neuropsychological rehabilitation and cognitive stimulation. It requires a professional (expert) to perform a neuropsychological assessment in order to establish the initial profile of cognitive impairment and design a personalized treatment. Therefore, the objectives were twofold: to (1) design and develop a cognitive training self-management program and (2) to integrate the GNPT with PERSSILAA by making specific adaptations to it’s framework.

c. What was done? How?
In the PERSSILAA project the proposed approach was that every end-user would execute the complete set of cognitive training tasks. Therefore, in the initial phase a suitable set of cognitive training tasks were selected by Guttmann based on previous experience in other projects (e.g. the FP7 funded CLEAR project). Two groups of tasks were selected, the first group (Block 1) are assessment-oriented and the second group (Block 2) are training-oriented tasks. Block 1 is composed of 10 different tasks and Block 2 is composed of 25 different tasks. Both groups of tasks cover the main cognitive functions involved in ADL.

Therefore after completing Block 1 tasks, users began to iteratively execute Block 2 tasks over 12 weeks training, 3 sessions per week with each session lasting one hour. Each task in Block 2 is assigned a difficulty level with four levels of difficulty in total (L1, L2, L3, L4) according to each task’s specific input parameters. After each task is complete the user gets a performance score ranging from 0% to 100%. The system then defines three different ranges of performance according to each task’s score:
- Therapeutic range, when the score is between 65% and 85% of correct answers. The user has executed the task with an appropriate difficulty configuration in order to get the best treatment effectiveness.
- Infra-therapeutic, when the score is below 65%. The difficulty level of the task is too high for the patient's capacity and could lead to frustration.
- Supra-therapeutic, when the score is above 85%. The difficulty level is too low for the patient's capacity and neurological activation is likely to be insufficient, also potentially leading to frustration.

This algorithm was tested and its contents translated into the three languages of the study (English, Italian and Dutch). Individual modules were developed for each of the two validation regions (Campania and Enschede). Usability testing was performed in each region and the algorithm was integrated into the PERSSILAA platform to be evaluated in both regions.
d. Results? Experiences?
Usability testing performed in both regions showed satisfactory results; 6.4 on the system usability scale (SUS). Cognitive training has been performed in both validation regions. In Campania cognitive training was offered during 15 collective sessions with a total of 223 attendees. As older adults trained in groups and people came multiple times not every 223 reflect a single user. In total 53 user were identified. In Enschede 18 older adults used the cognitive module out of the 46 involved in the integrated platform evaluation. They together performed 893 tasks during 107 sessions.

e. Recommendation(s)
Recommendation 1: 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 2: 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 3: 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 4: 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 5: 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.

The investigators make several recommendations for further study based on their experiences developing the PERSSILAA cognitive training module. The self-management cognitive training algorithm was installed as a desktop Windows PC application that can be separately installed into any Windows PC and can also be launched from PERSSILAA platform. Mobile devices have become an important part of personal computing as the capabilities of devices like tablets continue to improve and become integrated into the everyday life of older people.

Recommendation 6: 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).

The contents of cognitive tasks should be tailored to end users’ preferences. This customization can be achieved by including a “Preferences” field in the users’ profile. Current users profiles include typical fields such as identifier, username and age.

Recommendation 7: 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.

f. Target audience
The target audience includes older adults (> 65) at all levels of cognitive impairment, informal care givers (family, assistants, auxiliaries, informal carers) and healthcare professionals involved in public or private healthcare services, residential care homes, and social services (e.g. nurse specialists, geriatricians, neuropsychologists, psychologists, occupational therapists, internists and neurologists).

4.1.4.3 Physical Module

a. Background
Increased physical activity or regular exercise training are proposed as preventive strategies for frailty and its adverse outcomes. A recent systematic review showed that physical exercise interventions are beneficial for frail older adults in terms of functionality and ADL and can delay progression of functional impairment or disability (Giné-Garriga et al., 2014). However, there have been relatively few attempts to evaluate such strategies aimed at the prevention of functional decline in pre-frail, older adults.

One widely used home-based exercise intervention is the Otago Exercise Programme (OEP), which is a cost-effective home-based individually tailored falls prevention program delivered by physiotherapists (Robertson et al., 2001). As frail and pre-frail older adults are more likely to experience a fall than age-matched robust older adults (Fried et al 2001), this program might be a beneficial prevention strategy for pre-frail older adults to prevent or delay onset of frailty. However, the impact of this home-based exercise program in this population is unknown. In addition, to respond to demographic changes and the economic impact of (pre-) frailty it might be important to not only depend on the involvement of physiotherapists, a limited resource, but to increase self-management among this target group. This might reduce healthcare use and costs in the future.

b. Objective
To develop a technology-supported self-management program for use with PERSSILAA, based on the OEP to prevent functional decline in physically pre-frail, older adults who live at home.

c. What was done? How?
CoCo, an existing physical exercise platform, containing advice and instructional videos, was used as a starting point for the development of the PERSSILAA physical training module. The main challenge was to transform CoCo from a supervised exercise platform into a predominantly self-managed program. To understand what the requirements for such a self-management program for pre-frail older adults should contain, different actions were taken. For this, we used a user-centred design approach. This user centred design is an iterative process in which the needs of the end-users (physiotherapists and older adults) are addressed at each stage of the design process. The information that resulted from this approach was used to make a first version of the physical training module, which was validated with both older adults and physiotherapists. This was used to perform a requirements analysis, which resulted in a first version of the PERSSILAA physical training module. This first release was validated again and a final release was made after that. For a more extensive description of the development of the physical module see D3.3.

d. Results? Experiences?
Results are described in detail in D5.3.2. The results of the first cohort were analysed and will be described in a scientific paper, which will be finished in the upcoming months. The results described below represent an analysis of the first cohort involved in the mcRCT of PERSSILAA including 21 participants in the control group and 15 participants in the intervention group. These were requested to train online 3 times a week for 12 weeks.

