Co-funded by the Horizon 2020
Framework Programme of the European Union

REACH

Deliverable D30: User acceptance and motivation strategies (associated with tasks T 7.2 and T7.3)

Abstract: This deliverable describes the results and reflections by the partners' efforts on user acceptance and motivation strategies. The report presents the outcome of an identification and detailing of user acceptance and motivation strategies for the overall system (REACH, Touchpoints & Engine concept) and subsystems (Touchpoints, REACH toolkit elements), providing full consideration and detailing of ethical, privacy, legal and usability/accessibility aspects. The REACH system incorporates two strands of technological elements; on the one hand, sensing and monitoring elements, and, on the other hand, motivational and physical engagement elements. For both types, user acceptance is critical allowing for a user experience that leads to (intrinsic, extrinsic, etc.) motivation to more physical activity. The remainder of this Deliverable is structured as follows. First, we introduce the REACH-specific interplay of the concept "user acceptance" with the linked concepts "behaviour change/motivation" and "personalization" in the context of (early) physical activation of elderly persons, and outline the related work and activities conducted in REACH (overall and per TP). Second, we present an analysis and structuring of acceptability drivers (ethical, privacy/security, legal, and accessibility considerations) per Touchpoint. From this we developed an integrated view that represents REACH specific know-how about how to use these acceptability drivers to integrate advanced ICT-driven technology for early detection and intervention use cases seamlessly into age inclusive communities. Third, we present our findings in the context of the development of acceptability drivers for the use of sensing and monitoring elements. We conclude the deliverable by outlining acceptability related evidence and examples from REACH trials (based on Deliverable D27 findings), and by summarizing the overall findings of this deliverable.

Lead Partner:	DTU
Participants:	DTU, CU, Tu/e, SK, ZZ, HUG, AM, TUM
Document Identifier:	REACH Deliverable D30
Version (Date):	1.0 (31.01.2019)
Due Date:	31. January 2019
Linked WPs/Tasks:	WP7/ T7.2 + T7.3
Type:	Public
Authors:	Humira Ehrari, Henning Boje Andersen (DTU); Carlijn Valk, Yuan Lu (Tu/e); Thomas Visser (Philips); Rasmus Tolstrup Larsen, Christoffer Bruun Korfitsen, Henning Langberg (CU); Mirana Randriambelonoro (HUG); Barbara Schäpers (SK); Thomas Linner (TUM)

Date	Activity	Status
31.04.2018	Deliverable strategy ready	completed
31.09.2018	Deliverable structure ready	completed
10.12.2018	Deliverable content draft provided	completed
21.01.2019	Feedback integrated into the report	completed
31.01.2019	Revision by TUM completed and submission	completed

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 690425. The content of this report does not reflect the official opinion of the European Union. Responsibility for the information and views expressed in the report lies entirely with the authors.

Tasks of the involved partners with respect to the deliverable (and respective tasks) presented in this report:

Partner	Short task description
DTU	• Overall strategy, definitions, etc. • Extraction and structuring of acceptance aspects (acceptance assessments in TPs 1-4) from trials • Behaviour change and physical activity aspects • Accuracy and acceptability of wearable trackers
CU	• Contributions to testing related to TP4 • Behaviour change and physical activation • Accuracy and acceptability of wearable trackers
Tu/e	• Behaviour change and personalization process and schematics • Guidance for the usage of these processes and schematics in the various TPs • Generalisation towards REACH unique personalisation work-flow/process
Philips	• Facilitation of structuring of user experience and behaviour change techniques per TP • Contribution with regard to definitions, overall strategy, and work shop management
SK	• Support with structuring and analysis of trials with regard to user acceptance assessments in TPs 1-4
ZZ	• Contribution to trials with behaviour change and acceptability dimensions
HUG	• Contribution to trials with behaviour change and acceptability dimensions • Acceptability of sensing and monitoring elements: ethnographic study
AM	• Contribution to trials with behaviour change and acceptability dimensions
TUM	• Revision, strategy and structure; support with integration of material • Lead of analysis and structuring of acceptability drivers per TP and integrated view

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Key expressions

Abbreviations for partners:

AH: ArjoHuntleigh
AM: Alreh Medical
CU: University of Copenhagen
DTU: Technical University of Denmark
EPFL: École Polytechnique Fédérale of Lausanne, Switzerland
FIAIS: Fraunhofer IAIS
HUG: Hôpitaux Universitaires Genève
PSS: Product Service System
SC: SmartCardia
SK: Schön Klinik
TU/e: Eindhoven University of Technology
TUM: Technical University of Munich
ZZ: ZuidZorg

Acceptability (user acceptance): The REACH system incorporates two strands of technological elements; on the one hand, sensing and monitoring elements, and, on the other hand, motivational and physical engagement elements. For both types, user acceptance is critical allowing for a user experience that leads to (intrinsic, extrinsic, etc.) motivation to more physical activity. Acceptance and user experience in REACH are created by a coordinated interplay of a) high usability and convenient accessibility, b) accommodating need for privacy and autonomy, while counter-balancing this with the need for monitoring to secure health and responsible care; and finally, c) personalized design for behaviour change.

Acceptability related concepts: user experience design, behaviour design, personalization, privacy by design, ethical considerations, legal considerations, usability/accessibility, etc.)

ADL: Activities of Daily Living.

Baseline behaviour: The normal behaviour of the patient in absence of any interventions.

BCW: The Behaviour change wheel is a holistic behaviour change model

Behaviour change (BC): The change of one or more parameters, such as the activity levels, which characterize human behaviour.

D: Deliverable report.

End user: There are two primary end users, patients and elderly citizens receiving care and their professional care givers. Family and friends are, by voluntary invitation from the elderly, secondary users. REACH has a greater focus on patients and care-receiving citizens than on caregiver users.

Engine: The REACH Engine describes the analytics infrastructure of the REACH system, and serves as a back-end system for the Touchpoints. The Engine monitors the incoming data streams from the different Touchpoints, analyses them and takes actions if needed. Its two main components will be Subsystem 1 (*Analysis & Planning*) and Subsystem 2 (*Motivation & Intervention*).

FBM: BJ Fogg's Behaviour Model is a design behaviour change model.

Intervention/Treatment: Action designed to bring about a change in a process or an individual.

IP: Intellectual property, intangible assets

PROs: Patient Reported Outcomes; this expression is usually meant to cover reports of a patient's health condition that comes directly from the patient and without interpretation or re-phrasal by anyone else and thus not from any clinician or even family member; gains importance as user experience and acceptability measure.

Personalisation: A solution can be personalized to a user's preferences, abilities (physical, education level), context factors and many other aspects. It can be done by adjusting tone of voice, wording, visual elements like shape and colours, style and material. By personalizing a product, a feeling of familiarity and similarity can be created, which in turn results in a positive attitude towards the product and eventually using the product more often. In REACH personalization is used to enhance the impact of behaviour change strategies and other interventions.

Persuasion profile: Pattern that explains how a user with particular characteristics would respond to an intervention. If the profiles are tailored to an individual, then we call them intra-personal, and when they are tailored to a group of similar people, then we call them inter-personal.

Response: a behaviour change that happened as a result to some intervention.

RFT: The Regulatory Focus Theory is a design behaviour change model.

SDT: Self-determination theory

T: Task defined in the project proposal.

Touchpoints/Engine concept (TP&E concept): Structures the envisioned REACH product-service-system architecture into manageable research and development clusters.

Touchpoints (TP): The "Touchpoints" act as "graspable" front end towards the end users (elderly). The Touchpoints will serve as data gathering devices as well as mediator of services and interventions coordinated by the Engine towards the end user. Each Touchpoint is modular and made up of several subsystems which allow to adapt the system both for a certain person or setting as well as over time.

TP: Touchpoints - the "Touchpoints" will act as "graspable" front end towards the end users (elderly). The Touchpoints will serve as data gathering devices as well as mediator of services and interventions coordinated by the Engine towards the end user. Each Touchpoint is modular and made up of several subsystems which allow to adapt the system both for a certain person or setting as well as over time.

TPB: The theory of planned behaviour is a psychological behaviour change model.

TTM: The Trans-Theoretical Model (i.e. the Stages of change theory) is a psychological behaviour change model.

Use case setting: Use case setting refers to the four solution operators and this report called them the use case setting since they reflect concrete application scenarios.

WP: Work package defined in the project proposal.

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1 Background and summary of tasks and activities related to T7.2-3/D30

This chapter introduce the activities and tasks performed in each touchpoint in context of Deliverable D30, outlines the larger context in which the work presented is situated, introduces the definition and role of acceptability (user acceptance) in REACH, and gives an overview of the contents presented.

1.1 The Deliverable in the larger context of REACH

REACH engages elderly people in a variety of environments and contexts systematically in target-oriented physical activity, exercise, and rehabilitation to counteract inactivity and sedentary behaviour and their negative consequences. REACH goes its own way by developing value proposition and user acceptance around its digital-technological core and shared elements strictly through case sensitive adaptation and insertion into the ecosystem of a specific country, use case setting, and/or individual user's needs. In this section we describe the coordinated interrelations between REACH's value proposition, the Touchpoints and Engine concept (high level system architecture), the REACH toolkit (practical, low-level implementation process for a series of "raw elements"), and the demonstration of the exemplary adaptation and integration of essential REACH elements towards four (initial) use case settings through 4 (initial) Touchpoints.

REACH targets elderly at risk of inactivity and sedentary behaviour and covers in a highly dynamic and digitalized manner the whole life cycle of early intervention (sensing, monitoring/analytics, intervention) to engage elderly systematically in target-oriented physical activity, exercise, and rehabilitation. Goal of the interventions, techniques, products, services, and programs developed by REACH is to improve the health outcomes of the elderly target population, i.e. to improve their classification according to ICF (including better ability to perform ADLs, better grip strength), empower them for seamless and unrestricted participation in their communities, and thus ultimately increase their Healthy Life Years.

Compared to many other solutions on the market, REACH does this in a much subtler manner by putting **acceptability concepts** such (such as user experience design, behaviour design, personalization, privacy by design, ethical considerations, usability/accessibility, etc.) at the centre of the adaptation of the REACH toolkit elements to the ecosystems of a specific use case settings.

The REACH "Touchpoints and Engine concept" is the high-level description of REACH system architecture (see **Figure 1-1**). It guides the detailed structures of the REACH system architecture and its subsystems. With the "Touchpoints and Engine concept", the REACH´s so-called product-service-system architecture is divided into a set of manageable research and development clusters: four clusters of "Touchpoints (TPs)" that represent tangible connections between users (seniors, informal/formal caregivers, or physicians etc.) and the REACH system; one "Engine" cluster which is encompasses a digital toolkit (analytics and ML-elements, data transformation and platform solutions, privacy and security tools, software applications, etc.); and one "Interface" cluster which is composed of a set of elements that allow Touchpoints to connect/interact with the each other, engine elements, or the user. Each cluster is associated with a dedicated and independent development team coming from the project consortium members.

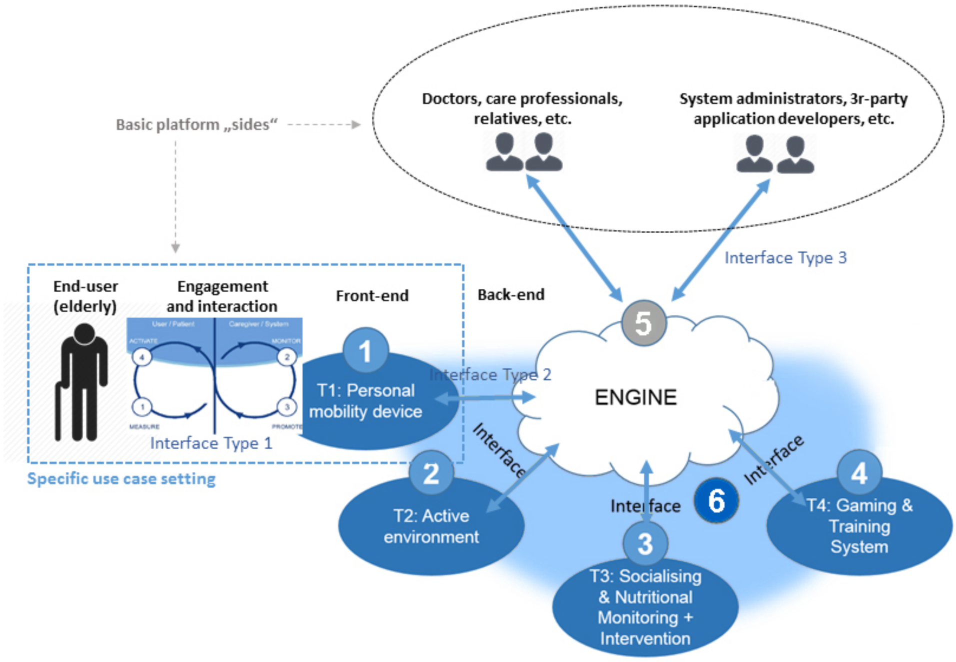

Figure 1-1: REACH Touchpoints and Engine concept

- **Touchpoint 1:** Touchpoint 1 draws on elements of the REACH toolkit to develop customized early intervention elements for independent but supported living solutions such as elderly residential solutions, activity and day care centres for elderly, and linked physical therapy practices. The early detection and prevention scenario can be outlines as follows: 1) All elderly enrolled in the target setting are equipped with a wearable (e.g. a Modus Health StepWatch 4) activity monitor to screen the elderly regarding signs of inactivity and the risk of falls and frailty. 2) Based on the monitored activity levels semi-personalized activation or rehabilitation is provided with the ActivLife device in a highly gamified manner using an optimized user experience to motivate and empower elderly for as much self-training as possible. 3) Finally, the training in the ActivLife device allows for further in-depth monitoring through a set of stationary sensors in and on the device to analyse, asses, and continuously monitor the detailed functional ability and its change over time.

- **Touchpoint 2**: In Touchpoint 2, based on the REACH toolkit, a full fletched activation care (and patient) room is developed. For the development, a patient room at Schön Klinik (rehabilitation clinic) is used as lead use case setting the initial scenario. The room is developed based strictly on modular principles (physical modularity, modularity on sensors and algorithms level, etc.) so that from this initial room dedicated, adapted versions for care homes and home care environments can be generated.

- **Touchpoint 3**: In Touchpoint 3, based on the REACH toolkit, a process-based system is co-created with elderly residents enrolled in a community and activation centre for elderly people (ZuidZorg). The system administers for independently living elderly, target oriented physical activation and training (i.e. targeted at training of functions needed to perform ADLs independently) through ICT and technology-based stimulation and ethically viable shaping of social behaviours and community activities (including cooking and nutrition).

- **Touchpoint 4:** The Lyngby use case setting is closely linked to Touchpoint 4 and states the major naturalistic use case setting in REACH. The Lyngby municipality, provides high-quality care through a combination of well-trained home nurses, smart homes for elderly, and ward-based care/day care centres. To serve this setting Touchpoint 4 developed based on the REACH toolkit a gamified and seamlessly into the daily-life context integrated engagement environment with Playware tiles and fitness trackers at its centre complemented by couple of solutions learned and drawn from the other Touchpoints.

1.2 Definition and role of acceptability (user acceptance) in REACH

Acceptability in REACH is an important term. Solutions must not simply be “accepted”, but acceptance must be solid and must include several aspects each of which is critical to the success of the final system.

