UNIVERSITEIT TWENTE.

RESEARCH PROGRAM

PERSONALISED EHEALTH TECHNOLOGY

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CONTENTS

1. INTRODUCTION

The University of Twente has decided to develop specific 4-5 years' research programmes which cross the boundaries of the faculties. These research programs are embedded in institutes and focus on specific high-potential themes with respect to growth and impact. One of the selected themes in the first round is "Personalised eHealth Technology". The objective of this document is to provide the background and relevance of this theme, to analyse the present and future opportunities, leading to a clear roadmap and actions with the ultimate goal to **become the epicentre for personalising eHealth technology research and expertise in Europe**.

2. BACKGROUND

> "Europe faces rising and potentially unsustainable health and care costs, mainly due to the increasing prevalence of chronic diseases, to an ageing population requiring more diversified care and to increasing societal demands. Health research and innovation also face new challenges as a result of new research paradigms and methodologies in line with increasingly complex medical and health challenges, including increasing awareness of the influence of external environmental factors."
>
> *European Commission, Horizon 2020, Work Programme 2018-2020*

The proportion of global population aged above 65 years old is increasing more rapidly than other age groups and its growth is expected to accelerate in the coming decades[1]. Such demographic changes pose several challenges to the healthcare systems, for example, as the labour force might not suffice to respond to the demands of the aging population. It is estimated that the proportion of population in EU-27 aged between 15 and 64 will decline from 67% in 2010 to 56% in 2060[2]. Additionally, the share of the population aged above 65 is expected to increase from 17% to almost 26% in 2030, and almost 30% in 2060[2]. The growth of the proportion of older population is even more accentuated in developing regions, with the United Nations estimating that in 2050 two thirds of the world's persons aged above 80 years old will live in these regions[1].

With aging come inherent biological changes that often lead to functional impairments or chronic diseases. The systematic review from Marengoni and colleagues suggests that at least 55% of the older population suffers from 2 or more chronic diseases simultaneously, with some studies pointing that the proportion of people with multimorbidity might reach 98%[3]. And these numbers are increasing: in the Netherlands, the proportion of people aged above 55 with four or more chronic diseases increased 300% between 1985 and 2005[4]. It is estimated that 6 out of 10 deaths worldwide are caused by chronic diseases[5], and this proportion might raise to 69% by 2030[6]. From the early deaths due to chronic diseases, 37% are caused by cardiovascular diseases, 27% by cancers, 8% by respiratory diseases and 4% by diabetes mellitus[7]. Taking these numbers into consideration, the World Health Organization states as Global Target "*a 25% relative reduction in overall mortality from cardiovascular diseases, cancer, diabetes or chronic respiratory diseases*"[7].

The World Health Organization defines 4 key strategies to cope with the burden of chronic diseases: (1) promotion of healthy behaviours, (2) prevention of premature deaths and avoidance of unnecessary disability, (3) treatment with the available knowledge, and (4) provide appropriate care to every individual in need. Healthy lifestyles, such as physical activity and healthy eating, are

key factors in all the steps abovementioned, in both prevention and management of chronic diseases.

It becomes more and more evident that the current approach to healthcare is not sustainable, especially when considering the increasing volume and demands of the chronic diseases, requiring a rethinking of strategies towards innovative solutions. The use of Information and Communication Technologies in healthcare – *eHealth* – is a promising strategy to improve healthcare worldwide. Within the developed regions, eHealth can alleviate the burden in the healthcare systems, where there is a lack of healthcare professionals facing the demand of an aging, and chronically ill population. In the developing areas, through eHealth, healthcare can be delivered in regions where otherwise healthcare would not be available, contributing to the United Nations' global goal of reducing inequality between developed and developing regions.

Biological (e.g. genetic pre-disposition), behavioural (e.g. lifestyles) and environmental (e.g. physical and social context) factors influence the surge and progression of chronic diseases. eHealth also allows to target this challenge of diversity, for example, by providing *personalized* solutions adaptable to each user, and also to changes over time. Every individual, dealing with any specific condition presents a distinctly unique case, highlighting the need for *Personalised eHealth Technology*.

3. VISION & MISSION

***Vision**: Moving from a "repair" towards a holistic approach of healthcare* taking the needs and preferences of each individual as a starting point, to personalise and target their treatment and support

Such change of approach applies especially for the increasing group of people with chronic conditions. Their chronic conditions cannot be cured, but it has become evident from many studies that the consequences of chronic conditions as well as the occurrence of comorbidities is strongly influenced by people's behaviour. However, changing behaviour, specifically turning towards and maintaining an active healthy behaviour is not easy; it requires continuous and persuasive support. In parallel, we should decrease the inflow of the people with chronic conditions towards expensive second line care, the hospitals, by supporting self-management and independent living.

Along these lines, there is on one hand a substantial need to change healthcare. On the other hand, there is a clear potential growing offer created by the rapidly developing technology in several key areas. The ambulatory sensor revolution allows us to measure many aspects of health with sampling rates much higher than we were used to do. Nowadays, almost every day new wearable sensors enter the market, which are comfortable to use, cheap and produce large quantities of data. 4G and soon 5G enable fast, reliable and low-cost transfer of the data, enabling collecting large sets of personal data reflecting many aspects of individual health and wellness. These rapid technology developments open the window towards a new area of research and innovative health services; we are now able to unobtrusively and quantitatively monitor peoples functioning in their own environment. The challenge is to turn this data into meaningful information to improve our understanding of behavioural patterns and then to turn this knowledge into innovative and motivating services for people with chronic conditions. Upcoming Internet of Things developments will offer new possibilities to deliver the persuasive strategies and information to the user in a way that is embedded in the daily environment (for example, through tangible interfaces, lighting and actuated wearables embedded in clothes). Furthermore, gamified interaction principles can be combined with ICT models to model the relation between interventions in the

system regarding mechanics, feedback, tasks and actions on the one hand, and the immediate impact on user behaviour on the other hand; this allows us to determine tailored feedback and intervention strategies to deliberately target certain persuasive effects on a particular user in a model based way.