Satisfaction
Participants that used the physical training module were very satisfied and evaluated the module as excellent on the system usability scale (SUS), an average score of 84. Initial problems with starting the physical module in the participants homes were mainly related to interface software problems (old internet browsers or the lack of flashplayer installed on their computers), which had to be corrected in order for participants to be able to watch the exercise movies. Those problems were resolved by setting up a helpdesk.

Adherence
The number of participants dropping out of the module was low. The main reasons for drop-outs were health problems (not related to the program) and technology problems (computer issues). Of the participants finishing the complete protocol (i.e. 12 weeks of training), the majority continued using the service for another 6-40 weeks. Participants trained on average about twice per week. The mean login time for each
exercise session was approx. 24 minutes. Participants preferred to perform the exercises in the morning (43%) or afternoon (47%) rather than the evening (10%). Most of the exercise sessions were performed during weekdays (83%) rather than over weekends (17%). Three older adults visited the login page weekly (once a week) to receive some additional feedback about the exercises. For one participant, the therapist used the option to turn some exercises off due to health problems unrelated to the program (pain in shoulder). In this way, this participant was able to continue using the program.

Health status
In the first cohort of 21 participants, the intervention group reported greater increases over time on the Mental Component Survey (MCS) of the Short Form 12 (SF12) compared to the control group. Scores on the MCS of the SF12 were significantly higher in the intervention group pre- and post-testing, whereas there were no significant changes over time in the control group. A trend was also found in the change of the self-reported health status over time (EQ5D-Index values) between the intervention and control groups.

e. Recommendation(s)
All older adults who screened positive for pre-frailty received access to the exercise module. However, only a small number of participants started using the module. Thus, simply making older adults aware of their health status and risk for developing frailty and functional decline (in this case physical), doesn’t mean that they will become motivated to exercise at home. In addition, even those who engaged with and used the exercise module, only a small percentage complied with the recommended exercise protocol of 3 times a week for 12 weeks.

Recommendation 1: 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.

The study found that pre-frail older adults were able to use their home computer and perform the recommended exercises correctly. Three participants chose to train at a central supervised location or to consult a therapist for further information (e.g. in case of persistent physical complaints unmasked by participating). This suggests that there is a very real future for home exercise programs for pre-frail older adults to prevent onset of frailty and functional decline.

Recommendation 2: 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.
The first results from the evaluation of the physical training module suggest that it is effective in increasing quality of life and the self-reported health status of pre-frail older adults using the module compared to a control group without access to the exercise program. This indicates that it is useful to motivate older adults to start using the module.

Recommendation 3: 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.

f. Target audience
This project suggests that the general population of older adults but especially those people at risk of frailty and functional decline (i.e. pre-frail older adults) would benefit most from the results of PERSSILAA’s physical training module. People in the community, rehabilitation centers, care centers and health care professionals would also be interested in such a training module.

4.2. ICT related recommendations
The central component of the PERSSILAA project was to develop an ICT supported platform to deliver a holistic screening, monitoring and intervention programme for pre-frail community-dwelling older adults. This section discusses recommendations arising from the development of the platform that might be useful to other researchers and programme developers designing future similar projects to mitigate the onset of frailty and functional decline.

4.2.1 Development of ICT supported platforms

a. Background
eHealth can be defined as a consumer-centred model of healthcare where stakeholders collaborate utilizing ICT including Internet technologies to manage health, arrange, deliver, and account for care, and manage the wider healthcare ecosystem.

b. Objective
The objective of PERSSILAA was to develop and implement the necessary technical infrastructure to allow the team to provide defined services to final end-users to target pre-fraility and prevent onset of functional decline across the three pre-frailty domains.

c. What was done? How?
As different clinical domains (physical, cognitive, and nutrition) are covered by PERSSILAA for different purposes (screening, monitoring and training) it was necessary to not only develop new specific services but to integrate this into existing
ones. The PERSSILAA platform relies on a technical architecture which consists of different building-blocks (modules) that group functionalities and features of the services together in order to offer it to the final (end) users including: user interface, personalization, privacy and security, interoperability, interoperability, screening, training and monitoring modules, a gamification layer, and an intelligent core.

d. Results? Experiences?
The PERSSILAA project developed an ICT platform incorporating all the modules and functionalities defined in the project. For this purpose, we have used Liferay, a free and open source enterprise portal project written in Java, which has features commonly required for the development of websites and portals. This includes a built-in web content management system that allows users to build websites and portals as an assembly of themes, pages, portlets/gadgets using a common navigation.

In order to have the platform up and running, available on-line, we installed it over a Nginx web server software on a Linux distribution, with a Tomcat servlet container using MySQL for the relational databases. In addition, a Data Warehouse was created to make queries and knowledge extraction easier, since it includes all the valuable clinical information pre-structured and pre-processed.

Regarding interoperability, the term is defined as the ability of (healthcare) ICT systems to work together within and across organizational boundaries in order to advance the health status of, and the effective delivery of healthcare for individuals and communities. In the PERSSILAA project we focused on defining the procedures and technical specifications needed to achieve both syntactic and semantic interoperability. After carrying out a proper and clear definition of the information that we want to store/exchange within the ICT systems involved in the project, ontologies were used to represent knowledge relevant to achieve the objectives of the project.