In the research and literature on user acceptance, the so-called Technology Acceptance Model (TAM) has been dominant **(Davis, Bagozzi, & Warshaw, 1989)**.This model has undergone a series of iterations, resulting in the Unified Theory of Acceptance and Use of Technology and in extended versions (**Venkatesh**, **Morris & Davis**, 2003). The key factors of the model that are invoked to explain user acceptance are: *Perceived Usefulness* and *Perceived Ease of Use*. These variables typically explain about half or somewhat less of users’ intention to use a technology (**K. C. Chen & Jang, 2010; Holden & Karsh, 2010; King & He, 2006; Legris, Ingham, & Collerette, 2003)** but other factors can play a role as well. In their 2011 review, Chen and Chan note that “recent studies provided preliminary evidence that different age groups may think differently and make different decisions when it comes to the adoption and use of technology” **(Chen & Chan, 2011)**. They also found that specific factors related to aging may be overlooked – in particular, bio-physical factors such as cognitive and physical decline as well as psychosocial factors such as loneliness, social isolation, fear of illness. Similarly, in the REACH study Lyngby 1 (see also **Section 5.1.4** in this Deliverable on use acceptance assessments in TP4), we have found that concern about privacy when considering the use of tracking and monitoring technology is also a factor that must be counter-balanced against the benefits such technologies make provide for feeling safe and secure that someone is “watching over me”.

The REACH system incorporates two strands of technological elements; on the one hand, sensing and monitoring elements, and, on the other hand, motivational and physical engagement elements. For both types, user acceptance is critical allowing for a user experience that leads to (intrinsic, extrinsic, etc.) motivation to more physical activity. Acceptance and user experience in REACH are created by a coordinated interplay of a) high usability and convenient accessibility, b) accommodating need for privacy and autonomy, while counter-balancing this with the need for monitoring to secure health and responsible care; and finally, c) personalized design for behaviour change.

So far, we have used in the REACH project user acceptance assessment methods that are largely within the design & usability / human factors tradition. However, there is rapidly growing literature on the development of and use of assessment methods of “patient reported outcomes” (PROs). This expression is usually meant to cover reports of a patient's health condition that comes directly from the patient and without interpretation or re-phrasal by anyone else and thus not from any clinician or even family member. **Fries, Bruge, Cella (2005)** have put it very well when describing the change in approach and professional perceptions the introduction of PRO as quality indicators meant:

*“A quarter of a century ago, Patient Reported Outcomes (PROs) were of only marginal interest to rheumatologists …The term “outcome” itself was little used. We had “dependent variables” for our clinical trials, which were laboratory-measured or physician-observed. The “gold standards” were the tender joint count and swollen joint count, the physician global assessment, grip strength, ring size, the timed 50-foot walk, …and rheumatoid factor titer. Now, while some of these measures have survived and even prospered, a new “gold standard” for many if not most rheumatologists has become the patient’s own self-report. These measures are truly “outcomes”. They are about things that affect patients’ lives in major ways. They measure the impact of the disease process, and they reflect patient values …Perhaps closer to the heart of some trialists, they often have better measurement characteristics than the more traditional clinical variables, and may in some cases be more reliable, more valid, more meaningful, and less expensive to obtain.(**Fries, Bruce, Cella, p 53, (2005)**)”*

Several of the partners are using PRO measures in their research projects and even in daily operations, and in the following project period we shall adapt and apply PRO measures in tandem with standard usability and acceptance assessment methods in order to obtain a more comprehensive and valid picture of end-user perceptions.

1.3 Role of WP7 in REACH

As part of **WP7** acceptability regimens (user experience design, behaviour design, personalization, privacy by design, ethical considerations, usability/accessibility, etc.), are iteratively analysed, developed, and optimized during the insertion of REACH toolkit elements into the use case settings‘ ecosystems. **WP7** initiates, coordinates, and summarizes linked efforts cross the consortium’s activities.

1.4 Tasks/ Deliverable in the context of WP7

WP7 is concerned with the iterative analyzation, development, and optimization of acceptability regimens. Task **T7.1** (identification and detailing of strategies and degrees of personalisation for all subsystems; presented in **Deliverable D29**) laid the theoretic ground work for the work packages activities. Tasks **T7.2** and **T7.3**, deepened the understanding and concepts applicable in the context of REACH in a hands-on manner through the realization of user acceptance features during the insertion in and adaptation of REACH systems/sub-systems (toolkit elements) into the four use case settings. In this Deliverable the analysed and developed regimens are outlined summarized per Touchpoint. They will in a next step be detailed and systemized further and fed back as concrete schemes (and indeed IP or intangible assets on which REACH, and its partner scan capitalize on) into the REACH toolkit of elements (i.e. in the upcoming Tasks **T7.4** and **T7.5** and the respectively linked **Deliverables D31** and **D32**).

1.5 Overview of contents presented in this Deliverable

The remainder of this Deliverable is structured as follows. First, we introduce the REACH-specific interplay of the concept “user acceptance” with the linked concepts “behaviour change/motivation” and “personalization” in the context of (early) physical activation of elderly, and outline the related work and activities conducted in REACH (overall and per TP) (**Chapter 2**). Second, we present an analysis and structuring of acceptability drivers (ethical, privacy/security, legal, and accessibility considerations) per Touchpoint. From this we developed an integrated view that represents REACH specific know-how about how to use these acceptability drivers to embed advanced ICT-driven technology for early detection and intervention use cases into age inclusive communities (**Chapter 3**). Third, we present our findings in the context of the development of acceptability drivers for the use of sensing and monitoring elements (**Chapter 4**). We conclude the deliverable (**Chapter 5**) by outlining acceptability related evidence and examples from REACH trials (based on **Deliverable D27** findings), and by summarizing in a compact way the overall findings of this deliverable (**Chapter 6**).

2 User acceptance, behaviour change, and personalization

User acceptance is critical allowing for a user experience that leads to (intrinsic, extrinsic, etc.) motivation to more physical activity. In this chapter we shed light on the coordinated interplay between user acceptance, behaviour change/motivation, and personalisation elements. First, we review the general role of behaviour change and personalisation in REACH (**Section 2.1**) and its specific use in the context of the promotion of physical activity in an ageing society (including associated acceptability barriers, **Section 2.2**). Second, we analyse the state of play per Touchpoint and developed in workshops and working groups guidance for the upcoming development and optimisation phases (**Sections 2.3 and 2.4**). Third, based on the previous steps outlined, we introduce a behaviour change enabled design process for the development of personalized motivational strategies developed in the context of TP3 will next step wise be generalized (through coordination and integration with other TPs) as a REACH unique work flow and asset (**Section 2.5**).

2.1 Behaviour change and personalisation in REACH

The consortium in REACH is outstanding because it is composed of many specialists from different areas. In particular, several REACH partners focus on behaviour change. The content of Behaviour Change Workshop (held on 5th of September 2019, in Berlin; lead: Philips, Tu/e, DTU, TUM) is important for upcoming work and deliverables.

In **Deliverable T4.1-D14** several behaviour change theories, techniques, applications and a Definition of behaviour change for REACH were introduced (see **Figure 2-1**).

Zimbardo & Weber, 1994 / American Psychological Association:

The systematic use of principles of learning to increase the frequency of desired behaviors and/or decrease the frequency of problem behaviors.

Current report D14:

Change of (lifestyle) behaviors, that results in an overall increase in physical activity. A behavior change is seen as successful if the user is able to maintain this changed behavior during a longer period of time (at least a few weeks) after the onset of an intervention.

Figure 2-1: Definition of behaviour change in REACH context

In the Behaviour Change Workshop, the REACH partners worked out which techniques were successful and which ones could not be successfully implemented in each of the Touchpoints. These results should be of great help to the whole knowledge community of REACH. Even failures of certain theories in certain circumstances can bring helpful insights. Therefore, for example, two years ago Philips developed a smart watch with sleep tracking function. It was unfortunately not successful since it was too complex for user, maintaining, interchanging, etc. This insight is taken into account in the development of future products.
Engagement is a very difficult topic. Following tools (see **Figure 2-2**) should help each REACH partner and each TP to develop a behaviour change strategy. Psychologi-

cal/psychosocial theories describes the process a person goes through, holistic models try to answer the question how it works, design models map the context, environment etc.

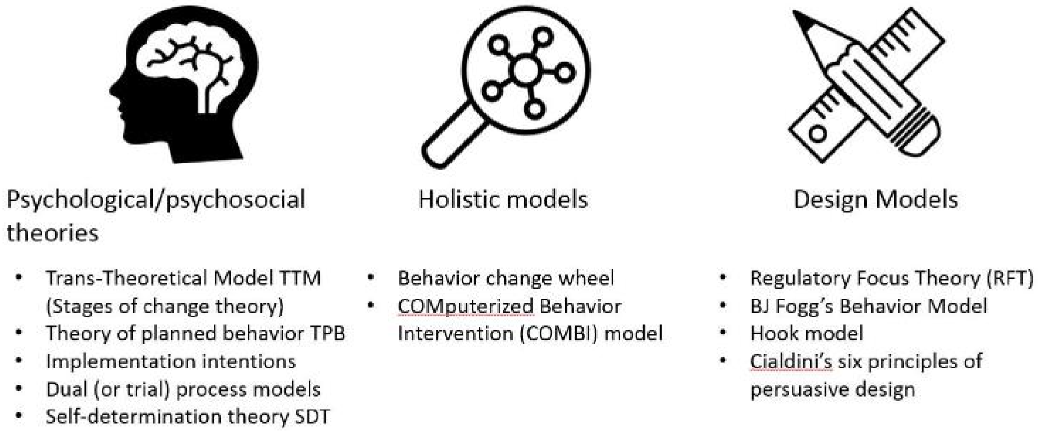

Figure 2-2: Three types of models

A very important tool is the Behaviour Change Wheel (see **Figure 2-3**). It should be used like a framework or taxonomy, it should not tell how to do the behaviour change. In general, trying to achieve behaviour change in tiny habits is much more effective. The use of gamification and playfulness (goal setting, competition), feedback education and connectedness as behaviour change technique is possible.

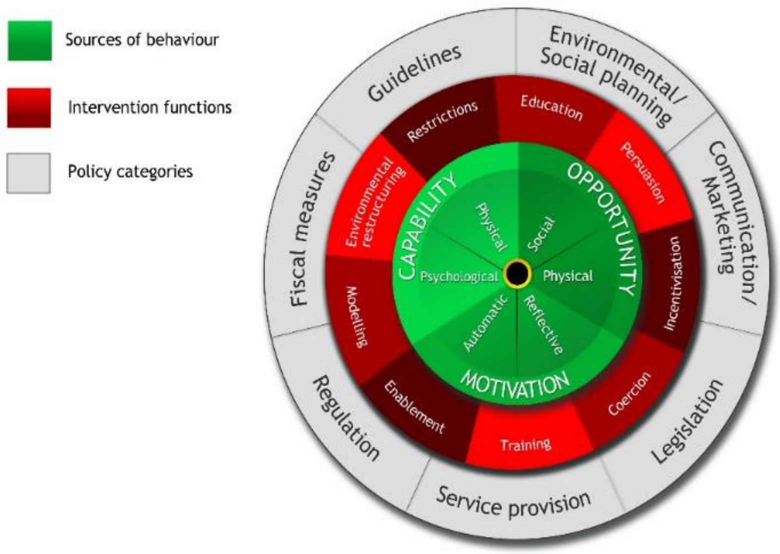

Figure 2-3: Behaviour Change Wheel

The results presented in the workshop from the different TPs should help to get a broader understanding. In the workshop, the reason why something worked and why something else did not work out is elaborated. In the end of REACH the publication of several papers about behaviour change techniques for especially elderly should be considered. The papers should include just suggestion, not new models etc. Inviting experts and professionals from this area of research to conferences and meeting would be useful.

2.2 Introduction to promoting physical activity and behavioural change in older adults

Across the touchpoints in REACH, different approaches to promoting behavioural change in older adults are used. The theoretical frameworks for the interventions include psychological models, holistic models and design models. The theoretical framework should be used to understand the needs, motivators and barriers among the older adults.

2.2.1 Introduction Barriers and motivators to exercise and physical activity in older adults

The identification of reliable predictors of exercise adherence will allow healthcare providers to effectively intervene and change patterns of physical activity in sedentary elderly.

Age-specific barriers and motivators unique to this population are relevant and must be acknowledged. Previous qualitative studies confirms this multifactor approach, and address barriers (*beliefs about exercise, health, environment, physician advice, unpleasant sensations associated with exercise, knowledge, childhood exercise)* and motivators *(self-efficacy, perceived benefits of exercise, prompts, music, demographics, personality and goals)* **(Chao, Foy, & Farmer, 2000) (Schutzer & Graves, 2004) (Resnick & Marie Spellbring, 2000)**. Interventions that focus on teaching older adults about the benefits of exercise, establishing appropriate goals, and decreasing unpleasant and increasing pleasant sensations associated with exercise may be useful to improve adherence to a regular exercise program. Furthermore, a cross-sectional study from Germany has reported the three most frequently cited barriers from their study population (older adults, n=1602) were poor health, lack of company, and lack of interest **(Moschny et al., 2011)**.

Ashford et al. found, in a meta-analysis of intervention studies explicitly targeting self-efficacy in order to change physical activity behaviour, that interventions that included feedback on past or others' performance produced the highest levels of self-efficacy **(Ashford, Edmunds, & French, 2010)**.

The REACH consortium aims to use different tools to facilitate behavioural change. **TP1** uses social support, gamification and performance support (feedbacks, rewards). **TP2** uses 'relate, repeat, reframe'. **TP3** uses self-awareness, peer-support and intergenerational support. **TP4** uses feedback, gamification and motivational interviewing. The behavioural change theories of the four touchpoints are all targeting motivation for change, feedback from activities and self-efficacy. Self-efficacy, or confidence in one's ability to make health behaviour changes, is addressed throughout the interventions via emphasis on setting small, measurable and achievable health behaviour change goals that facilitate a sense of confidence and mastery that can be built upon throughout the intervention.

Outcome expectancies, or beliefs about the benefits of health behaviour change and the barriers that might get in the way, is also addressed in the interventions. Participants should be encouraged to identify expected benefits of improvements to physical activity, as well as the barriers that might hinder their progress; they should also be assisted in using a problem-solving approach to addressing barriers.

The social-environmental context in which health behaviour change occurs is equally important. Multi-level support for change (i.e., from family, friends and community) should be used. Participants should also be encouraged to identify supports for health behaviour change, particularly in relation to maintenance, and to develop strategies for increasing supports.

The REACH system incorporates two strands of technologies - on the one hand sensing and monitoring and on the other motivational and physical engagement. For both types, user acceptance is critical allowing for a user experience that leads to (intrinsic, extrinsic, etc.) motivation to more physical activation and. Acceptance and user experience in REACH are created by a coordinated interplay of a) high usability and convenient accessibility, b) accommodating need for privacy and autonomy, while counter-balancing this with the need for monitoring to secure health and responsible care; and finally, c) personalized design for behaviour change.

2.3 Analysis of state of play per Touchpoint

Analysis of behaviour change/ personalisation regimens developed so far (until September 2018)

Several different trials and tests related to behaviour change have already been executed in the Touchpoints and in the different use case settings. The representatives from the Touchpoints and the Use case settings briefly summarized their results.