The to turn the newly obtained health and behaviour data into new knowledge and then to turn this knowledge into innovative and motivating health services, is strongly supported by the rapidly developments in (positive) health models, knowledge on behaviour change and new insights on effective coaching strategies. Vice versa, the developments in technology enable holistic approaches in monitoring, e.g. by combining experience sampling of subjective experiences with continuous physiological measurements of health and functioning. This opens a new area of research into health and behaviour.

Mission. It is our mission to use the advances in technology to create innovative personalised eHealth services that substantially contribute to a sustainable, efficient and effective healthcare for all citizens, especially for those with chronic conditions.

With the aim to support these citizens in their vitality, self-management and independent living using a holistic personalised approach, enabled by technology.

With the aim to support the professional care givers in decision making, using holistic monitoring strategies, combined with advanced models and reasoning technology.

In 5 years, we aim to be THE centre for eHealth Technology in the Netherlands and one of the major centres in Europe, covering the whole translational chain from development towards contributing to sustainable implementation in daily care.

The University of Twente is especially suited to realise this mission, due to the unique ecosystem. UTwente has all the required disciplines on board, such as biomedical engineering, computer science and behavioural science as well as a strong tradition in design. UTwente also has a noticeable infrastructure (e.g. DesignLab, XP lab) and this will be extended with the upcoming TechMed lab and the existent Tech4People lab developed by BMS. There is a substantial and growing collaboration with the two major hospitals (Medische Spectrum Twente and Ziekenhuisgroep Twente) and the major care institutes in the region, substantially facilitating demonstration and evaluation studies as well as paving the way to sustainable implementation. Twente has earned during the past years the three-star status in the European Innovation Partnership for active and healthy ageing, which reflects that the Twente region has the knowledge and experience to develop and implement healthcare innovations for primary and secondary prevention.

4. RESEARCH PROGRAM

4.1. Building blocks for personalised eHealth applications

Figure 1 shows the key building blocks that are involved in most personalised eHealth systems:

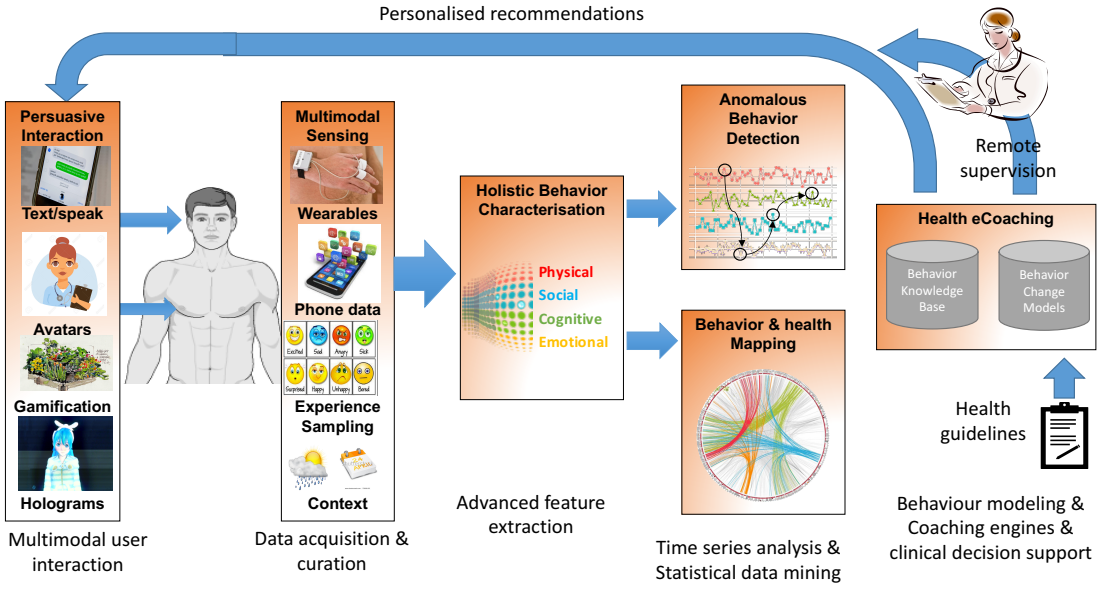

FIGURE 1 - THE BUILDING BLOCKS FOR PERSONALISED EHEALTH TECHNOLOGY SYSTEMS.

To illustrate this architecture, a scenario for monitoring and coaching could be the following:

An eHealth Technology scenario, illustrating the functions of the building blocks

Personal data are gathered from a subject using multimodal sensing. The sensing involves physiological and medical data from wearables, phone data reflecting patterns of use in terms social and physical active, experience sampling randomly or triggered by events and data reflecting context and environment, which have influence on the human behaviour. The next step is to use advanced feature extraction and engineering to turn the data into meaningful variables reflecting health, social, cognitive and emotional status. From here on, two approaches are used, time series analysis and statistical datamining. Time series analysis is dedicated towards detecting anomalous changes in the time course, like a slow but meaningful deterioration of health status reflected in one or multiple features. The data mining is focused on detecting interrelationships between features representing the main components, physical, social, cognitive and emotional, of behaviour within the holistic map of behaviour. The results of both approaches is input for the clinical decision support and coaching models, resulting in personalised advices to the patient and supporting the involved clinician in decision making towards the best interventions. A final step is to convert the derived content into an understandable, clinically relevant and persuasive way to the patient, using context dependent modalities to motivate actual behaviour change and support interventions."

4.2. Research Lines

The five key research areas that need to be mastered in order to deliver successful Personalised eHealth solutions are listed in Figure 2.