The specification and definition of this knowledge was done using information provided by previous work done to define each work package expanded using data obtained by a new round of interviews and specification with the experts in each pre-frailty domain (cognitive, physical, and nutrition) and general frailty. This successfully integrated all the external services that were used in the PERSSILAA platform. In this context external services refers to the applications, software and platforms developed outside the framework of the project itself, but included as part of the final PERSSILAA platform as services provided to end-users. The methodologies and procedures followed for integrating the training modules (Guttmann Neuro Personal Trainer, CoCo and Nutriageing website), the Endocare platform (used in Italy for screening users), and the monitoring module (both the Fitbit application and the Guttmann Neuro Personal Trainer cognitive monitoring tasks) were carefully defined.
Finally, being able to understand and interpret the information managed and stored in ICT platforms such as PERSSILAA is crucial for clinical projects. In this regard, the main objective of the intelligent layer of PERSSILAA is to process and analyse data in order to automatically detect changes in user behaviour and provide responsive personalized suggestions by comparing previous results of users with similar characteristics. To achieve this, we first carried out a state of the art review examining relevant projects, solutions and techniques that could be applied to the intelligent layer of PERSSILAA. Then, we defined the three main parts of the intelligent layer: 1) a classification layer (process) on top to cluster users based on the results obtained in screening; 2) a monitoring layer (data warehouse) where all information gathered from the different services of PERSSILAA is stored, pre-processed and structured to facilitate queries and knowledge extraction; and 3) a specific clinical layer resulting in what is called the PERSSILAA profile, where data from each of the three training modules and the periodically monitored information is fed into the initial profile of each participant to ‘fine-tune’ the “frailty profile” of a person.

### e. Recommendation(s)
Projects such as PERSSILAA shows that ICT is can realistically provide remote health services such as online screening, assessment and monitoring, which in the case of PERSSILAA relates to the management of pre-frailty among community-dwelling older adults in order to prevent onset of frailty and functional decline.

**Recommendation 1:** *ICT and telemedicine solutions can overcome geographical barriers in assessing and monitoring community-dwelling older adults for pre-frailty, extending service provision in a more efficient and sustainable manner.*

Data collected using ICT platforms such as PERSSILAA) in real-time can be used to create innovative, responsive and adaptable solutions to everyday problems. The growing use of mobile devices increases, even among older adults, is opening up new and promising opportunities to change and improve user’s lives focusing on what is most important to them, their ADL.

**Recommendation 2:** *Incorporating automatic behavioural patterns into intelligence-based ICT supported platforms that manage pre-frailty among older adults appears to be practical and should focus on activities of daily living.*

### f. Target audience
The targets for recommendations relating to the development of the PERSSILAA platform and how this could be reproduced and expanded to assess and monitor for pre-frailty include engineers and ICT developers and others with an interest or specialisation in telemedicine or biomedical engineering i.e. those interested in developing and applying IT solutions to healthcare problems.
4.2.2 Acceptability and adoption (accessibility) of ICT supported services - Measures to improve accessibility of ICT supported training platforms for pre-frail community-dwelling older adults to manage pre-frailty.

a. Background
It is not known if ICT supported services such as PERSSILAA are acceptable and accessible to older community dwelling adults, specifically those with pre-frailty i.e. those at risk of developing frailty and functional decline. PERSSILAA investigated the process of implementing and adopting technology supported ICT services in everyday life and routine clinical practice.

b. Objectives
To discover if older adults are ready and able to adopt ICT supported self-management services by investigating the responses of those participating in the PERSSILAA project to understand what motivates older people to engage with ICT supported services. We also investigated if these are acceptable to older adults in the Netherlands and Italy.

c. What was done? How?
As part of the PERSSILAA project ICT supported services were developed and implemented in the community targeting older adults aged between 65-75 years. This service consisted of different modules; a screening module and three training modules. Older adults were particularly involved in the early stages of the study and design of the modules. Their feedback and input was integrated using an iterative approach. In this way PERSSILAA communities were involved, informed and empowered to appreciate how ICT tools can improve their health. Investigating the adoption of PERSSILAA services was the main goal of the Italian pilot in Campania. Training modules were designed to match the preferences, values and priorities of older adults to ensure their interest and engagement. ICT tools were gradually embedded into the face-to-face training, seamlessly integrating with daily activities. Assessing acceptability provided information about how and to what extent ICT-supported services can be implemented and adopted by older adults on a regular basis, how much older adults can become self-sufficient in monitoring and how much they use PERSSILAA ICT supported services. Addressing health and ICT literacy gaps with an integrated approach was pivotal to ensure adoption, both for the service providers and the older adults.

d. Results
In the Netherlands the general practitioner invited patients between 65-75 years of age to participate in the PERSSILAA project and sent them a request to fill in a questionnaire. A total of 4071 older adults participated of whom 1053 responded online (26%). A total of 3131 answered that they have access to the Internet (77%).
which suggests that despite this less than 1/3 of participants were in a position to adopt the online screening module in the Netherlands. Older adults did not seem to be fully aware of the need to become proactive (with respect to managing their health), with many suggesting that ‘they will go to the doctor if something happens’. From those persons that were, initially, eligible for online health training (i.e. the pre-frail), only a small group used the online physical training module. Later on, we provided all older adults that we had an email address for with access to the online physical training service. This resulted in only 81 users in total. For the cognitive module, an additional 18 persons made use of this. The participants who used the physical training module completed the SUS and a modified version of the unified theory of acceptance and use of technology (UTAUT). These older adults also scored the usability as good with an average score of 83.7 (SD 12.1) on the SUS scale. The score on the SUS for the cognitive module was lower; 63.2 (SD 10.4). This indicated a satisfactory rating and was within the acceptability range. For the UTAUT, ‘the intention to use’ domain for the physical module scored an average 6.3 (SD 1.0) (based on a 7 point scale), which indicates that they would use the module again. The average score on the satisfaction domain of the UTAUT for the cognitive module was also high; 6.3 (SD 1.1).