2.3.1 Touchpoint 1

- Results of AM: The core research question is if the motivation to do more physical activity is the same for seniors after using activLife at activity centre or do exercising at home following the advices from physiotherapists. Participants should be more active and exercise 2x per week. Group 1 consisted of 21 people, which got a guideline from physiotherapist and should train at home. Participants from group 1 have a higher barrier to be active scores after intervention than at the baseline. Group 2 consisted of 22 people and the participants should train with a sport coach (see **Figure 2-4**). Surprisingly, the sport coach had a very important role in motivating the participants and had a core role in personalization. The behaviour change techniques social support, gamification and performance support (feedbacks, rewards) were used.

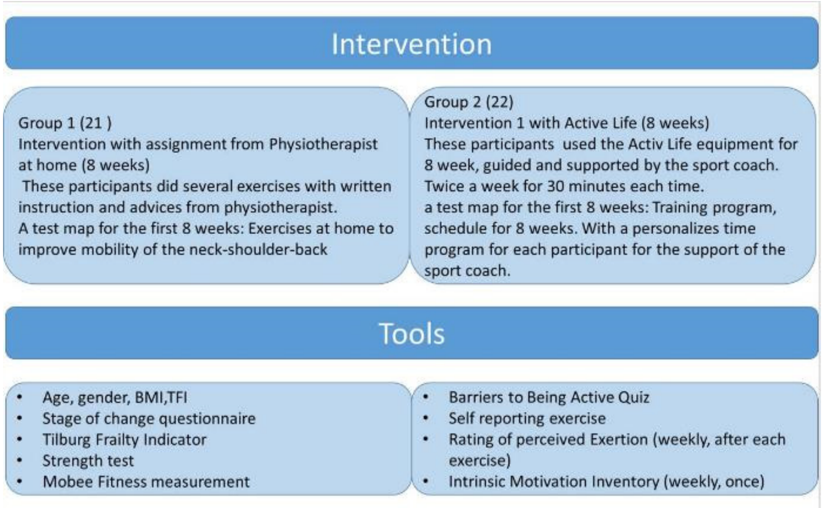

Figure 2-4: Test details of trials

- Results of ZZ: The previous test (ActivLife Test) was carried out in ZZ. For elaboration see **D27 appendix 1,** trial number 14. It is a meeting centre for elderlies, everyone is welcomed. ZZ influences greatly its guest's life, so they can increase their health and happiness level. The elderly will be engaged to be part of community again. Attention is given to the fears and worries of each individual elderly. For example, volunteers can pick up the elderlies from home.

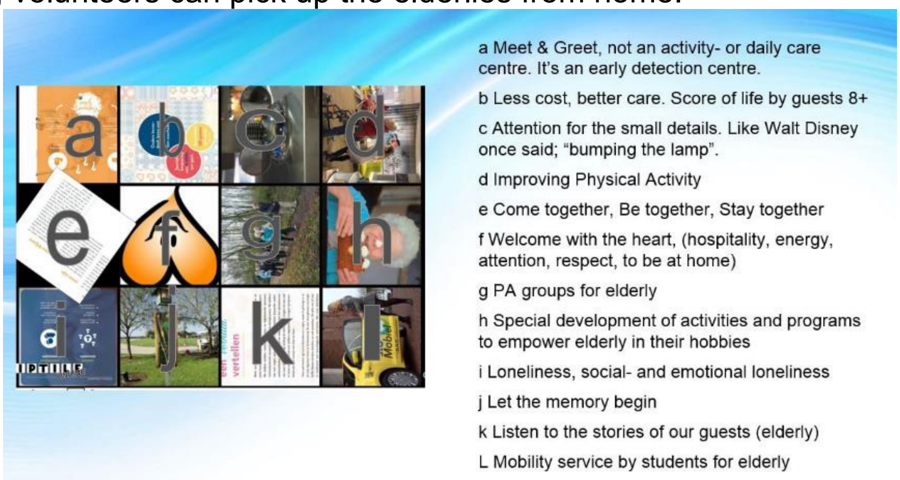

Figure 2-5: Summary of activities related to ZZ

Behaviour change is a very big research topic in REACH, in each Touchpoint this topic is one main core. REACH need to generate same parameters for all Touchpoints and use case settings.

2.3.2 Touchpoint 2

- Results of SK: Most patients of SK experienced a stroke, so it is extremely important for a successful therapy and to prevent further adverse events to change unhealthy behaviour. Firstly, they start to change their behaviour, but they soon go back to their behaviour before the initial incident. Only 1 out of 10 patients with a life-threatening diagnosis holds on to a healthier lifestyle for more than 1 month. Practical experience from physicians showed that facts, fear and force are not effective for behaviour change. When negative consequences being communicated to the patients, they start to connect the fear (and other negative feelings) to the specific action recommended. In consequence, the stress level increases. Much more successful behaviour change methods were to relate, to repeat and to reframe (see **Figure 2-6**). Important for patients is to communicate with persons at the same level who experience similar situations (**Deutschmann, 2007**). These persons are supposed to have sympathetic attitudes. The conversations with the patients should concentrate on realistic changes, not on negative consequences. The changing process should progress in small steps over years. But there is no “one-fits-all” solution for every patient. As motivation is a very individual process further investigation is needed to address the different requirements with different tools. Intensive research for developing successful concepts would be useful (e.g., principle of tiny steps in weight reduction, AME).

Table 2-1: Specifications to Relate, Repeat, Reframe Model (Deutschmann, 2007)

relate	repeat	reframe
embedding	concentrate on chances, not on negative consequences	link to existing routines
same situation		small steps
equals	everyday base	think in years
understanding	be specific	prepare relapses
sympathy	be realistic	

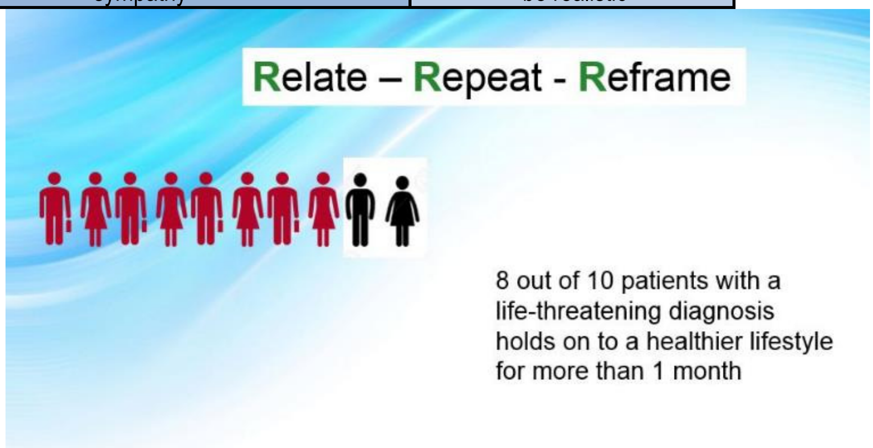

Figure 2-6: Successful behaviour change methods: Relate, Repeat and Reframe (Deutschmann, 2007)

2.3.3 Touchpoint 3

- Results from Tu/e: The core research question of TP3 is what personalization opportunities can be used to promote physical activities and healthy eating behaviour among older adults. Each person and his/her behaviour is unique. It must be worked out which intervention is suited for which user. One important step is the creation of user behaviour profiles (capability (physical, psychological) which includes Capability (physical, psychological), motivation (automatic, reflective) and opportunity (physical, social) and user profiles (personal, psychological, social, environmental) (see
- **Figure** 2-7). The used behaviour change techniques are self-awareness, peer support, intergenerational support, social support, feedback and recommendation.

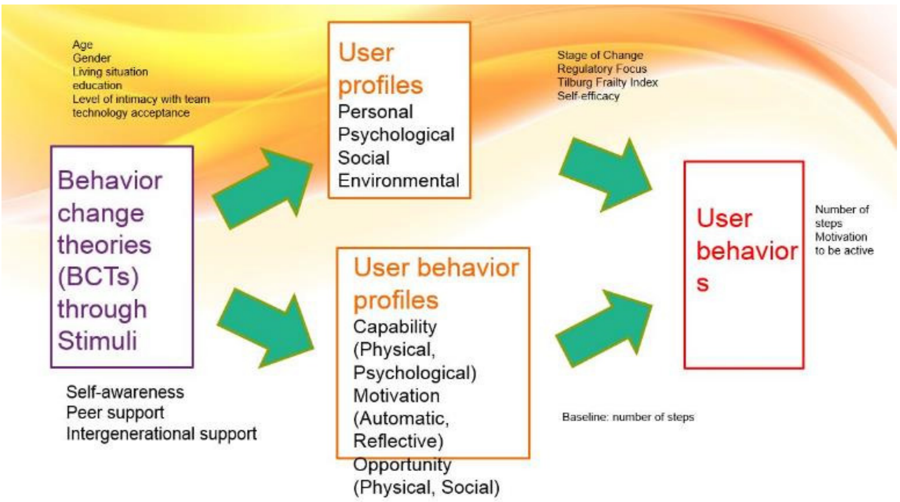

Figure 2-7: TP3 Personalization Strategy Research in Continued Test Eindhoven

- Results of EPFL: Presented data is from a previous study, however the setting is similar with the one in TP3. Inactive behaviour should be changed into active behaviour. The study includes 48 young people (students). After a baseline from 5 days a mobile app enables the participants to pair up with a partner, send each other messages, and earn badges (see **Figure 2-8**). The activity improved through the intervention about 62%. It has to be tested whether these results also can be applied to elderlies.

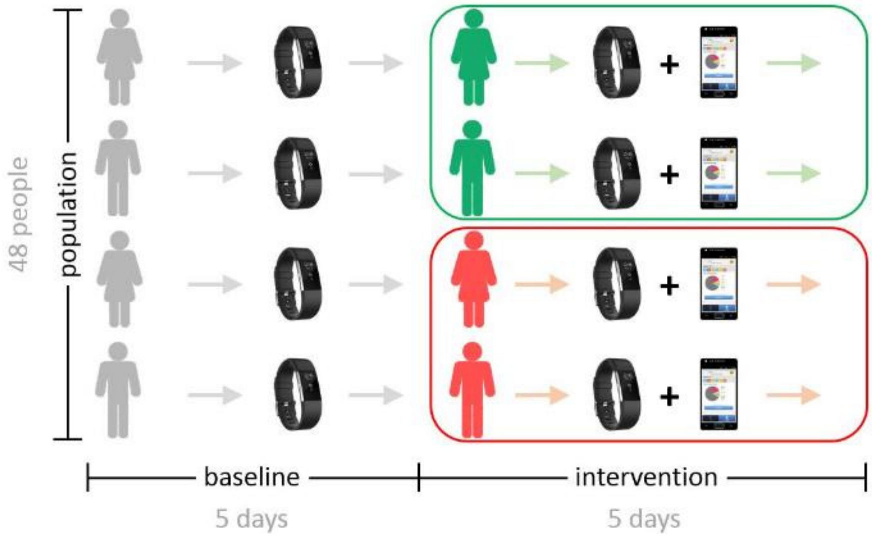

Figure 2-8: Exemplary construction of a study to behaviour change

- <u>Results of HUG:</u> MiranaBot aims to help people to identify special habits and then change them in the long term. Main research question is if MiranaBot is as effective as speaking with a nutrition professional. A person tells MiranaBot what he/she eats, and the system will give feedbacks through visualizations (see **Figure 2-9**). In addition, MiranaBot should overview the regularity of eating. Step by step, the behaviour should change. Right now, MiranaBot is just in French available, but multiple languages are possible. Expertise of MiranaBot is the diversity of food, not how much someone eats. MiranaBot uses voice recognition, text recognition and text analysis, recommendation system is not completed yet. The used behaviour change techniques are Feedback, self-awareness, personalization, goal setting and tiny habits. In the coming weeks more intensive cooperation with Professor Lu and Biozoon will be sought. For tests in Eindhoven, however, a Dutch version of MiranaBot would be necessary. For elaboration see **D27 appendix 1** trial number 23.

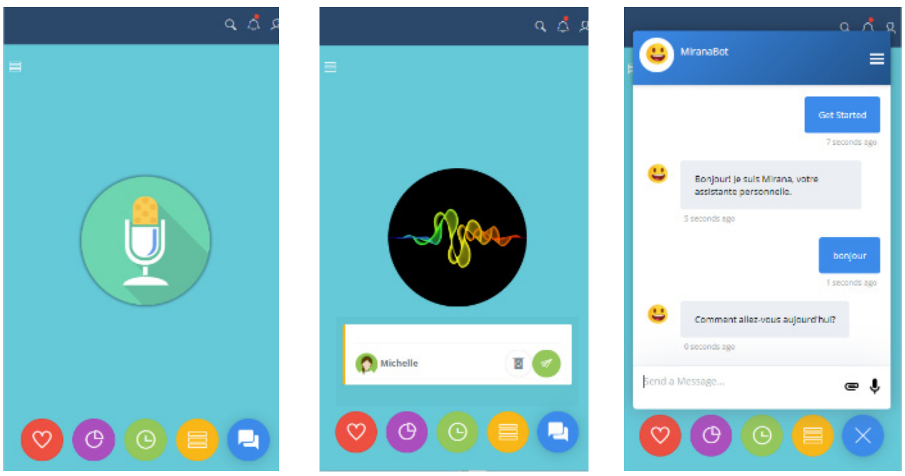

Figure 2-9: MiranaBot

2.3.4 Touchpoint 4

- <u>Results of DTU:</u> Lyngby trial 1 should answer the question, whether receiving feedback on physical activity level would lead to any change in the level of physical activity. 22 elderlies suffering under dementia or physical impairments took part in this trial. During the interview 68% of the individuals indicated that they felt motivated to become more physical active (see **Figure 2-10**).

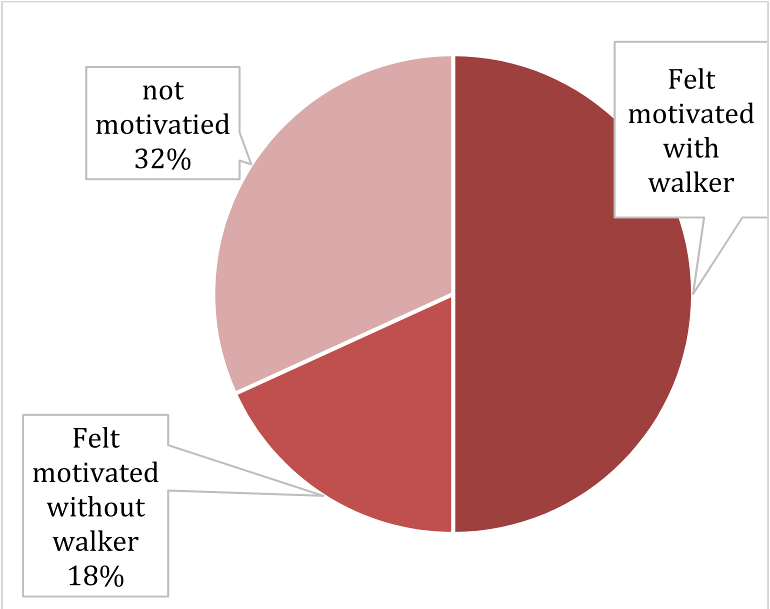

Figure 2-10: Results of Lyngby 1

Lyngby 2 and 3 examine to what extent playful physical exercise improves physical and functional abilities and is accompanied by changes in physical activities outside exercise sessions. Playware Tiles were used to motivate the elderlies (see **Figure 2-11**). All participants had physical improvements, just small and not significant improvement in the balance tests. The used behaviour change techniques were feedback and gamification. For elaboration see **D27 Appendix 1,** trial number 19 and 20.