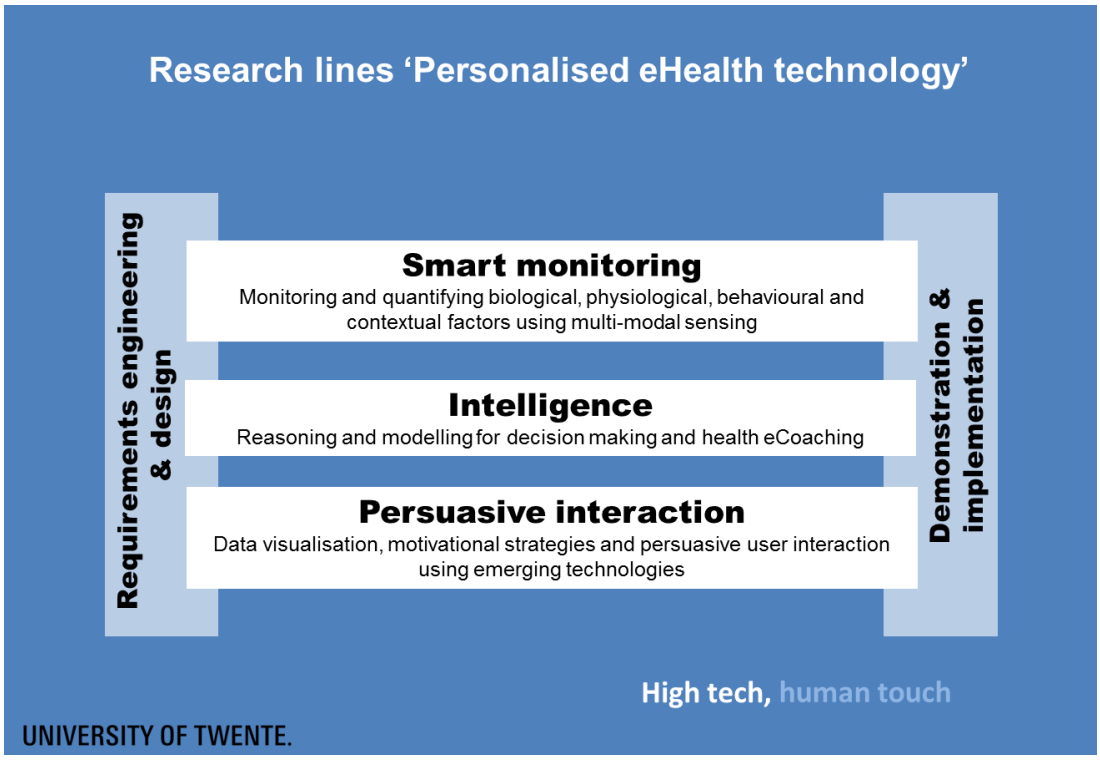

FIGURE 2 - RESEARCH LINES OF PERSONALISED EHEALTH TECHNOLOGY RESEARCH PROGRAMME.

In order to shortly illustrate these five research lines, we define a high level, typical personalised eHealth scenario and quickly highlight the defining features of these five elements. A typical eHealth scenario revolves around a patient or user group suffering from a chronic condition. The goal is to develop a tool that can help the user self-manage his condition, or prevent/delay the condition from arising, thus limiting his dependency on professional healthcare. A more complete overview of the research lines can be found in Annex 1.

Requirements engineering and Design – A crucial first step on the path to a successful personalised eHealth solution is understanding the needs and desires of the target users – typically a primary user or patient and the stakeholders surrounding the user – such as healthcare professionals, informal caregivers and the user's social environment. For the context of personalised eHealth technology, these activities should cover functional design, as well as the development of associated care protocols or service models. Research activities will involve:

- Investigate new design research approaches that do not rely exclusively on asking what people would like to have/use, but use innovative methods for example through gamifying requirements elicitation sessions. At the same time, develop and validate online tools that allow for online requirements elicitation, but that do foster the same atmosphere as can be created in face-to-face meetings, allowing to gather requirements from a group of diverse people that are geographically dispersed and difficult to get together.
- Developing a taxonomy for classifying requirements for eHealth, and subsequently creating a platform for distributing them should enable a huge gain in efficiency while engineering requirements.

- Incorporate the issue of 'trust' as a critical point to the count on high end-user acceptance. But at the moment, our knowledge of the coming about and workings of trust with respect to personalised eHealth technology are very limited.

Smart Monitoring and Multi-Modal Sensing – Any personalised eHealth solution will involve gathering of data from various sources and with different characteristics. The first level 'building block' therefore consists of development and usage of technologies that help us understand the user (typically focusing on the primary user/patient) and quantify his biological, physiological, behavioural and contextual factors. The challenge of the monitoring is to obtain a holistic view on the functioning of the person in his/her context. This will involve several layers of sensing, ranging from sensing of biological and physiological processes, up to more behavioural aspects involving social, cognitive aspects, subjective experiences on health and wellness and contextual information to support a proper interpretation of all health and wellness aspects. The sensor data characteristics are basically very different in their characteristics, not only in their scales but also with respect to their sampling rates. Feature engineering will be needed to create homogeneous longitudinal datasets that enable further analysis. It is not our intention to develop sensors themselves, but seeking collaboration with experts in this area, like the sensor program at UTwente and use state of the art sensing technology commercially available. Major challenges that we will address will involve:

- Creating models and approaches of data gathering, that allow us to create holistic maps of physical, cognitive, social, emotional, and environmental parameters in relationship to the person's health or wellbeing;
- Develop and apply new feature engineering technology to extract and synchronise the key variables in streaming data sets, reflecting key health and wellness aspects at group and individual level.
- Integrate new on-body or in-body sensor technology with our holistic approach to gain new knowledge on their interaction and create new models on monitoring of diseases.