In Campania, in Italy, older adults (aged >65) from the two initial communities recruited were invited to become stakeholders and to meet with researcher and healthcare professionals from PERSSILAA. Two more communities were invited and using an iterative approach, older adults were enrolled in the screening and training activities. In all, 359 lessons were held, modules focusing on ICT and health literacy, with a total attendance of 2560, an average of 13.5 older adults/lesson. Six themed lessons were held where contents were selected in collaboration between professionals and older adults. ICT lessons were integrated into all the other courses, to allow exploitation of PERSSILAA tools when the older adults ready. Topics included healthy lifestyles, disease prevention and food safety. The training task force involved university professionals, GPs, ICT experts and food safety experts.

In order to assess the adoption of PERSSILAA services by older adults, we carried out a UTAUT study on the new ICT supported services and used the SUS to assess how PERSSILAA services met the needs of the end users (e.g. ease-of-use, and other prerequisites the end-users brought into the modules/platform during R&I). The SUS was used to assess the level of satisfaction with using the PERSSILAA services. The average score was 48.19/100, with a polarized distribution of the individual satisfaction level scores. From the content of the interviews, older adults all basically agree that PERSSILAA services increase the level of their individual performance under the social, physical, cognitive and nutritional domains. Older adults agree that PERSSILAA is easy to use, allows collective use of the tools, but at the same time they believe that there are currently no facilitates or measures available to support them in using such services due to constraints within the current social and healthcare system, particularly the lack of supportive infrastructure. Older adults rated the
importance of PERSSILAA services to their family and social environment as very high.

Thus, one could say that the acceptance of the digital services is high, the adoption by own initiative in PERSSILAA was rather low. We should however realize that the PERSSILAA project has been pioneering in this challenge and that the process has provided us with invaluable lessons for successfully offering digital, preventive health services for older adults. By bringing adults into the design process early their preferences were integrated into the design of every element in the study. These end-users consistently rated it as useful, accessible and important. PERSSILAA assessed the process of adoption of ICT supported services to prevent frailty in community dwelling older adults in “real” environments. The challenge of adherence to the services has been addressed by conjugating the health and ICT content that was delivered in the training, thus increasing the value of the intervention. A long lasting adoption of this kind of services requires a major mind shift and needs a proactive approach from older adults themselves to “own” the process and engage with the learning process. Developing the process has provided us with invaluable insights into ways to successfully offer digital, preventive health services to older adults, which take into account important contextual factors such as the value that older adult place on socialization opportunities when ICT supported services are provided as a group activity. It must be noted however, that this was evident in Italy but not in the Netherlands, where participants valued their privacy.

e. Recommendation(s)
ICT literacy was generally low among older adults in Italy (Campania region). Nonetheless, older adults are receptive to using ICT supported services, particularly when they see an added value to it. Being able to access reliable information about their health status in a “user-friendly” format that takes local and older adult specific factors into account appears to encourage adoption among older adults. When ICT is gradually and seamlessly integrated into the lives of older people through use of the training modules, it becomes part of their daily routine, further encouraging adoption. This means that training can be regarded as an essential part of a “healthy lifestyle”.

While a majority (77%) of older adults in the Netherlands (Enschede region) have access to the Internet, only approximately one third were able or interested in using online approaches to screening. We recommend that at present, while the number of older adults with access remains less than the average percentage for all age groups combined, that older adults should be able to self-screen using multiple formats. More research is needed, that aims to explain why older adults do or do not use online health services. Such insights are crucial for formulating successful implementation strategies. Increasing the health and ICT literacy of older adults should be a part of providing this ICT services.
Recommendation 1: Older adults should be offered self-directed screening for pre-frailty, targeting them in their communities, through both online and traditional pen and paper postal questionnaires.

In the PERSSILAA project, the adoption of the different training modules was very modest when they were offered exclusively as remote ICT tools. Some of this seems to be related to a lack of familiarity with the use of ICT tools in a healthcare context and a lack of awareness of the importance of preventing the development of frailty by identifying pre-frailty and engaging, where appropriate, with tailored strategies (in this case the PERSSILAA platform) to prevent onset of frailty and functional decline. Knowing that identifying pre-frailty improves independence by engaging in appropriate and tailored strategies (in this case the PERSSILAA platform) may also encourage adoption and adherence. Given this, it seems important to make older adults more aware of the importance of managing their own health, of which activities can impact their health and to make them aware what it really means to be active. Further, older adults often think they are already sufficiently active because they walk every day. But it is important to take into account other dimensions of physical capacity, such as balance, flexibility, strength and endurance in order to prevent health related problems and (physical)

Recommendation 2: More attention should be paid to health and ICT literacy among older adults using ICT supported training services, either remotely or through face-to-face activities, by providing information about the benefits of preventing health related problems such as frailty and on age appropriate standards and targets so that they can better understand their current status.

Recommendation 3: Simple, conventional indicators such as page hits may not adequately reflect the acceptance and adoption of the digital services such as PERSSILAA. More research is needed, that aims to explain why pre-frail older adults do or do not use online health services. Such insights are crucial for formulating successful implementation strategies.

f. Target audience
The groupings most likely to benefit from these recommendations are older adults, caregivers (where appropriate) and community-based healthcare professionals and educators managing the care of older people. Public health managers and policy makers would also be interested in the benefits of this sustainable and effective approach.
4.2.3 Evaluation of ICT supported training platforms – Evaluation of the PERSSILAA module

a. Background
It is not known whether ICT supported services targeting specific pre-frailty domains and general pre-frailty can prevent onset of frailty or functional decline and improve health related quality of life.

b. Objective
The objective of the PERSSILAA project was evaluate how this could influence the outcomes of pre-frail community dwelling older adults in the community as a evaluation/proof of concept study.