Figure 2-11: Use of Playware Tiles to motivate elderly to improve their physical health

- Results of CU: This randomized controlled trial is about behavioural change strategies for increasing physical activity in elderly. The study will include >128 participants aged 70 or above who own a smart phone and are not suffering from extreme disease like Parkinson. One group (control group) gets just monitors and the other group gets monitors plus feedback from health care provider (through phone) (see **Figure 2-12**).

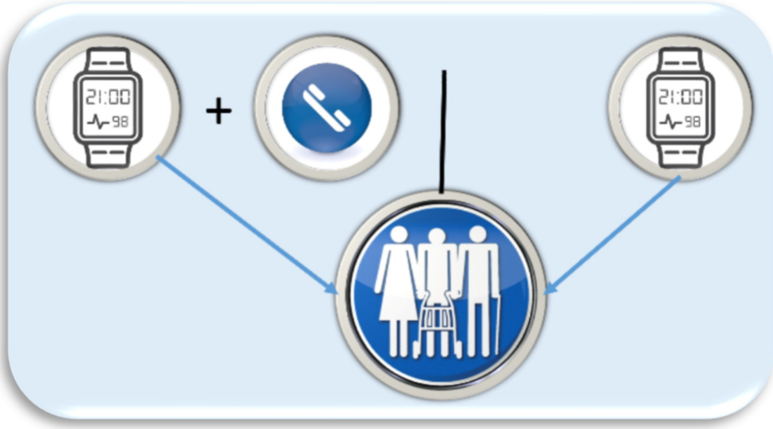

Figure 2-12: Study construction

There will be a flow diagram about how to speak with the elderly on phone. Primary outcome are steps per day. Social Cognitive Theory, which includes social factors like acknowledge of friends, was used as a behaviour change technique. Recruiting will be done through connection to ZZ, emails, newspaper etc. Participants should be "normal" elderlies.
Technology acceptance is a big issue to be considered for the elderly population. The requirement of the trials that the participants have to own already a mobile phone sort out people with very limited technology acceptance in advance. For elaboration see **D27 Appendix 1,** trial number 21.

2.4 Regimens and guidance for upcoming work

Group work in the Touchpoints (joint development of next steps per TP, beyond September 2018).

In the following, the progress in each TP should be review in a structured way. An overview about which techniques the REACH partners used should be given. In order to compare the different results, the Touchpoint must specify their user group, the used behaviour change techniques, the context, age group specific aspects, cultural challenges, the level of success, the current status of the TPs and the outcome (see **Table 2-1**). This task allows finding crossovers and transferring the insights of one Touchpoint to another Touchpoint.

Table 2-2: Template to be filled by the Touchpoints

A) User group/study group	…

B) Behaviour Change Techniques	…
C) Domain/Context	…
D) Age Group specific aspects	…
E) Cultural Challenges	…
F) How successful?	…
G) Process, next steps (Tested/Piloted/…)	…
H) Metrics + Outcomes, Study Design etc.	…

2.4.1 Touchpoint 1: Personal Mobility Device

Figure 2-13: ActivLife Test in ZZ

Touchpoint 1 is about a mobility device to prevent, mitigate and reverse functional loss due to immobility. It addresses seniors who experienced an event such as stroke or falling accident and is in a post-event rehabilitation, seniors with physical decline and healthy seniors. The TP has to deal with the problems lack of motivation, the low technology acceptance, the fear (of technology and falling) and perceived weakness of the elderlies. The aim is to motivate the elderly to do physical activity through behaviour change techniques such as social support, feedback, rewards, gamification and personalization. Particularly successful in the test was social support, in the test represented by the sport coach. Since he/she knows the test person, he/she could motivate the person individually, depending on which technique are most suitable for the test person. AM wants to focus on social support more deeply in the future. The effectiveness of sport coaching must be scientifically proven in future work, for example through a cost-benefit analysis. The tests in ZZ are finished, the next tests in HUG are in planning (see **Table 2-3**).

Table 2-3: Results of the group work of Touchpoint 1

A) User group/study group	Healthy seniors Post-event rehabilitation (seniors) Seniors with physical decline
B) Behaviour Change Techniques	Social support Feedback Rewards Gamification Personalization
C) Domain/Context	PA
D) Age Group specific aspects	Lack of motivation Low technology acceptance Fear Perceived Weakness/Illness
E) Cultural Challenges	Technique Social conservatism
F) How successful?	We need to base on social support
G) Process, next steps (Tested/Piloted/…)	ZZ finished HUG planned
H) Metrics + Outcomes, Study Design etc.	Change in motivation: continuous engagement Post-Intervention

Figure 2-14: Touchpoint 1 at group work

2.4.2 Touchpoint 2: Smart Patient environment:

Figure 2-15: PI²U scenario for a senior apartment

In Touchpoint 2, a smart environment (see **Figure 2-15**) is being developed to prevent, mitigate and reverse functional loss associated with immobility. With the assigned use case setting in SK, this Touchpoint focuses on patients who suffer from fear of falling, and have motor and cognitive constraints (see deliverable 1.1, 3.2. Use Case 2: SK, pg. 41 et seq.). The patients are hospitalised for neurological rehabilitation and have to deal with regaining functions supported by therapeutic interventions. In this vulnerable state appropriate behaviour change techniques must be used. Therapy must be personalized, and physicians, therapists and caregivers have to work goal-oriented and with a high repeating frequency. The use of robotics and sensor systems is beneficial to save resources and reduce therapists' and caregivers' workload. Self-awareness is also an important aspect in the behaviour change techniques in Touchpoint 2. Like the other Touchpoints, Touchpoint 2 has to deal with the low technology acceptance of the elderly population.

In order to be able to carry out a test in a hospital in Germany, several preparations must be made in advance. At present, the Touchpoint 2 works on the ethic application for two scientific projects. The tests in SK will take place in July 2019. The outcomes in SK will be focused on motor function, cognitive function, technical acceptance (users, therapists, and caregiver), motivation, ADL. Highly specific assessments such as BI (**Mahoney, 1965; Collin et al., 2009**), BBS (**Berg et al., 1995; Scherfer et al., 2006; Stevenson, 2001**), SPPB (**Guralnik et al., 1994; Treacy & Hassett, 2018**), 5xSST (**Bohannon, 2006**), Hand grip strength (**Allen & Barnett, 2011**), MoCA (**Nasredinne et al., 2004**), IMI (**Ryan, 1982; Deci et al., 1994**), and NASA-TLX (**Hart & Staveland, 1988**), will be applied.

Table 2-4: Results of the group work of Touchpoint 2

<table>
<tr><td>A) User group/study group</td><td>Patients</td></tr>
<tr><td>B) Behaviour Change Techniques</td><td>Repetition – personalization (therapy)
Feedback – self-awareness (autonomous training) + goal oriented</td></tr>
<tr><td>C) Domain/Context</td><td>Activity
Movement
Cognitive function</td></tr>
<tr><td>D) Age Group specific aspects</td><td>Fear of falling
Technology acceptance
Mental state</td></tr>
<tr><td>E) Cultural Challenges</td><td>Stakeholder/care taker Involvement</td></tr>
<tr><td>F) How successful?</td><td>July 2019</td></tr>
<tr><td>G) Process, next steps (Tested/Piloted/…)</td><td>In planning (ethics application)</td></tr>
<tr><td>H) Metrics + Outcomes, Study Design etc.</td><td>Physiotherapist + Neuro-psychologist outcomes
<table>
<tr><td>Moto function</td><td>Cog. Function</td><td>Therapist</td><td>Motivation</td></tr>
<tr><td>BBS
CST
FRT</td><td>TAP
MOCA</td><td>NASA-TLX
SUS</td><td>IMI</td></tr>
</table></td></tr>
</table>

Figure 2-16: Touchpoint 2 at group work

2.4.3 Touchpoint 3: Socializing & Nutritional Monitoring & Intervention

Figure 2-17: REACH HealthyTogether (TU/e + EPFL)

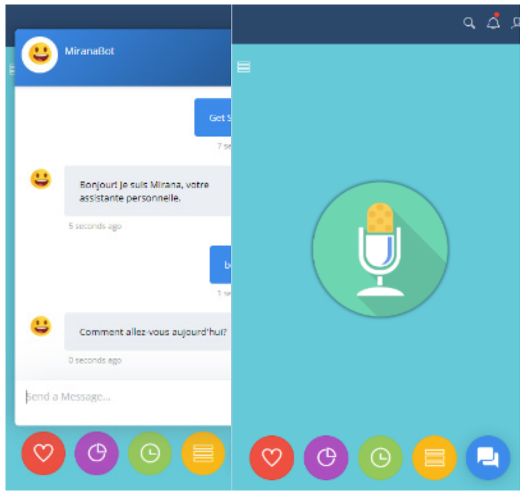

Figure 2-18: MiranaBot

Touchpoint 3 is about developing Socializing and Nutritional Monitoring and Intervention to prevent, mitigate and reverse functional loss. Through the promotion of social activities in combination with eating/drinking a large number of different elderlies with different problems should be addressed. ZZ focus on elderlies with a certain degree of frailty who are living alone, HUG address obese patients and BioZoon developed interventions for patients with swollen challenge. ZZ focus on physical activity, the behaviour change techniques social support, self-awareness and feedback were tested. Especially successful was social support, to be precise peer support and intergenerational support. The measured outcome is number steps. HUG focus with MiranaBot on food. MiranaBot use self-awareness, self-reflection, feedback, goal setting, tiny steps, personalization and education as behaviour change techniques. HUG is working right now on the test prototype. Also, Biozoon works on prototypes in the food context. The used behaviour change techniques are social support, feedback, recommendation, personalization and goal setting (see
Table 2-5)

Table 2-5: Results of the group work of Touchpoint 3

	ZZ	HUG	BioZoon
A) User group/study group	Elderly living alone with certain degree of frailty	Obese patients	Patients with swollen challenge
B) Behaviour Change Techniques	Social support (peer support and intergenerational support), self-awareness, feedback	Self-awareness, self-reflection, feedback, goal setting, tiny habits, personalization, education	Social, feedback, recommendation, personalization, and goal setting
C) Domain/Context	Physical activity	Food	Food
D) Age Group specific aspects	-	-	-
E) Cultural Challenges	Participants are motivated already for social activities	-	-

	ZZ	HUG	BioZoon
F) How successful?	Peer support+ intergenerational support-	Still working on test prototypes	Worked on prototypes
G) Process, next steps (Tested/Piloted/…)	Not finished	Not finished	Not finished
H) Metrics + Outcomes, Study Design etc.	Number of steps	Categories of food	Categories of nutrition

Figure 2-19: Touchpoint 3 at group work

2.4.4 Touchpoint 4: Gaming & Training System

Figure 2-20: Playware Tiles at Trial Lyngby 2 and 3

In Touchpoint 4 a gaming and training system is developed to prevent, mitigate and reverse functional loss through the promotion of physical activity. This Touchpoints includes cognitive training/simulation and rehab training. The trial at DTU addresses inactive adults over 65 years. The average age in the trial was 85 years. Through playful group exercises, the elderly were able to improve their balance. The Bergs Balance Scale, steps and feasibility are the medical outcome of that trial. The trial at CU address seniors over 70 year who owns an own smartphone. Through motivational interviews, the Social Cognitive Theory should be applied as a behaviour change technique. Preparations for the trial are done, the trial can be conducted as a validated randomized controlled trial.

Table 2-6: Results of the group work of Touchpoint 4

		DTU	CU
A)	User group/study group	65+ (avg. 85), “In need of activity”, activity centres	Community dwelling, 70+, smartphone user
B)	Behaviour Change Techniques	Playful group exercise/engagement	Social Cognitive Theory = Motivational interviews
C)	Domain/Context	Physical function + activity	Physical activity + self
D)	Age Group specific aspects	-	-
E)	Cultural Challenges	-	-
F)	How successful?	5% improved balance % physical activity change	Stay tuned
G)	Process, next steps (Tested/Piloted/…)	Completed	SP complete, validated RCT to be conducted
H)	Metrics + Outcomes, Study Design etc.	Bergs Balance Scale + obj. physical activity (steps) Cross-over RCT (feasibility)	Obj. steps/day Proms RCT

Figure 2-21: Touchpoint 4 at group work

2.5 The concept of personalization in the context of user acceptance and motivation: REACH personalization process

As part of **TP3** a behaviour Change Enabled Design Process for the development of Personalized Motivational Strategies was developed (Tu/e, Philips, ZZ) and will now step wise be generalized (through coordination and integration with other TPs) as a REACH unique work flow and asset.

Early Testing

The purpose of the early testing in touchpoint 3 was to explore the level of physical activity, kinds of physical activity and type of cooking habits of the older adult members of the senior community centre. From this early testing, researchers discovered that the level of physical activity done by older adults is very divers. It was also observed that both social engagement and self reflection could have merit as motivational strategies. From this early testing hypothesis were formulated to be tested in continued testing. Furthermore, early testing allowed researcher to better understand the barriers to technology participants faced in order to set up an improved test protocol for continued testing, using increased technology support.

Continued Testing

Continued testing built on the findings from early testing resulting in better protocol, decreased data loss and improved participant support through out the trail. The purpose of the continued testing was to answer certain hypothesis raised by early testing. Behavioural, contextual and phycological information on participants was collected to create motivational profiles. Two mobile applications were designed which each incorporated one of two motivational strategies; the first used self-reflection and the other social reflection. The number of steps participants took during the baseline measurement and while using the intervention application can be compared to identify which personal profile factors might be indicators for which of these motivational strategies to use.

Co-Design

Future steps for this on-going investigation include a co-design process where users evaluate the applications used in continued testing. Also in this process design researchers collaborate with older adults to ideate concepts these end-users expect will support their motivation to live more active lives. An analysis of the motivational strategies used will be done to evaluate which motivational strategies are more relevant in addressing older adult end users with a particular motivational profile. In addition, the creative ideas which will flow from this co-design collaboration will fuel the creation of prototypes built and tested in the next phase of this on-going study into how to motivate older adults to live more active lives.

Co-Creation

The goal of the Co-creation phase is to prototype and test ideated concepts from the Co-design study. In this phase older adults and design researchers work enter a co-creation process in which they build on selected ideated concepts. The prototyped concepts will then be tested in a living lab environment using a very similar protocol to that which was used during continued testing in order to also make these results comparable. The purpose of this study would be to yield usable porotypes and more specific knowledge on which design interventions and motivational strategies best addresses the different and identified motivational profiles of the older adult community.