Intelligence for Decision Making and Coaching – Whereas smart monitoring and sensing provides the first level of interpretation of sensor data – additional reasoning is often required to feed the user interfaces that enable the interaction with the various user groups. As a central building block, intelligence and decision making provides the bridge between sensing and interaction. In this research line, we will be dealing with (i) *high level semantically meaningful concepts*, (ii) *deriving information post-hoc from multiple data sources*, and (iii) *defining fluent models of users or context*. Major challenges that we will address involve:

- Creating holistic models that allow us to understand the intricate complexities of interactions between physical, cognitive, social, emotional, and environmental parameters in relationship to the person's health or wellbeing goals;
- Defining and constructing models of users or health status in ways that foster interoperability in a rapidly digitizing environment;
- Designing the digital mind of the coach of the future – paving the way for truly natural and personalised interactions between virtual coaches and users;
- Creating open, collaborative platforms for the collection, storage, and analysis of large scale heterogeneous multi-modal data;
- Integrating the rapidly advancing technologies in the area of data science, deep learning and artificial intelligence in order to make optimal use of the wealth of data collected.

Persuasive Interaction – This building block concerns the design and development of user interaction tools, strategies and visualisations. The underlying knowledge about the user, goals, motivational regulations, and context is translated into concrete interactive tools that are tailored to the end-user in a motivating, understandable and engaging manner. The persuasive interaction line deals with building the right tools for the specified user, on a given interaction device,

translating the desired intention into successful interaction strategies. We will address the following key challenges in this line of research:

- Derive fundamental knowledge-base for device- and technology-agnostic personalised user interaction and persuasive communication;
- Design and develop efficient and usable interactive tools using emerging technologies such as virtual reality, holograms, and future interactive technologies;
- Create persuasive and steering interaction strategy models to understand the interaction between motivation strategies for behaviour change and persuasive strategies for engagement and adherence;
- Create persuasive profiles, using data and real-time strategies (Just in time adaptive interventions to change behaviour);
- Develop methods to link the personal preferences, besides attitude or different physical capabilities, of any target group into a specific model for persuasive interaction design.

Demonstration, evaluation and Implementation studies – User studies are a vital part of creating successful personalised eHealth applications throughout the design and development of the technology, as well as to provide evidence needed for successful implementation into daily practice. Through iterative design and continuous user evaluations, design decisions can be validated as the eHealth solution matures. As eHealth solutions are both complex and disruptive, innovative evaluation methods are required to effectively generate evidence needed for implementation into daily care practices. Key challenges of this research line are:

- Development of iterative evaluation approaches, testbeds and methodologies that fit the iterative design approach and grow with the maturity of the technology
- Development of automated new outcome criteria coming from the sensing and end user interaction modules
- Research into implementation scenarios and behavioural change strategies to ensure real uptake in by users in daily practice
- Development of business modelling methods and tools that give insight in the revenues and costs for the whole pallet of stakeholders involved as well as for each of them involved, separately.

5. TOWARDS AN ECOSYSTEM

Within the Personalized eHealth Technology program, we aim to create a regional ecosystem that will serve as a lighting example in Europe on how to organise a translational chain from research towards sustainable implementation. To realise this ambition, we want to create an ecosystem (Figure 3) of sufficient size that an autonomous growth becomes possible. Important elements of such an ecosystem are the community, infrastructure, a balanced portfolio of projects and activities and strategic embedding in the region, national and European.

5.1. The community

The community to be developed, can be seen as a multi-layered entity. In the core are the research groups of the University, the research facilities (e.g. labs) and the supporting staff (e.g. acquisition machine). In a second layer are the preferred partners, with which a structural relationship is created. This will involve health centres, major hospitals, outpatient care, mental health care, rehabilitation centres, companies, insurers, local authorities, provincial authorities and other universities. A third layer consists of preferred but non-structural (inter)national partnerships.

5.1.1. UT core partners

The UT core partners, at the start of the eHealth Technology program are from four faculties (EWI, TNW, BMS and Engineering Technology), emphasising the strong multidisciplinary approach being involved in the eHealth Technology program. In more detail, the following research entities are strongly involved from the beginning:

MIRA. The eHealth Technology program is embedded in the TECHMED research institute (formerly MIRA). Essential contributions to the eHealth Technology Program will especially originate from research groups Biomedical Signals and Systems (BSS) in the area of holistic approaches to monitoring combining objective and subjective approaches, feature engineering, Telemedicine systems design, decision support systems and artificial coaching, data driven modelling and the Biomechanical Engineering group in the area of intelligent support systems, combinations of biomechanical and physiological modelling. Collaboration with the research group working on lab-on-a-chip and implantable sensors will be established in due time.

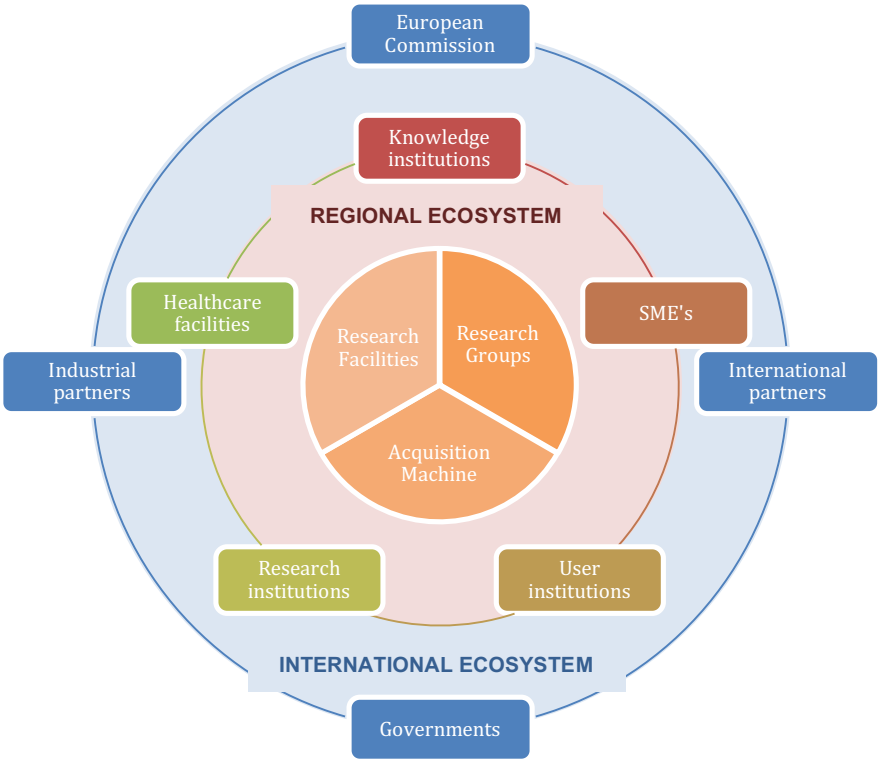

FIGURE 3 - ECOSYSTEM OF THE PERSONALIZED EHEALTH TECHNOLOGY RESEARCH PROGRAM WITH THE CORE UT PARTNERS IN THE CENTER, FOLLOWED BY LAYERS OF REGIONAL AND (INTER)NATIONAL PARTNERS.