c. What was done? How?
To evaluate the effectiveness of the ICT supported training the study design of a “cohort multiple randomized controlled trial” (cmRCT) was used. A cmRCT aims to replicate the in real world routine healthcare, by (1) recruiting a large observational cohort of patients with the condition of interest; (2) regularly measuring outcomes for the whole cohort; and (3) bringing the capacity for multiple randomized controlled trials with new releases of technology supported service over time. After each second screening held in the Enschede region of the Netherlands, every participant was given an information letter about this study and the training modules. If they gave informed consent, the older adult was asked to fill in a questionnaire every three moments about their health status. A part of this cohort group was randomly assigned to the intervention group and were asked if they wanted to use the online training module(s). A new intervention group was randomly assigned every time a new release of the platform was ready.

d. Results
The results showed that there were no significant differences between the cohort and intervention groups over time. Cognition did however seem to improve over time using the intervention, although this was not statistically significant. The intervention group scored above the cut-off point of functional decline compared to the control group who scored below the cut-off point at the end of the study, but again this difference was non-significant. Quality of life also seemed to improve initially after use of intervention but this effect was not sustained after a longer period of time and again was not significantly different between the intervention or control groups.

We experienced that commitment to the training module was variable. If something went wrong with one of the modules, people quit easily and did not start using the module again when fixed. Some participants explained that they did not use the
module often because it did not fit into their daily routine and changing this was difficult. On the other hand, there are some very motivated users, especially the physical module, who used the training module for much longer than the 24 weeks they were prescribed. They stated that the training module helped them to stay fit and did not want to miss this training routine.

e. Recommendation(s)
Recommendation 1: *It is important to know whether older adults have a preference for unobtrusive or more interactive modules before beginning training/monitoring with ICT platforms designed to manage pre-frailty (where they are constantly engaged) to ensure compliance.*

Recommendation 2: *The physical training module seems to improve quality of life and older adults tend to adhere to these services.*

This study’s use of the cmRCT design appears to be a useful methodology for rapidly evaluating the effectiveness if evolving technologies.

Recommendation 3: *A cmRCT design appears to be a useful methodology for evaluating rapidly involving technologies such as the PERSSILAA platform and could be used in studies designed to assess/validate ICT platforms that manage pre-frailty.*

f. Target audience
The target audience for the use of the ICT training modules should be pre-frail older adults themselves because they would benefit the most from training to prevent health related problems. In the future it will be more common for this target group to use computers/ICT. The ICT modules developed during the project are improved with the feedback of the participants and if the acceptance and awareness of the benefits of working on your own health is raised so will the effectiveness.
4.3.4 Utility of Gamification - techniques as a way to engage and maintain/promote active and health ageing among pre-frail older adults.

a. Background
Using gamification in a healthcare context can contribute to long-term engagement by adding elements of meaning and fun. Engagement is however fully dependent on how well the game is designed. When developing games for health, it should always be kept in mind that motivation and engagement are intricate principles that may require an artistic and creative approach rather than a scientific one. It is essential to take into account user preferences and abilities although this is often underestimated or even overlooked. To create a motivating and engaging experience for ageing users, it is important to provide meaning, explanation and context to all actions. It should at all times be clear how and why for example exercise results are reflected in a game, to lower the threshold of both initial and prolonged adherence to the game and underlying training goals. Over the course of several years, game preferences of older adults have been explored extensively and a method has been developed to not only structure these preferences but also create guidelines to determine a suitable design strategy to incorporate them into an engaging gamified system. With the rise of gamification in many different settings, for example in corporate environments and marketing from where it originates, we have learned that deciding the right approach demands great care. Game mechanics that are too simplistic or rely on behaviour conditioning principles may be attractive for a short while, but will certainly not be useful in a long-term training goal as is the case for PERSSILAA. Efforts in creating gamification to motivate the older adult should aim to facilitate a diversity of preferences.

b. Objective
To evaluate if gamification techniques could be applied to pre-frail older adults participating in the PERSSILAA project to increase and maintain engagement with the training modules i.e. to develop a gamification layer with the main goal of creating coherence, meaning, engagement and motivation for users was incorporated into the PERSSILAA platform.

c. What was done? How?
In order to develop acceptable and effective gamification strategies for PERSSILAA, three studies were conducted. These studies were conducted to provide insight into the state-of-the-art of gamification as a strategy and on the possibility of tailoring game design and content to create a personalised experience for older end users when interacting with ICT platforms.

We performed a series of studies, each logically following on from the result of the previous, starting with a literature review to gain insight in the state-of-the-art of
gamification. This first study found that there is no clearly defined concept of gamification relating to older people in the current literature and no strong guidance on how to classify game preferences for this target group.

The second study, involving 243 participants, investigated the relationship between end-user personality and game preference by means of an online questionnaire, in order to tailor game content to the needs of individuals or user groups. The results showed that there are several significant correlations between personality and game preference for younger people (<60 years of age) but that they are minor such that we not conclude that personality clearly indicates game preference for this group. No significant relationship was found for older participants (>60 years and older).

In the third study, we further investigated whether there is any relationship between personality and game preference. We hypothesized that this correlation exists for older people but wasn't captured in the questionnaire. To investigate, 12 people between the ages of 65 and 75 were given tablet computers with a set of specific games to play over 5 days. While significant correlations between personality and game preference were not found, we gained a vast amount of information on user’s preferences. Preferences were grouped into profiles and, content design and usability guidelines were written accordingly. The PERSSILAA game concept has been designed based on these profiles and guidelines and was evaluated with 40 older adults to confirm these findings. These studies provided a theoretical foundation for the gamification layer.