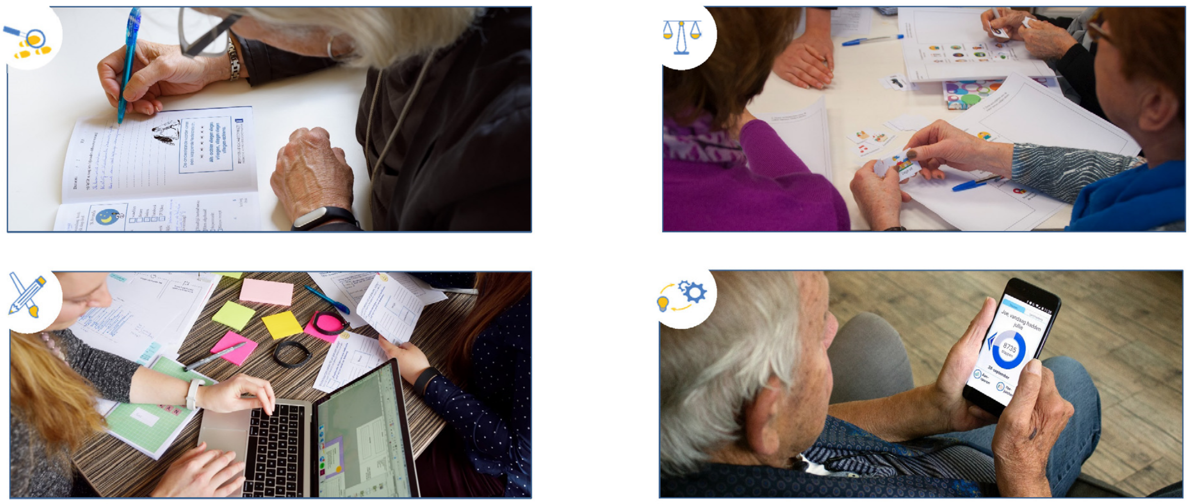

Figure 2-22: REACH process for the creation of personalized motivational strategies

The progress made in **TP3** builds on earlier findings from results and insights gained through preceding process stages. In the overall process of research and development, work within **TP3** moves from discovering, designing, evaluating and implanting these insights and interventions.

Key elements of the REACH process for personalised motivational/behavioural strategies:

1. **Discovering (early testing):** The purpose of the early testing in touchpoint 3 was to explore the level of physical activity, kinds of physical activity and type of cooking habits of the older adult members of the senior community centre. From this early testing, researchers discovered that the level of physical activity done by older adults is very divers. It was also observed that both social engagement and self-reflection could have merit as motivational strategies. From this early testing hypothesis were formulated to be tested in continued testing. Furthermore, early testing allowed researcher to better understand the barriers to technology participants faced in order to set up an improved test protocol for continued testing, using increased technology support.

2. **Designing (continued testing):** Continued testing built on the findings from early testing resulting in better protocol, decreased data loss and improved participant support throughout the trail. The purpose of the continued testing was to answer certain hypothesis raised by early testing. Behavioural, contextual and psychological information on participants was collected to create motivational profiles. Two mobile applications were designed which each incorporated one of two motivational strategies; the first used self-reflection and the other social reflection. The number of steps participants took during the baseline measurement and while using the intervention application can be compared to identify which personal profile factors might be indicators for which of these motivational strategies to use.

3. **Evaluating (co-design):** Future steps for this on-going investigation include a co-design process where users evaluate the applications used in continued testing. Also, in this process design researchers collaborate with older adults to ideate concepts these end-users expect will support their motivation to live more active lives. An analysis of the motivational strategies used will be done to evaluate which motivational strategies are more relevant in addressing older adult end users with a particular motivational profile. In addition, the creative ideas which will flow from this co-design collaboration will fuel the creation of prototypes built and tested in the next phase of this on-going study into how to motivate older adults to live more active lives.

4. **Implementing (co-creation):** The goal of the Co-creation phase is to prototype and test ideated concepts from the Co-design study. In this phase older adults and design researchers work enter a co-creation process in which they build on selected ideated concepts. The prototyped concepts will then be tested in a living lab environment using a very similar protocol to that which was used during continued testing in order to also make these results comparable. The purpose of this study would be to yield usable porotypes and more specific knowledge

on which design interventions and motivational strategies best addresses the different and identified motivational profiles of the older adult community.

3 Analysis and structuring of acceptability drivers: ethical, privacy/security, legal, and accessibility considerations

This chapter analyses and structures knowledge generated about key acceptability drivers (ethical, privacy/security, legal, and accessibility considerations) during the insertion of REACH elements (i.e. Touchpoints) into the ecosystems of the four use case settings (HUG, SK, ZZ, Lyngby). The elicited and outlined knowledge represents REACH specific know-how about how to use these acceptability drivers to embed advanced ICT-driven technology for early detection and intervention use cases into age inclusive communities.

The acceptability drivers identified, used, or applied during the developments of the four Touchpoints are outlined in **Sections 3.1.2 – 3.1.5**. From this review per Touchpoint a generalized integrated view was generated, which also links the findings to nationally and international accepted guidance documents (e.g. ISO standards). The work conduced and outlined in these deliverable builds on previous work, i.e. the analysis and outline of privacy issues along the patient journeys of each Touchpoint (see **Figure 3-1**, showing exemplarily the privacy issues for the **TP2** patient journey; see **Appendix of Periodic Report No. 1** for more details on the other TPs)

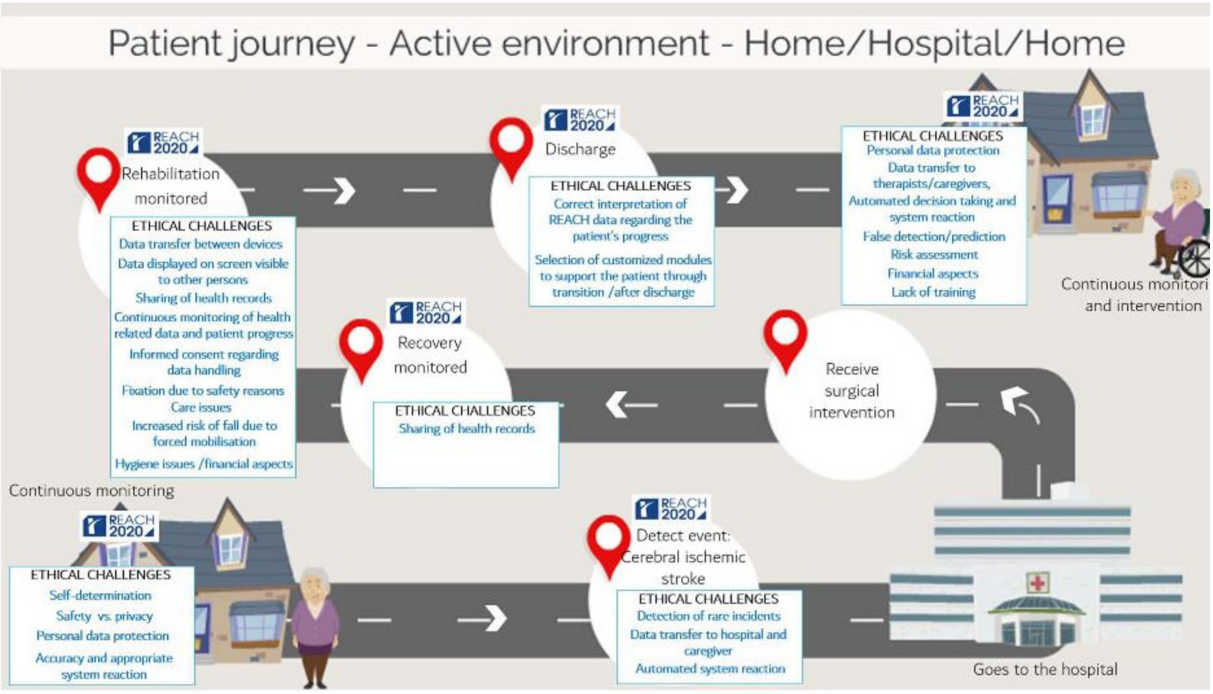

Figure 3-1: Privacy issues plotted along the TP2 patient journey (see Appendix of Periodic Report No. 1 for more details on the other TPs)

3.1.1 General, integrated overall REACH view

	Ethical, social, and inclusion dimensions	Privacy aspects	Legal and liability aspects	Usability, accessibility and acceptability
Key aspects to be considered (in TPs and overall REACH level)	• Ethical feasibility of screening-like sensor based early detection • Avoid stigmatisation • Combat loneliness and facilitate socialising and community-based solutions • Selective/differential automation/assistance: amount of technical assistance provided or (intentionally) not provided needs to be carefully adapted to the situation • Understand ecosystem and context in which REACH solution is inserted • Choice, adaptability, personalisation • Adhere to user-driven design and user + stakeholder co-creation principles • Interoperability of REACH with existing and other solutions • Adapt (i.e. minimize) number of sensors used and data generated to the specific goals • Transparency and fairness of data collection and ML pipelines • Possibility to object to, influence, or revise the automated processing of data. • Use of proper and non-stigmatizing wording both during development and for communication of the results and developments.	• Compliance with the GDPR • Avoid uncontrollable centralised "data oceans" (a la US and China) and create flexible local, distributed, and goal/use specific platforms • Application of privacy by design principles • Informed consent • Responsible handle data re-use • Apply proper pseudonymisation (i.e. codification)/anonymisation • Regulate accountability and data/information access • Minimise the amount of data generated and processed by integrating need for sensor readings and algorithm design • Balance data need for personalisation and user profiling vs. privacy needs • Enhance digital literacy of elderly	• Support later CE certification through systematic and well documented development processes • Consider legal and liability aspects arising from REACH Engine/analytics components and automated or semi-automated ways of decision-making regarding detection and intervention • Assessment of potential risks (harm and negative consequences) for elderly or patient through REACH solutions • Application of risk management techniques • Development of appropriate user manuals and training instructions for use of REACH solutions in the different environments needed.	• Co-creation and user participation: involvement of users into the requirements engineering and development process needs to be ensured. • Systematic requirements engineering • Usability: use of proper metrics to assess the capability to properly use the devices (e.g. NASA task load index) • Systematic verification and validation: technical, professionals, users, stakeholders, etc.) • Acceptability: Emphasizing elderly needs and requirements that each REACH concept is trying to answer • Acceptability: Understanding how the whole REACH concept fit into the elderly environment (home, care home, clinical environment) • Acceptability: iterative testing needed to assess the circumstances/condition of acceptance of functions and designs of the furniture. • Use of qualitative and Ethnographic studies • Accessibility: employment of concepts such as "design for all", "personalisation", and "accessibility" •
Documents that provide guidance	a) ISO 26000 Social Responsibility b) WHO Screening criteria and good practices (e.g. Wilson and Jungner and updated versions) c) CWA 17145-1:2017 (WI=WSSAT001) Ethics assessment for research and innovation - Part 1: Ethics committee d) ISO/ DTS 17033 Ethical claims and supporting information – principles and requirements	a) REACH Deliverable D10.1/ D43: Ethics, Privacy, and Data Management b) The EU's General Data Protection Regulation (GDPR) c) The OECD privacy framework d) CEN/CLC/JTC 8 Privacy protection by design and by default e) ISO/IEC 20889:2018 Privacy enhancing data de-identification terminology and classification of techniques	a) ISO14155:2011 Clinical investigation of medical devices for human subjects – good clinical practice b) IEC/ISO 31010:2009 Risk management - Risk assessment techniques. c) ISO 31000:2009 Risk management - Principles and guidelines. d) ISO 13485:2016 Medical devices - Quality management systems -- Requirements for regulatory purposes	a) EN ISO 9241-161:2016 (WI=00122208) Ergonomics of human-system interaction - Part 161: Guidance on visual user-interface elements (ISO 9241-161:2016) b) EN ISO 9241-11:2018 (WI=00122223) Ergonomics of human-system interaction - Part 11: Usability: Definitions and concepts (ISO 9241-11:2018) c) ISO 21542:2011 Building construction -- Accessibility and usability of the built environment

	e) IWA 18:2016 Framework for integrated community-based life-long health and care services f) ISO TC 314 Ageing societies: WG1 – age inclusive work environments; WG2 - dementia inclusive communities g) ISO/TR 2222:2006 Health informatics — good principles and practices for clinical data warehouses	f) ISO/NP 31700 Consumer protection — privacy by design for consumer goods and services g) ISO/AWI 22697 Health informatics – application of privacy management to personal health information h) ISO/IEC 29100:2011 Information technology – security technologies – privacy framework i) ISO/IEC 29101:2013 Information technology – security techniques privacy architecture frameworks j) ISO/TR 18638:2017 Health informatics – guidance on health information privacy education in health care organisations k) ISO/IEC AWI 27030 Information technology – security techniques – guidelines for security and privacy in internet of things	e) National medical devices laws (e.g. German Medizinproduktegesetz: MPG) f) European MDD (Medical Device Directive), 93/42/EEC -includes regulations on medical CE marking, etc. g) Clinical Evaluation Report (CER) according to MEDDEV 2.7/1 rev4 and MDD (or MDR)	d) ISO TC 136 Furniture e) ISO/IEC JTC 1/SC 35 User Interfaces + user interface accessibility cultural and linguistic adaptability and accessibility f) ISO/TS 20282-2:2013 Usability of consumer products and products for public use -- Part 2: Summative test method g) ISO/TR 16982:2002 Ergonomics of human-system interaction -- Usability methods supporting human-centred design h) IEC 62366-1:2015 Medical devices -- Part 1: Application of usability engineering to medical devices i) ISO 9241-960:2017 Ergonomics of human-system interaction -- Part 960: Framework and guidance for gesture interactions j) ISO/IEC TR 29138-3:2009 Information technology -- Accessibility considerations for people with disabilities -- Part 3: Guidance on user needs mapping k) ISO/DIS 21801 General guidelines on cognitive accessibility l) ISO/CD 24552 Ergonomics -- Accessible design -- Accessibility of digital information visually displayed on small consumer products m) ISO/IEC 29138-1:2018 Information technology -- User interface accessibility -- Part 1: User accessibility needs

3.1.2 *Touchpoint 1: Acceptability drivers in the context of the Smart Walker (ActivLife)*

System components		Ethical, social, and inclusion criteria	Privacy aspects	Legal and liability aspects	Usability, accessibility and acceptability
Item	**Application**				
PI²Us/Modular mechanical setting and devices:	People at risk of falls are enabled to perform alone safe training in a device that holds and guides them. The device states a training stander with a novel kinematic and mechanical structure that allows the safe and independent execution of a wide ADL-focused training programs	• The safe training device and the training settings (including games) shall be designed/set up in a way that avoids stigmatisation. • To facilitate social and cognitive activities the training sessions should be designed for being administered and performed in groups rather than alone • The device shall allow to control the level of assistance (e.g. secure holding) provided	*--- not applicable*	• What certification processes (CE, medical CE, Safety, etc.) would be required for what type of environments (physical therapy practices, elderly activity centres, clinical environments, etc.)? • Development of appropriate user manuals and training instructions for use in the different environments needed. • Document proper requirements engineering from the beginning to facilitate later CE certification. • Assessment of potential risks (harm and negative consequences) for elderly patients and people administering the trainings	• Co-creation and user participation: involvement of users into the requirements engineering and development process needs to be ensured. • Systematic requirements engineering • Usability: use of proper metrics to assess the capability to properly and safely use the ActivLife devices (e.g. NASA task load index)
Sensing/ Sensing and data gathering sub-system:	Groups at risk of a) Fall & Frailty, b) Neurodegenerative diseases, or c) cardiac issues are given a wearable to further verify high risk (screening). If the risk is verified there are administered training with TP1 elements. TP1 sensors: wearable sensor, step count, EMG, gesture tracking and feedback about games performed. Linked platform: CARP	• The sensor based early intervention strategy of this TP equals a screening procedure: is it ethically feasible in this context (e.g. does the reduction of risk of falls outweigh the fact that it may also have negative consequences, e.g. induce fear and turn elderly into "unhealthy" people at risk of falls or even patients. Are sufficient enough treatments (i.e. trainings) available to really counteract the diagnosed risk of falls?	• The sensor used in the screening context should be simple and obtain as less health values and data as possible, i.e. only those needed to generate a minimal viable analytics result. • Ensure that data storage and processing for the screening is done in a local, secure silo (e.g. by creating local instances for CARP or HSDP) by the institution (e.g. a practice of a general practitioner) administering it. • The use of ML to provide feedback and modulate trains should in a top down manner ideally decide type and number of sensors needed.	• Consider the available CE/medical CE certifications of the sensor to be used for screening. • Consider the available CE/medical CE certifications for the sensing and data collection system used to administer and modulate trainings.	• Use of qualitative and Ethnographic studies to determine under what circumstances the users accept the monitoring by the sensors