CTIT. Several research groups are and will be involved, delivering key contributions in the areas of the human computer interaction, virtual embodied agents, dialogue systems (Human Media Interaction group, HMI). There is strong expertise in on body and environmental sensor networks, feature engineering and reasoning (Pervasive Systems), bundled together in Internet of Things

systems. A third area concerns the development of new concepts and implementations of databases and big data analytics (Database group).

BMS. The faculty BMS will contribute in several ways, especially within the track eHealth. The department of Psychology, Health and Technology (PHT) will strongly contribute with their expertise in coaching strategies, roadmaps (CEHRES roadmap) for successful development and implementation of eHealth technology, persuasive profiling and designs to motivate users to change attitudes and behaviors. BMS Health has established an Implementation Workplace (with UMCG) to support professionals (local government, industry, science etc.) with implementation models and approaches.

The **Interaction Design (Department of Design, Production and Management, Faculty of Engineering and Technology)** generates knowledge on how to design for the interaction between people and the technology they surround themselves with. The focus is on ways to design products and systems that people can understand and appreciate in a context where technological advancements fade the boundaries between hardware and software, device and users. A special application area of the Interaction Design group (IxDgroup) is the self-management of (chronic) diseases and care through eHealth. Within the IxD group, the focus is on the user perspective; people as being in control over their situation enabled by ICT. Building on the vast experience on user-centered design and expertise on interaction design, the IxD group will contribute strongly mostly the research lines *Requirements and Design***,** *Persuasive Interaction and Demonstration, evaluation and Implementation studies*

The **Centre for Monitoring and Coaching (CMC)** is a research centre at the University of Twente founded in 2015, that integrates the work of 3 different key disciplines – biomedical engineering, ICT science and behavioural science – to create high tech solutions with a human touch. CMC aims to research, develop and demonstrate beyond state of the art solutions for smart remote monitoring and artificial coaching and other services that support people with chronic conditions in their well-being. An important application area are the user interfaces and user experiences in (mobile) e-health coaching systems. Another area of special interest and expertise is the coaching, including both artificial coaching based on mathematical modelling and reasoning and the behavioural models developed by behavioural and social science. CMC integrates both approaches into new models and self-learning personalised coaching strategies that are able to support behaviour change in a persuasive and effective way.

The Personalised eHealth Technology programme will interact with the other UTwente research programmes being proposed at the moment as follows:

- **Robotics**: there are high expectations on how robots can assist in the daily functioning supporting independent living of those with chronic diseases;
- **Sensing Science & Technology**: sensing is a core component of personalized eHealth technology, as the development of unobtrusive sensing technology might allow for longer studies to be deployed in everyday life, leading to better understanding of the human behaviour and improved personalized eHealth solutions;
- **Smart materials**: developments in the smart materials might lead to innovative ways of sensing and coaching, for example, blended in the everyday environment of the individual.
- The **digital Society**: good provision of health and wellness are key elements of a prosper society, enabled by digital approaches like developed in the eHealth Technology program.

5.1.2. Regional Partnerships

The following entities, with which there is already a fruitful existing partnership, will be the start of the regional ecosystem:

- **Roessingh Research and Development (RRD)** is a research and development SME in the area of rehabilitation technology and telemedicine with strong formalized links to one of the largest rehabilitation Centres in the Netherlands (Roessingh Rehabilitation Centre) and the University of Twente. The mission of RRD is to carry out scientific research and contribute to its commercialization and implementation in clinical practice. RRD develops innovations in a multidisciplinary team and in close collaboration with all stakeholders (patients, informal and formal caregivers, academia, health care organisations and industry).
- The **Twentse Zorgacademie** (TZA) represents a unique collaboration between education, healthcare and technology. The Living Lab Enschede from the TZA facilitates an environment where citizens with and without need of care, students, professionals and care givers can collaboratively work in the design, development and evaluation of healthcare technology. TZA brings together partners from education (e.g. ROC van Twente), healthcare facilities (e.g. Livio), research (e.g. Roessingh Research and Development) and governmental instances (e.g. Gemeente Enschede).
- In 2016 eleven partners from the Twente region decided to join efforts in a common mission: transform Twente into the most vital region in the Netherlands. Currently, the **Vitaal Twente** foundation facilitates the collaboration between the Menzis health insurance company, the 14 Twente municipalities, research and education institutions (UTwente, Saxion and ROC Twente), the GGD Twente, Roessingh Research and Development, the Ziekehuisgroep Twente and Carint Reggeland. In August 2017, Vitaal Twente was granted a subsidy from the Ministry of Health, Welfare and Sport (VWS).
- **Novel-T** (previous Stichting Kennispark Twente) is de motor of the ecosystem for high-technology innovation and entrepreneurship in the Twente region and surroundings. Novel-T establishes the connection with the right partners through an (inter-)national network of investors, researchers, entrepreneurs and talent. The ambition of Novel-T is to become the best ecosystem for innovation and entrepreneurship in Europe. To achieve that, Novel-T aims to broaden and strengthen the current ecosystem by profiling itself in the international scenario leading to better visibility. The funding members of Novel-T are the University of Twente, Saxion, Municipality of Enschede, Regio Twente and Provincie Overijssel.