We also performed several short evaluation studies: to investigate and solve usability issues at an early stage of development, to analyze actual user data from log files to detect errors and ‘bugs’, to determine the user’s appreciation for game features and to gather first-hand user feedback to improve the overall experience for the player. To make the game more accessible and lower the initial threshold for new users, another online questionnaire was used with 14 participants. Using data from the evaluation studies and through an iterative design process a viable end product – usable for a prolonged period of time – was released.

A final evaluation was performed to gain insight into the added value of gaming in PERSSILAA, the estimated long-term effects (engagement and compliance), and the validity of the user profiles, to refine the design. This answered any remaining questions before expanding the game layer to reach its full scale and optimal functionality.
d. Results
This study found that older adults are a heterogeneous group with respect to their preferences for game content, interests, abilities and experiences. Many modern day video games do not meet older adults’ game preferences, are inaccessible and lack usability. We have created a model that gives an overview of all possible elements of game content that can be used to map the preferences for these aspects of games for individual users or groups of users in future. Based upon this a content profile for an older target group was set up with additional guidelines for game design that can be used to design gamification strategies to address a multitude of people. The findings that most influenced game design include the fact that 1) it is the usability of modern day video games rather than their concept that hinders older people from engaging with them, 2) the effect of and desire for social interaction/group activities when gaming is often overestimated and that older people, much like reading a book, would prefer to play the game by themselves, 3) the connection between ‘training’ and the game should always be evident to the user to sustain their motivation that 4) a game should always increase the user’s sense of competence, reinforcing their motivation to engage in healthy behaviors.

e. Recommendation(s)

The results of PERSSILAA also show that not all users see the use of a game as a serious matter or appropriate approach, particularly when it comes to healthcare, and some may even see it as a waste of their precious time. However, many participants across a diverse range of evaluation studies indicate that they see the advantage of games in achieving their training goals, particularly in rehabilitation.

Recommendation 1: When choosing to utilize gaming as a motivational strategy for pre-frail older adults, it should always be kept in mind that even if a fantastic game has been developed, not all users are intrinsically motivated by games.

Recommendation 2: The added value of gaming in the context of an ICT supported platform for managing pre-frailty such as PERSSILAA depends on the openness of the older users to an approach that is not as common for them as it is for younger people.

f. Target audience
It is expected that ICT developers will benefit from these insights as well as the older adults who these ‘serious games’ target. We expect that it will be increasingly interesting to address this target group through games, as future generations are more and more accustomed to games and other digital applications.
4.3 Institutional recommendations

4.3.1 Organisational model: advice for organisations (e.g. healthcare organisations, governmental including public policy departments, small and medium sized industries etc.) on how to develop organisational models to identify and manage pre-frailty.

a. Background
Developing an eHealth service comprises more than technology alone. If it is to be implemented in daily care and to be accepted by all end-users and stakeholders, the development of an organisational model is very important. Such an organisational model should appeal to all parties involved and should preferably be targeted towards their values. The development of such an organizational model due to the myriad of parties involved, their complicated relationships and the intricate financing structures is by no means an easy task. The design literature is quite unanimous in its advice that involving end-users and stakeholders in the design of technology and the accompanying organisational model is a prerequisite for successful design.

b. Objective(s)
To develop a Pan-European technology design and organisational model for a service to identify pre-frailty and to improve the health of those who are pre-frail.

c. What was done? How?
We held numerous meetings with end-users or their representatives and other stakeholders. Initially, we held plenary meetings to elicit the end-users’ and stakeholders’ values and to map an ‘ideal’ organisational model. Subsequently, we held meetings on a smaller scale with organizations that were expected to implement and execute the service on a local level. This way, we could fine-tune the ideal to the reality of a local implementation site.

d. Results
We developed a Pan-European organisational model for a community-based, technology-supported service for identifying and preventing frailty. Furthermore, we developed a functional design for the technology that should support this service. Technology that takes into account the needs, wishes and context of the designated end-users. We experienced that involving end-users and stakeholders and translating their input into the design of the organisational model and technology (depending on the stakeholders’ importance; not everybody’s wishes can be realized due to practical impossibilities or conflicting needs) creates a sense of ownership between the developers and adopters, which promotes smooth acceptance and adoption.
Next, we found that creating one Pan-European organisational model that perfectly caters to all the needs and wishes or local implementation sites is an impossibility. Rather, one should develop a general ‘ideal’ organisational model, which should subsequently be tweaked to fit each local implementation site.

**e. Recommendations**

It is important to involve all end-users (older adults and their carer where appropriate) and other stakeholders in the development of ICT platforms that manage specific healthcare conditions/syndromes such as pre-frailty. In this sense it is important to create, an inclusive ‘ideal’ organisational model at first and fine-tune it with local stakeholders later on to accommodate the challenges of different implementation sites.

Recommendation 1: *Involve all end-users and stakeholders in the design of organisational health models and the involved technology.*

European countries differ, counties within each country differ. Likewise, cities and villages within a county differ. To ignore these differences and to force a general organisational model upon them is likely to create barriers for acceptance and adoption. Instead the PERSSILAA investigators suggest that those planning similar ICT projects to address pre-frailty and hence prevent onset of frailty and functional decline, create a general Pan-European model at first and fine-tune it to local implementation sites later on.

Recommendation 2: *When creating innovative service models for important public health issues such as pre-frailty, do not expect to end up with one Pan-European model that fits all.*

**f. Target audience**

This includes health policy makers, eHealth developers and health service developers.
4.3.2 Business modeling and testing

This section provides recommendations to organisations (e.g. healthcare organisations, government organisations including public policy departments, small and medium sized industries, research parties etc.) on ways to develop sustainable business models based on telemedicine solutions like the PERSSILAA ICT supported service.

a. Background

Telemedicine, specifically eHealth, is an emerging area of medical research. When developing eHealth solutions it is pivotal to create sustainable business models that ensure implementation and large scale adoption. However, the research methods employed are not always optimal or appropriate for telemedicine research. This is likely due to the fact that telemedicine is a relatively new area of research and that specific methods designed specifically to test eHealth technology are in their infancy.

b. Objective(s)

To develop successful business models to ensure sustainable implementation and adoption of eHealth technology by all involved stakeholders in the PERSSILAA project.

c. What was done? How?