Analytics/ Software and Algorithms:	ML (unsupervised learning) is used to classify elderly into groups and assign the right training schemes. During the training ML (supervised learning) is used to intelligently modulate the trainings.	• Ensure that neither clustering algorithms nor training data sets facilitate discrimination. • Ensure that despite use of ML at various stage in the detection-analytics process, there is enough room for choice and human interaction.	• Compliancy with the GDPR needed and the national data protection regulations • Informed consent needed • Does the ML-system require a re-use of the data for other purposes? • Supervised learning requires as many (multivariate) parallel sensor readings in parallel – to what extent does this conflict with privacy regimens asking to obtain only the necessary data?	• How can we ensure that the ML modules (or the software through which they will be deployed) meets all safety/certification/clinical requirements and will be allowed for use in hospital (clinical) and care home/home care (non-clinical) use. • Who is liable if based on the ML and the trainings provided negative consequences/health outcomes for an individual elderly are the result? • Can the patient object to any use of ML in the context of contact with the screening or training system?	• Systematic verification and validation (technical, professionals, users, stakeholders, etc.) of the performance of the ML-based system components
Intervention/ Schematics for engagement, behaviour change, and physical/cognitive training:	Modular training schemes (ADLs, falls, cognitive, cardiac, etc.) embedded into software games that can be played through the ActivLife device. In the games a variety of behaviour change techniques are integrated, such as gamification, goal setting, peer pressure, etc.	• Patient empowerment to more self-training with the Active Life device should not lead to less social contact. • In the context of personalised behaviour change elements embedded into trainings and games to performed with the ActivLife device: • how are the "goals" set? • how is it ensured that the system nudges and not manipulates? • how is it ensured that the system still provides choice?	• Handling of data and information obtained in the context of the development of personalised trainings with ActivLife • Both elderly and the providers of the personalised trainings (sports coaches, physical therapists, etc.) should be trained in using the systems in a privacy preserving manner	• What certification processes (CE, medical CE, Safety, etc.) would be required (in particular for the modular physical) for the training/gaming software for what type of environment? • Training and behaviour change schematics: validation and liability requirements for administering them in in home, care home, and clinical environments? • Assessment of potential risks (harm and negative consequences) for elderly patient • Ensure that people do not over exercise.	• Acceptability: iterative testing needed to assess the circumstances/condition of acceptance of functions and designs of the training functionality • Acceptability: the designed intervention (games) should be personalized to the user needs, ability and preferences. • Use co-creation and user participation to develop the underlying concepts (e.g. goal setting and behaviour change mechanism) of the personalisation regimens
User interfaces:	Software that allows to play the games, select specific games, display progress over time, etc.	• Interfaces should be designed in a way that they do not disadvantage any user group (male/female; skilled/un-skilled), and allow for broad accessibility (elderly, care givers, physio therapists, younger people, etc.)	• Management of data obtained through gaming (e.g. screen time, games played, performance). • Allow users through the interface to set/adjust their privacy preferences • Interfaces and data sharing with higher level systems and platforms (e.g. Philips HSDP) • Privacy by design, e.g. according to ISO/PC 317	• Consider medical CE certification for clinical context use/adaptation	• Ensure broad Accessibility: employment of concepts such as "design for all", "personalisation", and "accessibility"

3.1.3 *Touchpoint 2 Acceptability drivers in the context of the Smart Care/Patient Room*

System components		Ethical, social, and inclusion criteria	Privacy aspects	Legal and liability aspects	Usability, accessibility and acceptability
Item	**Application**				
PI²Us/Modular mechanical setting and devices: adaptable modular physical care/patient room environment (frame around PI²U-Bed, PI²U-MiniArc, PI²U-SilverArc, etc., i.e. Total Room Kit); adaptable to various care scenarios: home/smart home, care home, rehabilitation hospital.	Modular smart rehabilitation room for rehabilitation (clinical setting) and activation purposes (home); Modular system that a) integrates existing elements (e.g. existing beds), b) serves as carrier for unobtrusive sensing, c) allows flexible adding/removing of integrated training functionality, and d) can be adapted to a variety of settings.	• Adaptability: the integration of REACH solutions through PI²Us shall be highly context sensitive, adapted to a community's/institution's ecosystem (e.g. through modular combinations of toolkit elements) and individual users and their situations (personalisation) • Is the amount of physical support, assistance, and comfort provided suitable for the need and the context (i.e. not too much and not to less assistance or automation provided) so that enough assistance can be provided while still challenging people • Shall PI²Us make the integrated functionality "visible" or "in-visible/hidden"? • PI²Us shall follow a user-driven design and co-creation principles • The deployment of PI²Us in any environment shall not lead to any kind of stigmatisation • principles of social and public interest design could be taken into account	*--- not applicable*	• What certification processes (CE, medical CE, safety, declaration of conformity etc.) would be required for what type of environments (home, care homes, clinical environments, etc.) allow fast modular adaptation. • Development of appropriate user manuals and training instructions for use in the different environments needed. • Assessment of potential risks (harm and negative consequences) for elderly patient	• Co-creation and user participation: involvement of users into the requirements engineering and development process needs to be ensured. • Usability: where proper metrics used to assess the capability to properly use the devices (e.g. NASA task load index)? • Acceptability: iterative testing needed to assess the circumstances/condition of acceptance of functions and designs of the furniture. • Acceptability: how does it fit to the user's environment? • Accessibility: it needs to be ensured that the furniture/room elements can easily be used by a variety of users (elderly with different capabilities, care personnel, family members, etc.); therefore, employment of concepts such as "design for all", "personalisation", and "accessibility" (e.g. ISO TC 59 accessibility of the built environment, ISO TC 136 furniture, etc.)
Sensing/ Sensing and data gathering sub-system: network of a variety of ambient and wearable sensors (pluggable to CARP and HSDP) for use in context of HAR	Network of a variety of ambient and wearable sensors (for HAR); Human Activity Recognition requires a tailor-made set of ambient and wearable sensors.	• Is the type of sensors used appropriated and indirect enough to guarantee the users privacy and dignity? • The number of sensors used in the HAR environment shall not be excessive but minimised and tailored to what is necessary to perform the needed ML-tasks.	• Do the sensors and the components used (e.g. the wireless sensor network) in it ensure that unwanted access (e.g. through hacking) is prevented? • Does the data collection pipeline ensure that the data are handed over safely from process step to	• Consider the available CE/medical CE certifications of the sensors and the software part of the total room kit in the context of data collection and storage • Declaration of conformity • Suitable intended purpose	• Acceptability: In case of wearable sensors: to what extent it is feasibly that elderly wear or have attached a specific sensor continuously. • How do on board storage capacity and battery power affect efficient use in the clinical environment.

		• The deployment of wearable sensors as well as ambient sensors in the environment shall be done in a way that avoids over stigmatisation • Interoperability: is the deployed sensing and data collection solution compatible with existing digital and non-digital systems in the environment in question (e.g. home and building automation systems, sensors/clouds of other products needed by the user or the care givers, etc.)	process step (e.g. from the sensors to the sub-serves to the platform) • When and how are data pseudonymized (i.e. codification)/anonymised. • How is access to the data controlled and is accountability clearly regulated (e.g. who is the data controller) • What are advantages/disadvantages of a locally (e.g. at SK) deployed HDSP version and a CARP platform located in Copenhagen. • How much access and control are the elderly user (patient) given over the data?		• Accessibility: can then sensors easily be deployed and intuitively be used by the care givers, nurses, and the end-users alike?

Analytics/ Software and Algorithms: Human Activity Recognition Chain (HAR)	The automated ML-based recognition/prediction of Human Activities can serve as the basis for advanced and proactive interventions in any care environment.	• Does the training data set accurately represent the source/target population?
		• Are the logics/mechanics of the algorithm transparent?
		• Is it possible and ethically viable to obtain the necessary permissions (Ethics approval) for the obtaining of training data sets?
		• To what extent have elderly/patients the possibility to gain knowledge about, object to, or influence the automated processing of their data?
			• Compliancy with the GDPR needed and the national data protection regulations
			• Informed consent needed
			• Does the ML-system require a reuse of the data for other purposes?
			• HAR requires as many (multivariate) parallel sensor readings in parallel – to what extent does this conflict with privacy regimens asking to obtain only the necessary data?
				• How can we ensure a legally correct obtaining, use, and reuse of training data and data sets (ideally obtained in the same institution) needed to build up and train ML algorithms?
				• How can we ensure that the ML modules (or the software through which they will be deployed) meets all safety/certification/clinical requirements and will be allowed for use in hospital (clinical) and care home/home care (non-clinical) use.
				• Who is liable if based on the ML components output and the decisions made based on it negative consequences/health outcomes are the result?
				• Can the patient object to any use of ML in the context of his hospital stay or treatment?
					• To what extent are key acceptability drivers considered:
					  ○ Transparency of the whole data collection and processing pipeline and right to object or withdraw or determine privacy settings
					  ○ Is the value for the user high enough to justify and outweigh the case specific data collection and processing intensity?
					  ○ Is data security ensured?

Intervention/ Schematics for engagement, behaviour change, and physical/cognitive training: Activation through	Activation through room integrated mobilisation (verticalization, mobility, training, etc.) strategies and devices. Integration into every-	• The smart training room should prioritise the administration of training ADLs and social training) and empowerment solutions best able to stimulate further social inclusion.	• Handling of data and information obtained in the context of the development of personalised trainings and therapies	• What certification processes (CE, medical CE, safety, declaration of conformity, etc.) would be required (in particular for the modular physical) training functions and elements of the bed for what type of environments (home, care homes, clinical	• It is difficult to test and validate more than 1 or 2 behaviour change strategies in combination • General behaviour change regimens should be developed and fined tuned in an iterative manner

room integrated mobilisation (verticalization, mobility, training, etc.) strategies and devices	day furniture and environments allows for better self-use and independence and lowers accessibility and barrier of use (patient empowerment)	• Patient empowerment to more self-training should not lead to less social contact. • The seamless inclusion of training into the care/patient room should not lead to less social contact and more retraction. • Empowerment and assistive solutions (e.g. in the form of the iStander toileting function) must be carefully balanced against and adapted to the user's capabilities as of still to provide enough stimuli and not make sedentary behaviour to easy.		environments, etc.) to allow fast modular adaptation. • Training and behaviour change schematics: validation and liability requirements for administering them in home, care home, and clinical environments • Assessment of potential risks (harm and negative consequences) for elderly patient	including at several stages direct user feedback and user co-creation elements
User interfaces: Room management software	Room management software. By an appropriate GUI, the user can intuitively control the REACH system.	• Interfaces should be designed in a way that they do not disadvantage any user group (male/female; skilled/un-skilled), etc. • Can the interface be designed in a way that it facilitates the inclusion and activities of informal caregivers?	• Management of data obtained through its use (e.g. screen time and similar) • Interfaces and data sharing with higher level systems and platforms (e.g. Philips HSDP) • Privacy by design, e.g. according to ISO/PC 317	• Consider medical CE certification for clinical context use/adaptation • Declaration of conformity • Suitable intended purpose	• The user interface shall facilitate broad accessibility and inclusion; e.g. according to ISO/IEC JTC 1/SC 35 User Interfaces (which includes provisions on user interface accessibility cultural and linguistic adaptability and accessibility ISO/IEC JTC 1/SC 35)

3.1.4 Touchpoint 3: Acceptability drivers in the context of Socialising and Nutrition

System components		Ethical, social, and inclusion criteria	Privacy aspects	Legal and liability aspects	Usability, accessibility and acceptability
Item	Application				
B1: Pl²Us/ Modular mechanical setting and devices: Smart table Kooktafel, Pl²U-Silver Arc, ActivLife	People at risk of falls are enabled to perform independent safe training in a device that holds and guides them. The device states a training stander with a novel kinematic and mechanical structure that allows the safe and independent execution of a wide ADL-focused training programs	• Does the seamless integration of digital technology into day care centres/care homes by Pl²Us lead to an unwanted blurring of the boarders between real and digital world? • Pl²Us (Smart Table, Pl²U-Silver Arc, Active Life) shall follow a user-driven design and co-creation principles • The deployment of Smart Table, Pl²U-SilverArc, ActivLife in any environment shall not lead to any kind of stigmatization	• The physical environment and devices are in this Touchpoint designed to facilitate activities in the community, however these devices shall also ensure that people can still retract and keep certain activities and data private	• What kind of certifications are required for the installation of Pl²Us as furniture in day care centres? • Are the Pl²U furniture elements designed for on-site installation by professionals or non-professionals (i.e. whom do we expect to install the elements)? Who is liable in case malfunction/harm due to incorrect installation? • Pl²Us are complex types of furniture – are user manuals enough or are systematic training briefings needed?	• Does the smart cooking table allow to keep physical and cognitive stress levels (e.g. according to NASA TLX) low in order to ensure safe and intuitive use? • To facilitate socialising and the use in a community, all elements of this touchpoint must in particular ensure very broad accessibility (e.g. according to ISO standards or similar deign guides)
B2: Sensing/ Sensing and data gathering sub-system: Ecosystem of sensing and interface elements Mirana Bot, HealthyTogether App, SMAAK concept for a social eating platform, and FitBit	The HealthyTogether user interface (that allows tracking and social- or self-reflection based on PA data from FitBit) can be combined flexibly with a module for food tracking and a module for social eating and communication around food.	• From the available ecosystem of sensing elements, provided by this touchpoint, only those elements shall be selected which are really needed in a specific context. The minimization of sensing elements states a key privacy by design element.	• Both elderly and the care givers should be trained in using the systems in a privacy preserving manner • The system implies functionality of social platforms such as Facebook or similar, however the information obtained (about eating habits, steps, physical activity, etc.) are much more personal • Systems should be designed in a way which limits user's risks of unwanted or accidental data sharing	• Sensors may wrongly detect the input or fail to detect the input (e.g. in case of Mirana Bot or FitBit). Therefore, the accuracy performance of the sensors needs to be specified.	• Acceptability: In case of wearable sensors: to what extent it is feasible that elderly wear, or are otherwise continuously attached to, a specific sensor? • Acceptability: In case of application (Mirana Bot), to what extent it is feasible that the elderly can describe their nutrition habits (prompt with notification in case they forgot) / how easy it is to log their nutrition habits? • How do on-board storage capacity and battery power affect efficient use in the community in question? • Accessibility: can sensors be easily deployed and intuitively be used?
B3: Analytics/ Software and Algorithms: Philips dashboard and machine learning based personalization	Modularly combinable set of tools for interpretation of health and life style data in the context of behaviour change/engagement	• Does the training data set accurately represent the source/target population? • Are the logics/mechanics of the algorithm transparent?	• The use of data dashboards and ML in the community context must be made transparent to everyone taking part in the community activities) elderly, caregivers, and professionals, etc.)	• Who is liable in case a by the algorithm selected and recommended action, training, intervention leads to negative outcomes/consequences?	• To what extent are key acceptability drivers considered: ○ Transparency of the whole data collection and processing pipeline and right to