5.2. National and European partnerships

An ecosystem, aiming at Innovation of care should be organised first regionally to be efficient and effective. From there, collaboration will be sought with national and international partners. During the past years a substantial network has been built. Main partnerships involve:

- In 2012 the Innovative Medical Devices Initiative was started and after a selection process 8 Centres of Research Excellence were founded. Three of them are focusing on extramural technology: CCTR, NeuroControl and Sprint. With CCTR and Sprint a structural relationship was developed, visible in participation in the governmental bodies, joined projects, PhD's. It is foreseen that these collaborations will become stronger in new areas, like the elderly worker and people with chronic conditions, in which a more intense collaboration with Groningen (Sprint) is foreseen.
- In the many European projects in past and presence, an extensive network of academic, clinical and industrial partnership has been developed and maintained to facilitate consortium forming in future projects and joined valorisation trajectories
- There is already an active involvement in national collaborative programs like "The hospital at home", focusing on removing barriers for successful implementation of innovative eHealth services (coordinated by VitaValley).
- There is an active involvement in two national "Health deals", one focusing on chronic pain and one focusing on rehabilitation technology, which will facilitate bringing new technology and innovative healthcare services to the market.

- There is a growing interest expressed by universities and care organisations to establish formal working relationships with the University of Twente in the area of eHealth technology (e.g. Granada University, South KoreanUniversity, Guttmann Hospital).

5.3. Living Labs

The environment in which technology is being co-developed with end-users and other stakeholders can be described in three categories as described in the figure below.

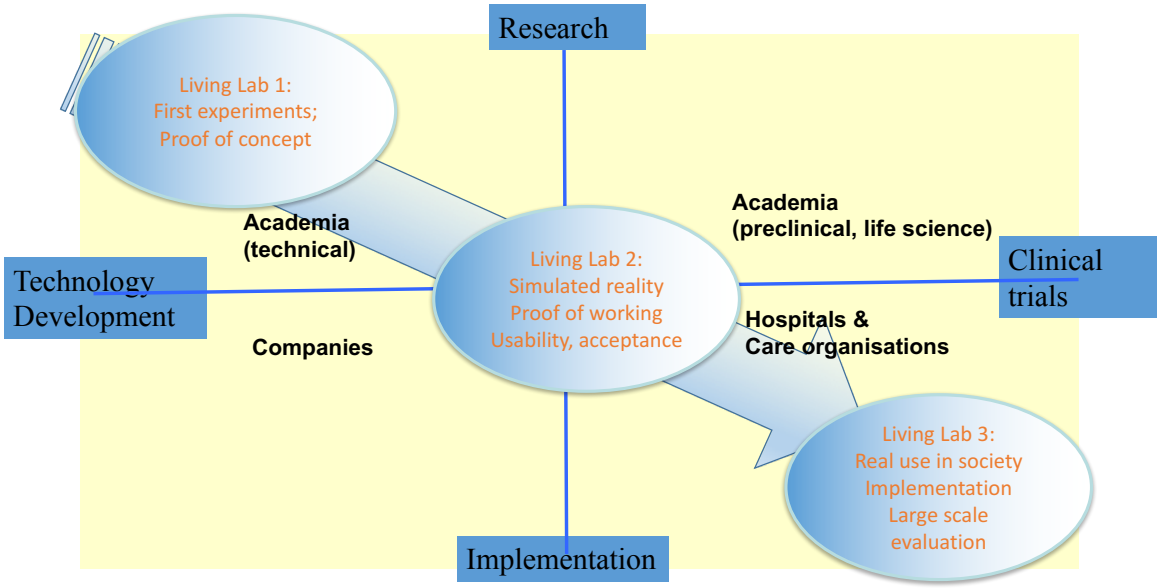

FIGURE 4 – THE DIFFERENT TYPES OF LIVING LABS, ECOSYSTEM OF THE PERSONALIZED EHEALTH TECHNOLOGY RESEARCH PROGRAM WITH THE CORE UT PARTNERS IN THE CENTER, FOLLOWED BY LAYERS OF REGIONAL AND (INTER)NATIONAL PARTNERS.

It illustrates 3 categories of living labs:

- **Living lab type 1**: the environment where the first experiments with technology take place to show and test working principles. Often with students and a loose experimental set-up. Examples are the labs every research group has.
- **Living Lab type 2**: a lab, where the reality is simulated to test the technology in a realistic setting but in a safe very controlled environment.
- **Living Lab type 3**: technology is used in the real-life, the natural environment where people live and do their things of daily living.

It has become clear that for successful translational research, all three types of labs should be present and interconnected, facilitating a smooth transition from one environment into the next one. During the past years, a substantial supportive infrastructure has been built and more is foreseen in the next years, involving:

- **The ECTM labs** that have been created to educate and train especially Technical Medicine students will be transferred and extended to the new TechMed building.
- **The wearable lab** will be situated in the new TechMed building and will involve several rooms where daily living situations can be simulated and new wearables can be tested, validated and monitored.

- **The DesignLab** is a creative and cross-disciplinary ecosystem at the University of Twente, connecting science and society through design. Faculty and students from all fields work together with companies and governments to implement and develop scientific and technological insights that can be used in finding and shaping creative, innovative and meaningful solutions for complex societal challenges.
- The **BMS Lab**, powered by Tech4People and located in the DesignLab and in the Cubicus building, aims to seek solutions to social challenges by developing, evaluating and implementing state of the art technology. A high-tech environment provides the opportunities for smart innovations which can contribute to a multidisciplinary based social science research.
- **HolyBehave** is a recently created infrastructure at the telemedicine group, that allows massive data gathering from smartphones and connected sensors, enabling easy implementation of eHealth services and large scale field studies.
- **Twentse ZorgAcademie**, where citizens, students, researchers and healthcare professionals can collaborate in the design, development and evaluation of healthcare technology, and where there is a fully operational apartment to conduct usability studies.
- **Lang gezond cohort**. A cohort of elderly people in Twente who have been included in the cohort as part of the "Lang gezond" study.