We involved all stakeholders in the design of the business model. We allowed for the model to differentiate, grow and adapt through an iterative process taking different contextual factors into account. We tested the business models in different settings (i.e. different implementation scenario’s) to see which model would be most feasible to implement and adopt.

d. Results

A defined business model was developed and the results are presented in Deliverable 5.6.

e. Recommendations

It is important to start business modeling activities early in such a project in parallel with the R&D processes. This allows involvement of all stakeholders and creates the possibility of tweaking the model to incorporate the latest technological developments. This ensures that changes in the technology can still be made i.e. if the model indicates certain functionalities are needed to follow the latest needs then the most appropriate interdisciplinary stakeholders can be brought together to solve the problem. Otherwise, if business modeling is completed by one party only after the technology is outmoded, this might result in a failing model or failing technology. Furthermore, testing of the model is pivotal to ensure sustainable implementation of the model and technology in each setting e.g. in society. This leads to the following set of recommendations:
Recommendation 1: Involve all relevant stakeholders early in the development of the design of business models for ICT supported services for pre-frail community dwelling older adults.

Recommendation 2: Accept that the pan-EU business model needs tuning and differentiation to cope with regional factors that influence the business model on local, regional or national level.

Recommendation 3: Include ‘feasibility tests’ when designing business models for ICT supported services for pre-frail community dwelling older adults to confirm if the model still fits the requirements of relevant stakeholders. This will allow adjustments throughout via an iterative process.

Recommendation 4: Design, implement and scale up the business model iteratively. Start small and gradually scale up the implementation instead of top-down large implementation for ICT supported services for pre-frail community dwelling older adults.

f. Target audience
This includes healthcare policy makers, financiers, healthcare organizations, eHealth developers and healthcare service developers.

4.3.3 Health economic assessments
This section provides advice to organisations (e.g. healthcare systems, governmental organisations including public policy departments, small-medium sized industries and research companies etc.) on how to perform a health economic assessment of eHealth solutions such as the PERSSILAA ICT supported service.

a. Background
Telemedicine has been suggested as a solution to the demographic challenges that healthcare systems in many European countries are facing. A potential to reduce costs and improve care is seen as one of the main advantages of telemedicine in healthcare settings i.e. being able to use technology in an efficient and effective manner. A health economic assessment (i.e. cost-benefit or cost-effectiveness analysis) can be done to show the economic potential of this approach and is important in developing the business plan of the eHealth solution. However, performing a health economic assessment of telemedicine interventions is difficult because current methodological techniques do not allow us to inadequately draw conclusions about their potential (Drummond et al., 2005).

b. Objective(s)
To perform a health economic assessment in the form of a cost-effectiveness analysis to show economic potential of the PERSSILAA ICT supported service.

c. What was done? How?
We performed a cost-effectiveness analysis (CEA) to show the economic potential of the PERSSILAA solution. This was done to create a solid business case to support the business modeling and scaling up of the PERSSILAA solutions in the exploitation tasks. From a societal level, control and intervention cohort data were gathered on health related quality of life, resources used, mortality risks and impact on daily life. The data were used as parameters to populate the EU and EIP-AHA co-developed monitoring and assessment framework tool (MAF-EIP) (Boehler et al., 2015) to perform a CEA.

d. Results
The CEA resulted in an average incremental cost of 211.73 EUR, an average health outcome of 0.077 QALY per person. Furthermore, an Incremental Cost-Effectiveness Ratio (ICER) of 2,746.20 was produced. By comparison the Willing-To-Pay (WTP) threshold of preventive programs in the Netherlands is currently set between 15,000 and 20,000 €/QALY.

However, this health economic modeling was done with a certain degree of uncertainty. Assumptions were made based upon a literature review instead of solid data obtained from the PERSSILAA cohort. In an ideal case, all data would be gathered and analysed from our own study population. However, time was limited, the size of the study population was small and the design of the research did not allow us to gather this data consistent with best practice. Further study, following subjects using the PERSSILAA ICT supported service for longer and including a larger sample is now required. Future research is also required to compare the effectiveness of a similar business model with the results of the PERSSILAA evaluation in different regions.

e. Recommendations
It is important to show the economic potential of eHealth solutions to facilitate their adoption and whole scale implementation within healthcare systems. To ensure this we recommend the following:

Recommendation 1: Appropriate health economic assessment techniques should be incorporated into the design of studies validating eHealth solutions among frail community-dwelling older adults such as the PERSSILAA ICT supported platform to ensure their cost effectiveness.

Recommendation 2: It is important to perform a health economic analysis in all studies validating eHealth solutions among frail community-dwelling older adults in
order to compare the cost effectiveness of such interventions in different countries/regions and healthcare systems.

**Recommendation 3**: We recommend the further application and validation of the EU and EIP-AHA co-developed monitoring and assessment framework tool (MAF-EIP) for validating eHealth solutions among frail community-dwelling older adults such as the PERSSILAA ICT supported platform.