		• Since the solution for this TP involves the use of high-dimensional neural networks and similar techniques: can it be ensured that the decision logics of the algorithms at work can be comprehended and retraced? • Is it possible and ethically viable to obtain the necessary permissions (Ethics approval) for the obtaining of training data sets? • To what extent have elderly/patients the possibility to gain knowledge about, object to, or influence the automated processing of their data?	• Possibility to opt out or limit data collection by the system must be possible without being excluded from the community activities the system shall facilitate		object or withdraw or determine privacy settings ○ Is the value for the user high enough to justify and outweigh the case specific data collection and processing intensity? ○ Is data security ensured?
B4: Intervention/ Schematics for engagement, behaviour change, and physical/cognitive training: Personalised engagement regimens in combination with personalised food receipts and cooking guidance, and gamified social training at activity centre	Schemata and guidance for the implementation of engagement and behaviour change regimens in the context of socialising and nutrition	In the context of personalised behaviour change: • how are the "goals" set? • how is it ensured that the system nudges and not manipulates? • how is it ensured that the system still provides choice?	• Very personal data about food preferences, health states, friends, etc. are generated: users shall stay in control with regard to sharing, cross integration, and sharing of this data.	• Who is liable if people are nudged into a certain behaviour with negative consequences?	• Behaviour change and personalisation regimens should be developed and fined tuned in an iterative manner including several stages direct user feedback and user co-creation elements
B5: User interfaces: HealthyTogether App	A novel app based on HealthyTogether to collect step data, identify activity patterns, derive personalisation strategies	• In particular in the community centre context, the interfaces should be designed in a way that they do not disadvantage any user group (male/female; skilled/un-skilled), etc.	• How is consent obtained when data are shared for motivation purposes (e.g. gamification) with peers?	---	• The user interface shall facilitate broad accessibility and inclusion; e.g. according to ISO/IEC JTC 1/SC 35 User Interfaces (which includes provisions on user interface accessibility cultural and linguistic adaptability and accessibility ISO/IEC JTC 1/SC 35)

3.1.5 Touchpoint 4: Acceptability drivers in Gamified Engagement Environments

System components		Ethical, social, and inclusion criteria	Privacy aspects	Legal and liability aspects	Usability, accessibility and acceptability
Item	**Application**				
B1: PI²Us/ Modular mechanical setting and devices: Combination of PI²U-MiniArc furniture with playware tiles	Novel combination of playwear tiles with a standing table allows for a variety of trainings	• Does the training-furniture setting allow that the elderly also conduct other, more natural ways of activity, e.g. does the training setting empower them so that they visit more often friends or shops or similar, since balance and walking speed increase.	---	• Who is liable if accidents happen during self- or supervised training sessions?	• Co-creation and user participation: involvement of users into the requirements engineering and development process needs to be ensured. • Usability: where proper metrics used to assess the capability to properly use the devices (e.g. NASA task load index)? • Acceptability: iterative testing needed to assess the circumstances/condition of acceptance of functions and designs of the furniture. • Accessibility: it needs to be ensured that the furniture/room elements can easily be used by a variety of users (elderly with different capabilities, care personnel, family members, etc.); therefore, employment of concepts such as “design for all”, “personalisation”, and “accessibility” (e.g. ISO TC 59 accessibility of the built environment, ISO TC 136 furniture, etc.)
B2: Sensing/ Sensing and data gathering sub-system: Set of playware tiles and ambient and wearable sensors for the upgrade of smart homes for the elderly	Co-adapted set of ambient and wearable sensors	• Is the type of sensors used in the smart homes for elderly appropriate and indirect enough to guarantee the users privacy and dignity? • The number of sensors used in the used in the smart homes for elderly shall not be excessive but minimised and tailored to what is necessary to perform the needed ML-tasks. • Interoperability: is the deployed sensing and data collection solution compatible with existing digital and non-digital systems in the environment in question (e.g. home and building automation	• Do the sensors and the components used in the smart home (e.g. the wireless sensor network) in it ensure that unwanted access (e.g. through hacking) is prevented? • Does the data collection pipeline ensure that the data are handed over safely from process step to process step (e.g. from the sensors to the sub-serves to the platform) • When and how are data pseudonymized/anonymised. • How does Carp ensure data privacy and security?	• What kinds of certifications are for the smart home sensors needed in the Danish context?	• Acceptability: In case of wearable sensors: to what extent it is feasibly that elderly wear or have attached a specific sensor continuously. • How do on board storage capacity and batter power affect efficient use in the clinical environment. • Accessibility: can then sensors easily be deployed and intuitively be used by the care givers, nurses, and the end-users alike?

		systems, sensors/clouds of other products needed by the user or the care givers, etc.).	• How is access to the data on CARP controlled and is accountability clearly regulated (e.g. who is the data controller) • How much access and control is the elderly user (patient) given over the data through CARP?		
B3: Analytics/ Software and Algorithms: ML for early detection (on device ML for accurate steps recognition for elderly + trends prediction) + device (playware) integrated functional assessment	The setting allows to perform assessment of functional ability using the gamified device	• The developed ML algorithms should consider the specifics of the user group (elderly) • On device assessment shall not lead to a loss of social contact e.g. with doctors of care givers.	• Does the ML-system require a reuse of the data for other purposes?	• How accurate is the on-device assessment of functional ability and who administers it? > what types of validation and certification needed. • Who is liable if the functional assessment was wrong and led to the inappropriate actions, suggestions, or trainings with negative consequences?	• To what extent are key acceptability drivers considered: ○ Transparency of the whole data collection and processing pipeline and right to object or withdraw or determine privacy settings ○ Is the value for the user high enough to justify and outweigh the case specific data collection and processing intensity? Is data security ensured?
B4: Intervention/ Schematics for engagement, behaviour change, and physical/cognitive training: Training plans and games for activation of elderly with playware tile	Training schemata provide target-oriented ADL trainings in gamified, fun inducing manner enhancing medical outcomes	• There are indications that more active elderly may actually consume more health care services. • How can we distinguish between activity stimulating “nudging” and “manipulation”	Very personal data about trainings and how certain interventions work for a certain person are generated.	• Who is liable if people are nudged into a certain behaviour with negative consequences? • How can over-exercising be avoided?	• It is difficult to use (as well as test and validate) more than 1 or 2 behaviour change strategies in combination • General behaviour change regimens should be developed and fined tuned in an iterative manner including at several stages direct user feedback and user co-creation elements
B5: User interfaces: Data collection and visualisation through DTU CARP and Philips data dashboard	Dashboard summarize and visualize the different datasets of importance to the researchers for behaviour research	• Can the interface be designed in a way that it facilitates the inclusion and activities of informal carers?	• Interfaces and data sharing with higher level systems and platforms (e.g. Philips HSDP)? • Privacy by design, e.g. according to ISO/PC 317	• What certifications are required for use in what context?	• The user interface shall facilitate broad accessibility and inclusion; e.g. according to ISO/IEC JTC 1/SC 35 User Interfaces (which includes provisions on user interface accessibility cultural and linguistic adaptability and accessibility ISO/IEC JTC 1/SC 35)

4 Acceptability of sensing and monitoring elements

In this chapter we review results of investigations into acceptability and accuracy of sensing and monitoring devices during the reporting period.

4.1 Ethnographic study: learnings for REACH acceptability regiments

An ethnographic study is qualitative and aims at understanding people's behaviours, attitudes and motivations towards a particular object or services. We (led by HUG and EPFL, as part of WP3) conducted an ethnographic study for 6 weeks with 20 senior people at their home. The ultimate goal of this project was to understand whether the older adults would accept to be monitored and whether they would adopt and integrate such tools in their daily life.

We report here older adult people's perception on activity tracking devices before and after usage:

1. The main barriers of being physically active were the absence of motivation, the incapacity due to health condition and the lack of perceived usefulness of physical exercise. Furthermore, although half of the participants were not technology oriented, personal interest and enthusiasm driven by family towards technology were observed.

2. Senior's usage intention and willingness to integrate the devices in their daily life could be explained by the systems simplicity, practicality, and the possibility to customize it to their needs and ability. Participants also demonstrated a stronger motivation when the device usage was linked to a personal goal they set. The usefulness takes an important role in user willingness to adopt such devices. Designers of systems that encourage being physically active should consider emphasizing the added value of the technology usage.

3. In addition, the devices really impacted some user's behaviour and induced a relation of dependence. As the seniors broke their old habits to integrate a new system in their daily life, once getting used to it, it became a part of their lifestyle. They considered the device as a companion, a buddy that shows interesting information without constraining them. The need for timely information became greater as well as the need for receiving message that makes them less lonely. Considering this inter-relational aspect would benefit researchers who would want to increase long term engagement in technology usage for behaviour change.

4. However, some participants still found it challenging to integrate the system in their daily life. The main reasons were linked to the fear of introducing novelty and breaking their old habits, the fear to be dependent of the tools, and the need of a human presence interacting with them.

After 6 weeks of usage, we discovered changes in behaviour and usage intention which allowed us to identify opportunities and challenges for the older adults to adopt sensors and application for health and activity management. This study showed the potential of acceptance and adoption of simple and manageable technology for behaviour change. As for usage intention, some older adults start to be eager to learn new tools as long as they are able to do it, which is more and more influenced by family from younger generation. However, designers and engineers should consider older adults' fear introducing novelty in their daily life as well as their need for social interaction and their need to remain in control of any system given to them.

A detailed description of the design, outcomes, and lessons learned of the ethnographic study conducted is presented in ***Deliverable D3.1*** **(Data collection requirements, ethnographic studies, etc.; Chapter 2).**

4.2 Accuracy and acceptability of wearable trackers to be used by elderly people

The REACH-contribution from University of Copenhagen consists of three projects investigating how to use physical activity monitoring to enhance the daily amount of physical activity in older adults.

4.2.1 Project 1: A systematic review and meta-analysis

Status: Protocol published and paper in review
The objective of this systematic review was to estimate the effect of Physical Activity Monitor-based interventions on physical activity behaviour in participants aged 65 and above. Subsequently we explored the effect on body mass index, physical capacity, and health-related quality of life and finally the impact of patient- and intervention characteristics.

Twenty-one studies with 2,783 participants were included. The median participant age in the studies was 70.5 years, the median percentage of male participants was 42%, and the median baseline daily step count was 5,268. Physical Activity Monitor-based interventions had a moderate effect (SMD=0.54, 95% CI: 0.34 to 0.73) compared to control interventions, corresponding to an average increase of 1,297 steps per day in the intervention groups. No impact of patient and intervention characteristics on the effect estimates were found.
Low quality of evidence was found for a moderate effect of Physical Activity Monitor-based interventions on physical activity compared with control interventions. More studies with higher research methodology standards are required.

4.2.2 Project 2: Criterion validity for step counting in four consumer-grade physical activity monitors among 103 older adults with and without rollators

Status: Will be submitted in early February
Few studies have investigated the measurement properties of consumer-grade physical activity monitors in older adults. We investigated the criterion validity of consumer-grade physical activity monitors in older adults and whether the measurement properties differed between older adults with and without rollators and if body placement of the same type of monitor affected the results.

Four physical activity monitors were included in this study; Misfit Shine, Nokia GO, Jawbone UP and Garmin Vivofit 3. A total of 103 older adults participated and for each monitor, a total of 206 measures were available. All hip-worn physical activity monitors fulfilled the a priori hypothesized moderate criterion validity evaluating all participants. The hip-worn Garmin Vivofit 3 fulfilled the a priori hypothesized criterion validities evaluating all participants, participants with rollator and participants without rollators. None of the wrist-worn physical activity monitors fulfilled the a priori hypothesized criterion validity for any of the three participant groups.

Wrist-worn monitors cannot measure number of steps in a population of older adults using rollators. The hip-worn physical activity monitors were not significantly different in terms of measurement error or criterion validity, but overall the Garmin Vivofit 3 seems to be the best performing device of the four.

4.2.3 Project 3: The MIPAM trial: A 12-week intervention with motivational interviewing and physical activity monitoring, to enhance the daily amount of physical activity in community dwelling older adults – a randomized controlled trial

Status: Will be conducted in 2019
To investigate if motivational-interviewing will enhance the expected effect from physical activity monitors, on physical activity in older adults, we will conduct a two-arm randomized controlled trial in 2019.

Both groups in the trial will receive a physical activity monitor for everyday use in the 12-week intervention period and a folder with information about the benefits of physical activity in older age. Participants in the intervention group will in addition to the use of the physical activity monitors receive a motivational feedback session by phone of about 20 minutes constructed from the theoretical framework of Motivational interviewing by **Miller, Rollnick & Butler, 2013** and Social Cognitive Theory by **Bandura, 1997**. The content of the session focuses on investigating the most relevant possibilities and barriers for the participant to increase his or her levels of PA.

The primary outcome will be between group difference in average steps per day throughout the intervention period, measured objectively by the physical activity monitor (Garmin Vivofit 3). Secondary outcomes include participant reported outcome measures such as ‘International Physical Activity Questionnaire’, ‘Nordic Physical Activity Questionnaire’, ‘EQ5D Quality of life questionnaire’, ‘UCLA Loneliness Scale’, ‘Self Efficacy for Exercise’, and ‘Outcome expectancy for Exercise’. To ensure 80% power with an alpha-level on 0.05, we will include 128 participants. The study will enrol in March 2019.

5 Evidence and Examples from REACH trials

This chapter provides evidence and examples from the REACH trials which aimed to inveterate technology acceptance of target group.

5.1 REACH trials and acceptability (per TP)

In the following section user acceptance assessment along with it results is presented per touchpoint. The acceptability assessments applied in each touchpoint are outlined in **Sections 5.1.1 – 5.1.4**.

5.1.1 User acceptance assessments in TP1

To assess the user acceptance of new devices in SK we use standardized questionnaires which we describe in the following. The most used test is the standardized System Usability Scale (SUS), consisting of 10 items to assess the subjective usability of a system. Each item contains five positive and five negative statements about the usability with an option to choose between five-points on the Likert-scale (**Brooke, 1986**). The SUS has a high reliability of 0.911 (Cronbach's alpha) and shows a high degree of robustness. Therefore, this test is suitable to record the usability of various user-interfaces and systems. The questionnaire results in a score of 0-100. Values above 80 are considered as very good and over 60 are interpreted as good. Values below 60 indicate significant usability issues. In addition, it should be recorded which kind of usability problems occurred. The users also get the possibility to annotate each questionnaire item (**Bangor et. al., 2008**).

Another often used test in our hospital is an instrument to measure the subjective workload and stress for the users on the particular task or system usage. The NASA Task Load Index (**NASA-TLX, NASA, Hart & Steveland, 1988**) covers the mental strain, the physical strain, the temporal strain, the overall performance, the effort and the level of frustration. In addition, the subject is asked about the effort, the satisfaction with the task fulfilment, as well as the experienced frustration. The rating ranges from an overall of 0 – 120 points out of 6 items with 20 points per item (very low = success, very high = failure). It is considered a standard procedure and is widely used as a reliable and valid instrument in healthcare (**Tubbs-Cooley, 2018**). We usually use the raw version of NASA-TLX (**Hart, 2006**).