6. FUNDING OPPORTUNITIES

The increasing awareness of policymakers that eHealth technology can contribute to sustainable healthcare is reflected in a clear increase of funding possibilities, both at a national and European level. These will be described in the following sections. More extensive descriptions and references to the websites are given in Annex 2 and 3.

6.1. National funding

No long term NWO agenda's regarding thematic funding are drawn up. NWO likes to pride itself with funding blue skies fundamental research. Regarding thematic funding NWO aligns its research agendas ad hoc with the NWA and the Topsectoren, organizing calls in collaboration with them. Main funding bodies in the Netherlands for Personalised eHealth Technology are: ZonMW, NWO TTW, NWO SGW, Topsector HTSM, Topsector LSH, Topsector Creative Industry and Commit2Data

In contrast with the EU, there are no long-term research agendas at NWO, therefore we can only rely on incidental calls from NWO. The NWA may lead to a longer-term horizon for certain research themes. Unfortunately, at the moment is it unclear whether structural funds will be allocated to the NWA 'routes'.

6.1.1. The "Nationale Wetenschapsagenda"

In the "Nationale wetenschaps Agenda" (NWA) the following themes are relevant:

- **Gezondheidszorgonderzoek, preventie en behandeling.** Een nieuwe kijk op gezondheid, met aandacht voor verschillen tussen mensen en een betere aansluiting bij hun persoonlijke beleving, is noodzakelijk om de zorg toekomstbestendig te maken.
- **Meten en detecteren: altijd, alles en overal.** Door meten tot weten. Onder dat motto groeit onze behoefte aan detailinformatie. Die groei stelt echter eisen aan de benodigde instrumentatie, aan de interpretatie van meetgegevens en aan communicatie, perceptie, en eigendom van meetresultaten.
- **Personalised medicine: uitgaan van het individu.** Precies de juiste en voldoende zorg voor elke individuele patiënt. Met een optimaal resultaat, een minimum aan bijwerkingen,

tegen minimale kosten, zo dicht mogelijk bij huis. Dat is in het kort het ideaalbeeld van personalised medicine.

- **Sport en Bewegen.** Bewegen en sport zijn in de hele levensloop belangrijk. Baby's beginnen met leren bewegen; kinderen hebben sport en spel nodig om zich lichamelijk en geestelijk te ontwikkelen; volwassenen bewegen om fit te blijven en welvaartsziekten op afstand te houden; ouderen blijven bewegen omdat het hen helpt langer vitaal te blijven, en daarmee langer zelfstandig en zelfredzaam. En sommige mensen ontwikkelen hun beweegtalent tot topsporter.

6.1.2. Topsector High Tech Systems & Materials (HTSM)

In the topsector HTSM, the following themes are relevant:

- **Healthcare.** Mensgerichte nano-elektronica, embedded systems en mechatronica ten behoeve van preventie, diagnostiek, interventie en therapie, nulde- en eerstelijnszorg en thuiszorg; en enabling technologies voor gezondheidszorg.
- **Security.** Bescherming van de veiligheid van personen en maatschappij, zowel bij geweld als door crises en rampen. Met technologie in de domeinen system-of-systems-oplossingen, cyber security en sensoren.
- **Embedded Systems.** Geïntegreerde hardware/software-systemen die intelligentie, besluitvorming en mogelijkheden toevoegen aan hightech producten, welke economische bedrijvigheid en kwaliteit van leven verhogen.
- **Advanced Instrumentation.** Systemen en technologie voor het meten van straling, licht en deeltjes; bepaling en controle van plaats, beweging en trilling; management, verwerking en interpretatie van big (sensor) data.

6.1.3. Topsector Life Science & Health

In the Knowledge and innovation agenda LSH 2018-2021, the following themes are relevant for eHealth technology:

- **Homecare & self-management.** Developing, assessing and implementing technologies, infrastructure and services that promote life span, i.e. individuals' abilities to live and function independently and to manage their own health, care and daily functioning, adequately helped by intelligent decision-support agents, technology and, when necessary, by healthcare professionals.
- **Health technology assessment, individual functioning & quality of life.** Development of methods and knowledge for health technology assessments in which the impact of health innovations on individual functioning and quality of life, cost-containment, and productivity is assessed.

6.2. Opportunities in Europe

6.2.1. The European agenda

The aim of EU policies and actions in public health is to improve and protect human health, and to support the modernisation of Europe's health systems, thereby contributing to the Commission's 2014-2019 priority on growth and jobs. Aside of being a value in itself, health is also precondition

for economic prosperity. Efficient spending on health can promote growth[1]. Europe needs smart investments in health:

- spending smarter - but not necessarily more, in sustainable health systems;
- investing in people's health, particularly through health promotion programmes;
- investing in health coverage as a way of reducing inequalities and tackling social exclusion.

EU action in the public health area is mainly linked to incentives and cooperation measures. The Commission has an important supporting role to play, providing guidance and tools to promote cooperation and help national systems operate more effectively. In accordance with the Strategic Plan 2016 – 2020 of the Commission's DG Health and Food Safety[2], actions focus on the following key challenges:

- achieving greater cost-effectiveness;
- competitiveness together with safety;
- tackling emerging global threats;
- evidence-based policy making;
- addressing the risk factors of chronic disease.

In line with the principles of proportionality and subsidiarity, the Commission's role is mainly to support the EU Member States' efforts to protect and improve the health of their citizens and to ensure the accessibility, effectiveness and resilience of their health systems.