**f. Target audience**
The target audience includes economists, financiers, eHealth developers, health policy makers, health service managers and healthcare professionals.
5 Conclusions

PERSSILAA is one of the first projects to address the important emerging public health challenge that an increasing prevalence of frailty among community dwelling older adults represents. PERSSILAA uniquely develops a personalized approach based on key pre-frailty domains (nutrition, cognition and physical function), using an ICT supported platform to encourage older adults to self-manage pre-frailty, in an attempt to prevent onset of frailty and subsequent functional decline. The evaluation process of this project allowed the PERSSILAA investigators to draw some of the first, clear and practical conclusions on how to address and manage pre-frailty from a clinical healthcare, an ICT and the broader organisational perspective. These recommendations provide concrete and future directed guidance on how to address the challenges of how to develop, implement and in time modify ICT supported services to address pre-frailty. These 43 recommendations could be used to support the development of guidelines on the prevention of frailty and functional decline in European countries and beyond. Given the current lack of guidance on this acknowledged, emerging public health crisis, these recommendations are to be celebrated as an important first step in the process of establishing consensus on the management of pre-frailty.
6 References


Fit for Frailty - consensus best practice guidance for the care of older people living in community and outpatient settings - a report from the British Geriatrics Society 2014


Appendix 1.

Use of an ICT supported multi-domain platform to manage the care of pre-frail, community-dwelling older adults: Recommendations arising from the PERSSILAA study.

A. Healthcare related recommendations

1. How to define pre-frailty for a study designed to manage pre-frailty that uses an ICT supported platform?

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.*

2. How to screen for pre-frailty using an ICT supported platform?

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 and nutritional pre-frailty 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. How to monitor for the development of frailty and functional decline using an ICT supported platform with pre-frail older adults?

Recommendation: *There is likely to be no ‘one-size-fits-all’ approach to monitoring older community dwellers for pre-frailty.*

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

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. How to use multi-domain (nutrition, cognition and physical function) training modules on an ICT supported platform to Manage Pre-frailty?

**Nutrition training**

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

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 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.

Cognition training

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

Physical training

Recommendation: The development of physical training modules on ICT supported platforms should include strategies to motivate pre-frail older adults to engage with them.

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.

**B. ICT related recommendations**

1. Insights gained from the project into the development of ICT supported platforms to manage pre-frailty.

Recommendation: ICT and telemedicine solutions can overcome geographical barriers in assessing and monitoring community-dwelling older adults for pre-frailty, extending service provision in a more efficient and sustainable manner.

Recommendation: Incorporating automatic behavioural patterns into intelligent ICT supported platforms that manage pre-frailty among older adults appears to be practical and should focus on activities of daily living.

2. Measures to improve accessibility of ICT supported training platforms for pre-frail older adults to manage pre-frailty.

Recommendation: Older adults should be offered self-directed screening for pre-frailty targeting them in their communities, through both online and traditional pen and paper postal questionnaires.

Recommendation: More attention should be paid to health and ICT literacy among older adults using ICT supported training services, either remotely or through face-to-face activities, by providing information about the benefits of preventing health related problems such as frailty and on age appropriate standards and targets so that they can better understand their current status.

Recommendation: Simple, conventional indicators such as page hits may not adequately reflect the acceptance and adoption of the digital services such as PERSSILAA. More research is needed, that aims to explain why pre-frail older adults do or do not use online health services. Such insights are crucial for formulating successful implementation strategies.
3. Insights gained from the evaluation of an ICT supported platform to manage pre-frailty.

Recommendation: It is important to know whether older adults have a preference for unobtrusive or more interactive modules before beginning training/monitoring with ICT platforms designed to manage pre-frailty (where they are constantly engaged) to ensure compliance.

Recommendation: The physical training module seems to improve quality of life and older adults tend to adhere to these services.

Recommendation: A cohort multiple randomized controlled trial design appears to be a useful methodology for evaluating rapidly involving technologies such as the PERSSILAA platform and could be used in studies designed to assess/validate ICT platforms that manage pre-frailty.

4. Insights gained into the use of gamification techniques as a way to engage older adults to use ICT supported platforms to manage pre-frailty.

Recommendation: When choosing to utilise gaming as a motivational strategy for pre-frail older adults, it should always be kept in mind that even if a fantastic game has been developed, not all users are intrinsically motivated by games.

Recommendation: The added value of gaming in the context of an ICT supported platform for managing pre-fraility depends on the openness of the older users to an approach that is not as common for them as it is for younger people.

C. Institutional (organisational) related recommendations

1. Institutional suggestions on how to develop ICT supported platforms to address pre-fraility among older adults.

Recommendation: Involve all end-users and stakeholders in the design of organisational health models and the involved technology.
Recommendation: When creating innovative service models for important public health issues such as pre-frailty, do not expect to end up with one Pan-European model that fits all.

Recommendation: Involve all relevant stakeholders early in the development of the design of business models for ICT supported services for pre-frail community dwelling older adults.

Recommendation: Accept that the pan-EU business model needs tuning and differentiation to cope with regional factors that influence the business model on local, regional or national level.

Recommendation: Include ‘feasibility tests’ when designing business models for ICT supported services for pre-frail community dwelling older adults to confirm if the model still fits the requirements of relevant stakeholders. This will allow adjustments throughout via an iterative process.

Recommendation: Design, implement and scale up the business model iteratively. Start small and gradually scale up the implementation instead of top-down large implementation for ICT supported services for pre-frail community dwelling older adults.

Recommendation: Appropriate health economic assessment techniques should be incorporated into the design of studies validating eHealth solutions among frail community-dwelling older adults such as the PERSSILAA ICT supported platform to ensure their cost effectiveness.

Recommendation: It is important to perform a health economic analysis in all studies validating eHealth solutions among frail community-dwelling older adults in order to compare the cost effectiveness of such interventions in different countries/regions and healthcare systems.

Recommendation: We recommend the further application and validation of the EU and EIP-AHA co-developed monitoring and assessment framework tool (MAF-EIP) for validating eHealth solutions among frail community-dwelling older adults such as the PERSSILAA ICT supported platform.