In order to additionally quantify the treatment experience, we use a questionnaire (TAEG-Komfort), which interrogates the technical affinity regarding the system, and emotional, perceptual and cognitive reactions of the test persons regarding the therapy (**Blasche et al., 2013**). In addition, possible pain or areas with discomfort can be drawn on a bodymap and graded on a scale (0-10). For elaboration see **D27 Appendix 1** – trial number 4.

5.1.2 User acceptance assessments in TP2

We conducted an ethnographic study for 6 weeks with 20 senior people (13 female, mean age 77.6 y) at their home. The ultimate goal of this project is to understand acceptance of the older adults to be monitored and whether they are willing to adopt and integrate sensors in their daily life. The following systems were used in the test: Fitbit Charge 2, Fitbit Aria, and Withings Body Cardio. We documented older adult people's perception on activity tracking devices before and after usage.

After 6 weeks of usage, we discovered changes in behaviour and usage intention which allowed us to identify opportunities and challenges for the older adults to adopt sensors and application for health and activity management. This study showed the potential of acceptance and adoption of simple and manageable technology for behaviour change.

Based on the Technology Acceptance Model (**Venkatesh & Morris 2003**), we conducted semi-structured interviews before and after the experiment to identify the perceived usefulness and the perceived ease of use of the system. This then allowed us to explain the attitudes towards the actual usage and the intention of usage before and after using the system. For elaboration see **D27 Appendix** 1 trial number 10.

5.1.3 User acceptance assessments in TP3

Within TP3 a random control trial (RCT) was conducted to investigate how to personalize motivational trial. The trial was set up to include a 4-week baseline period in which users got used to wearing the wearable fitness sensor and keeping the smart phone charged and allowing it to sync with the activity sensor daily. After this baseline period, participants were taught how to use the intervention application on the smart phone. Then the participants used the intervention application for four five weeks. Within in this investigation user technology acceptance was measured through a periodic questionnaire which was completed before the baseline, right after the baseline and before the intervention period and after the completion of the intervention period. In addition, it could be argued that the participation rate could also be an indication toward technology acceptance, because interaction with technology was an important part of their participation in the trial.

Results:

The average age of participants was 72.47 years. Of the 65 people originally onboarded 58 of these participants finished the entire trial period, resulting in a drop-out rate of 11.5%. This is relatively low compared to other sources who cite a dropout rate of anywhere from 6 – 36% (**Schmidt et al. 2000**). In this trial we also saw participants confidence with technology slightly improve, as the percentage of people who reported being "a little apprehensive or confused" in the pre-baseline questionnaire go down in the after-baseline questionnaire. Meanwhile, the percentage of participants who felt "somewhat confident" went up between these two measurements, see **Table 5-1**. Though the initial findings here are not yet conclusive, there seems to be a need for increased investigation into the topic of user technology acceptance. For elaboration see **D27 Appendix 1** – *responses by trial,* trial number 6.

Table 5-1: Participant self-reported level of confidence with mobile technology between onboarding (first) and 4-week point (second) surveys.

	First	Second
Very confident	16%	15%
Somewhat confident	**42%**	**49%**
A little apprehensive or confused	25%	22%
Very confused	4%	0%
I have never used a smartphone	14%	15%

Note that percentages were corrected for participant drop out. 57 people filled in the first and 55 people fill in the second survey.

5.1.4 User acceptance assessments in TP4

Within TP4, two trials (Lyngby 1 and Lyngby 2) were conducted to investigate the older adult's perceptions of monitoring technologies.

Lyngby 1

This study is based on interviews conducted after an activity monitoring study stretching over nine weeks. During that activity monitoring study, we collected data using Fitbit Charge HR from a sample of 26 older adults. The trial aims to determine whether daily feedback about the previous day's activity level (number of steps participants made) would lead to changes in the participants physical activity. The trial was a randomized cross-over trial where half the participants received feedback via a daily phone call (excluding weekends) on the number of steps they had made the day before whereas the other half received feedback on the amount of sleep and how many times they woke up during the previous night. After four weeks, we switched the two groups. After the first week of screening, four participants withdrew. Three these left because of health problems, one because he was worried about his privacy. Moreover, one participant died shortly after the trial. The remaining 21 four weeks after the Lyngby 1 trials, we conducted 21 semi-structured interviews on the participant's perception and acceptance of monitoring technologies. The interviews lasted around 45 minutes, and each of them was performed in the home of the participants by the two researchers they had daily contact with during the tracking trial.

Lyngby 2

The Lyngby 2 trial was a feasibility study conducted from April-July 2017 in preparation of the planned Lyngby 3 trial. The study involved nine elderly participants engaging in playful exercise and from whom movement tracking data were collected throughout the day over 8 weeks. In the same manner, we conducted seven Semi-structured interviews two weeks after Lyngby 2 trial. To explore older adults' attitude towards monitoring technologies, we gathered qualitative data (thought both trials) on older adult's perceptions about being monitored 24/7. During the interviews, the willingness to invest in the use of technology was frequently discussed with participants, particularly their willingness to commit to a personal effort so that a device could be used. The interview included themes not only about technology acceptance but also about privacy and the potential use of healthcare technology to support personal health and safety. The results revealed a number of sub-themes that related to the TAM factors.

However, it also showed that the elderly's acceptance of technology is not only dependent on technical factors, but the emotional and psychological factors play a significant role too. The joint results of both Lyngby 1 and Lyngby 2 are presented below.

Results Lyngby 1 and 2

In both trials, (Lyngby 1 and Lyngby 2), participants consistently reported their willingness to accept monitoring technology if it enables them to remain independent. Participants indicated their primary need is to stay safe and independent, and this need drives their willingness to acceptance technologies.

Most of the participants mentioned that there should be a limit to the type of information the participant must provide if they got offered monitoring technologies in the future. For example, everyone found video monitoring negative and perceived it as a concept that violates their privacy. Because wearable sensors can be in the background, it is better than video monitoring that makes people act passive and unnatural (**Townsend, Knoefel, & Goubran, 2011**). However, some participants indicated, their acceptance of technology depends on what behaviour is detected. For example, some of the participants indicated that they would accept the technology if they felt a need for it. As such, they would rather be monitored than lay unattended for several days. In this regard, we found that it is important for the participants that the monitoring device becomes a part of their daily lives without being annoying or a burden for them.

In Lyngby 1, the participants found that daily feedback via telephone very motivating and useful. Their opinion and answers to the question "did the daily feedback impact your daily activity level?" was very positive. They felt happy that someone took care of them through monitoring and daily feedback. It also created a sense of comfort and transparency. None of the participants felt the need to act unnaturally due to the monitoring part of the study. The active involvement of the participants in this feedback process has positively influenced the acceptance of the Fitbit tracker.

We also asked the participants opinion about sensor technologies managed as health care devices. Participants both from Lyngby 1 and Lyngby 2 indicated that they would not mind if they got an offer to be monitored daily or even permanently as long as their autonomy was respected. For example, they all wanted the opportunity to decide for themselves whether they need the technology rather than having the decision made for them (**Londei et al., 2009**). They also wanted health and technology providers to convince them that being monitored is necessary for fulfilling their health-related needs.

Following is a selection of results from Lyngby 1 trial.

Table 5-2: A selection of Lyngby 1 result. We asked participants, what their opinion would be if their caregivers offer them monitoring technologies managed as a healthcare device. 17 out of 21 would accept the offer.

Would you accept monitoring technologies managed as health care device if your municipality [care giver organization] would offer it?	%	n
Accept it	81%	17
Don't know	19%	4
Total	100%	21

In continuation of the same question, 15 out of 21 indicated that it will increase their safety. 12 out of 21 would not feel surveilled by accepting monitoring technologies, but they spontaneously indicated, that it will make them feel safe. Three out 21 indicated, that they will feel surveilled but at the same time safe. Four out 21 had no opinion about it. Their acceptance will depend on their health condition at that time.

Table 5-3: A selection of results from Lyngby 1: participant's opinion about being monitoring by technologies managed as health care device.

Would you feel surveilled?	**%**	**n**
Would not feel surveilled BUT spontaneously safe	57,1%	12
Feel surveilled & safe	14,3%	3
Feel neither surveilled nor safe	28,5%	6
Total	100%	21

Moreover, our finding from both trials (Lyngby 1 and 2) indicates that self-rated cognitive abilities play a significant role in the acceptance of different technologies (for elaboration, see **Tacken et al. 2005; Ziefle and Carsten 2010**). For example, the participants who felt competent in walking found Fitbit device very useful and began to improve their physical activity level by walking more. Comparing this to the participants who were weak, they did not feel competent to improve their physical activity level. Comfort level and fashion-based factors with the device was another notable aspect related to acceptance of any device in future. The physical look of the device played a significant role in making the participants feel comfort and unconcerned about privacy. Familiar devices such as the Fitbit charge HR has avoided drawing negative attention and possible stigmatization (**Luijkx, Peek, & Wouters, 2015**) since it looks like a digital watch. Hence, most of the participant felt no ease in using it and assumed it as a digital watch which reduced the negative concerns regarding their privacy.

Similarly, our findings indicate that older adults who are experiencing or recently have experienced health decline (e.g. asthma attacks, broken hip, haven fallen and unable to get up by themselves ...) are more willing to accept monitoring and are less concerned about privacy. Even though they perceive surveillance as being negative, they find it a helpful tool to stay safe. Hence, their previous experience of danger has created a sense of awareness of possible threats. To enhance their safety, they are willing to accept sensor-based monitoring.

Participants mentioned different factors that made them feel unconcerned about sensor-based monitoring. We found that membership in a social network influenced their opinion of being watched and using the technology. For example, some older adults recognized the device from similar ones used by their grandchildren or children. This created a sense of security and comfort where they were not concern about privacy issues. They expressed their concerns by referring to unusual gossips about undiscovered bodies. This fear related participants more towards sensor-based monitoring.

Overall, all participants were very excited about continuing to use and planned to use activity trackers such Fitbit in the future. Five participants from both trials felt a sense of relatedness to the device. One person among these five bought her own device after the study. She wanted to track her activity level each day in order to be sure that she reached her daily activity goals. All the participants said they did not feel monitored when we asked them: “Did you felt monitored during the experiment when we could track your physical activity level?" Instead, the participants were very relaxed about how their data might be used. The tracking of their location and video monitoring was mentioned as a privacy threat factor; however, the participant would accept it made them feel safe. For elaboration see **D27 Appendix 1** – *responses by trial*, trials number 18 and 20.

6 Summary, conclusions, future work

This section summarizes specific know-how about the acceptability drivers to embed advance ICT driven technology for early detection in intervention uses cases into age inclusive communities. Touchpoints incorporate two strands of technologies - on the sensing and monitoring related ones and motivational and physical engagement related ones. To motivate the target group towards behaviour change, for and through both types of technologies, user acceptance is key. User acceptance and motivation towards behaviour change is created by the coordinated interplay of high usability, convenient accessibility, and personalized design. **Table 6.1** summarizes the key aspects outlined and discussed in this deliverable per Touchpoint.

Table 6-1: Summarises the key points to give overview of TP´s at different stages and factors. These key points are generated on the basis of detailed trials reported.

	TP1	TP2	TP3	TP4
REACH-specific interplay of the concept "user acceptance" with the linked concepts "behaviour change/motivation" and "personalization"	The core research element is to motivate target group to become more physically active by using mobility device.	The core research element is to motivate target group towards healthy behaviour, by Improving the health outcome of the elderlies.	The core research element is to investigate what personalized strategy can promote physical activity and healthy eating among target group.	The core research element is to find out, what personalized strategy increase physical activity among older adults
	Acceptance and behaviour change are created by interplay of optimized user experience and personalized design for behaviour change.	Acceptance and behaviour change are created by interplay of personalized care and strategy.	Acceptance and and behaviour change are created by socializing and nutritional monitoring and intervention.	Acceptance and and behaviour change are created by use of feedback, gamification and motivational interviewing
	E.g. social support, gamification and performance support as tools to facilitate behaviour change and enhance user acceptance	E.g. related repeat reframe to facilitate behaviour change and usability and accessibility test to understand acceptance behaviour of target group.	E.g. to facilitate behaviour change, they use social activities in combination with eating, drinking and creating user behaviour profiles. The acceptance towards behaviour change is enhanced by use of behaviour change techniques such as self-awareness, peer support, intergenerational support, feedback and recommendation	E.g. They physical activity is facilitated by use of integrated engagement environment with playware tiles and fitness trackers. The acceptance towards behaviour change is enhanced by use of motivational techniques such as Social cognitive theory and feedback as its centres
Use of acceptability drivers (ethical, privacy/security, legal, and accessibility considerations)	Ethical: safe training environment to facilitate social and cognitive actives, with human interaction.	Ethical: Customized training environment to facilitate physical activity.	Ethical: design of interfaces that not harm any user group (skilled/unskilled)	Ethical: to facilitate physical environment safe training environment and devices

	Privacy: all involved stakeholder should be trained in using the system in privacy preserving manner. E.g. used devices must obtain as less health data as possible. Ensure data storage and process to secure local servers. Obtained Inform consent Accessibility: iterative test to access the condition of acceptance of functions and designs of the training functionality. Acceptability: personalized games that matches targets capability Use of qualitative, ethnographic studies and co-creation to determine concepts of personalized regime and user acceptance.	Privacy: Handling of data and information obtained in the contest of the development of personalized training and therapies by use of privacy by design concept. Accessibility: User interfaces that facilitate broad accessibility Acceptability: Smart training room that promote safe training and repetition-personalized therapy)	Privacy: Controlling of target group to avoid sharing of food preferences data. Accessibility: Acceptability: strategies such as self-awareness, Peer support, Social support are used.	that measures accurate activity level Privacy: target groups privacy is protected by using pseudonymised identifiers. The data are storage in secure local server. Accessibility: Safe training session with coaches. Acceptability: Behaviour change strategies such as gaming and feedback that meet target group perceived needs, but at the same time maintain the respect for their personal autonomy.
Acceptability drivers for the use of sensing and monitoring elements	To assist user acceptance of devices standard questionnaire such as system usability scale(SuS) and NASA are used Acceptability drivers for the use of sensing and monitoring are defined as following elements: - Social support - System simplicity - Practicality In addition, target group is asked about the effort, the satisfaction and frustration with task fulfilment	To assist user acceptance of and understand weather target group accept being monitored ethnographic study along with semi structured interview were conducted, to report target groups perception on activity tracker.	To assist user acceptance of devices periodic questioners were used. Acceptability drivers for the use of sensing and monitoring are defined as following elements: Strategies such as self-awareness, Peer support, Social support are used.	To assist user acceptance of monitoring semi-structured interview were conducted. Acceptability drivers for the use of sensing and monitoring are defined as following elements: - Social support - System simplicity - Practicality - Perceived gain that meet fulfil Perceived need

As part of upcoming work, we aim at a better consideration of “patient reported outcomes” (PROs). So far, we have used in the REACH project user acceptance assessment methods that are largely within the design & usability / human factors tradition. However, there is rapidly growing literature on the development of and use of assessment methods of “PROs (see **Section 1.2**). Several of the partners are using PRO measures in daily operations, and in the following project period we will apply PRO measures in tandem with standard usability and acceptance assessment methods in order to obtain a more comprehensive and valid picture of end-user perceptions.

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