6.2.2. Funding Opportunities

The third **EU health programme,** is the main instrument the European Commission uses to implement the EU health strategy. It is implemented by means of annual work plans which set out priority areas and the criteria for funding actions under the programme. The total budget for the programme is € 449.4 million. According to the draft version of the 2018-2020 Work Programme, funding for the upcoming three years will be canalized into the following areas:

- Better Health and care, economic growth and sustainable health systems
  - Personalized medicine
  - Innovative health and care industry
  - Infectious diseases and improving global health
  - Innovative health and care systems – Integration of care
  - Decoding the role of the environment for health and well-being
- Digital transformation in Health and Care
- Trusted digital solutions and Cybersecurity in Health and Care

The Overview of upcoming calls for proposals under the "**Health, demographic change and wellbeing" challenge – for the year 2020** can also be found in **Annex 3.**

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[1] See also the Investing in Health, Commission Staff Working Document – Social Investment Package and the Communication from the Commission on effective, accessible and resilient health systems

[2] https://ec.europa.eu/info/sites/info/files/strategic-plan-2016-2020-dg-sante_may2016_en_1.pdf

In addition to the previously mentioned funding opportunities, there are other three components of the H2020 explained in detail in Annex 3, that can be relevant for the Personalized eHealth Technology program, namely:

- the Marie Sklodowska Curie Actions (MSCA) under the First Pillar (Excellent Science)
- the Future and Emerging Technologies (FET) initiative under the First Pillar (Excellent Science)
- the ICT calls under the Second Pillar (Industrial Leadership)

6.3. Other Funding opportunities

Funding from private foundations, focussing on particular diseases, like Diabetes, heart, cancer is becoming more and more important, especially when applying for funding at the national level, as in-kind and in-cash contributions are required.

6.4. Recent successes

In the past two years, there was an increasing collaboration between the three core disciplines required for successful developments of eHealth technology. In addition, there is a growing interest from healthcare institutions to co-develop and implement technology supported innovations in their daily care. This has resulted already in some successes, like:

- Horizon 2020 European project **Council of Coaches**. This project was one of the eight projects accepted from 187 proposals, concerns a new approach to coaching towards sustainable behaviour change. A council of artificial coaches and avatars will be used to discuss lifestyle changes and create awareness. X Million euros were allocated at the region of Twente for this 3-year project.
- EFRO project "**Specialistische zorg thuis**", a network project to investigate and facilitate the transfer of intramural interventions towards the home situation.
- Best diabetes idea (50k) rewarded to ZGT, who is collaborating with UTwente towards a large scale healthy behaviour and self-management support program development for people with diabetes type 2.
- Since 2015 more than 10 vouchers in the regional **Pioneers in Healthcare program** were given to the core partners of the Personalised eHealth Technology for projects directed towards monitoring and coaching using personalised eHealth technology. This involved diabetes monitoring and coaching, heart failure personalised training, self-management of COPD and asthma, automatic sleep analysis, quantitative monitoring of early warning scores and lifestyle coaching for patients with obesities after surgery. All these proposals were initiated by clinicians from the MST and ZGT hospitals underlining their increasing interests in e-health technology. The AIRplay project, started in 2016, was one of the University of Twente candidates to the Klokhuiswetenschapsprijs.
- **VitaalTwente** recently received a special grant from VWS (budget 1500kE, funding 500kE), the first in the Netherlands, to enable growth during the next three years in its ambition to make life in Twente healthier, by implementing eHealth services on a large scale and support measures for sustainable implementation.
- In 2016 the Twente region was awarded as a **three-star Reference Site**, emphasising that Twente is able to successfully implement innovative healthcare services. This is a great recognition, which will also be very helpful in
- **Wear Sustain H2020 grant** (collaboration HMI / DPM – electronics / design) 50K to develop new wearable, robotic textile that gives haptic feedback for posture correction, planning following project to use similar wearable for breathing coaching for children (collaboration with MST).

6.5. The Acquisition Machine

In consideration of the increasing importance of external opportunities for funding, and the solid experience in acquiring external funding of the different participants in this program[3], an important priority of the eHealth Technology program consists in creating a so-called *acquisition machine* tool – which in the long term should justify the theme.

The acquisition machine aims at providing support to the researchers in their external funding endeavours, covering the entire acquisition chain: from identification of the relevant funding initiative to support on the Grant Agreement preparation phase.

A leading scenario that we intend to realise with the acquisition machine is the following:

> An UT ambassador attends meetings, workshops and has due to his excellent network a lot of incoming information on upcoming calls, programs and policies. In many, he participates himself contributing to roadmaps. When home, he discusses the information with the acquisition machine support staff (AMS), who will then look at the concrete possibilities and find out details.
>
> Then a call to the partners is sent out about the call by AMS and a meeting is set-up. At this meeting, the call is discussed in detail and reflected towards the offer the partners can jointly make. A decision is made whether to start a proposal making and who will be involved, as well as a schedule when what has to be finished. The writing team will be actively supported by AMS with advices, reading material, a database with old proposals for inspiration, etcetera.
>
> Some important principles in this trajectory are “no free ride” meaning that the participants have to be active and comply with the scheme made. A second principle is to “share efforts and rewards”. This means that PhD’s will never be allocated to one single research group, but always to at least two groups of collaborating researchers. Only in this way an efficient support of the program and an effective way of community building is obtained.

So, the acquisition machine will consist of a comprehensive approach to the external funding, that combines ad hoc events and workshops, format meetings, database and internal support from the UT, as described in the following:

- **Ad hoc events and workshops**: funding acquisition requires awareness on the existing possibilities, specific skills on writing proposals, addressing the challenges of the calls and knowing the strategy of funding institutions.
- **Proposal writing workshops:** These events will provide researchers with the capability to improve their participation in funding initiative, share their experience and expand their knowledge on funding initiatives and strategic positioning groups, as described in section. Experts from relevant institutions (i.e. National Contact Points for H2020) will be invited to also provide their guidance, advice and training for specific funding programmes.
- **Proposal development workshops**: Partners in the Personalized eHealth Technology program working on a cross-disciplinary proposal will receive support in specific parts of the proposal writing, such as budget definition.
- **Database(s) with project examples**: successful proposals, but also evaluation reports and reviewers’ s remarks are a precious source of information for improving existing

[3] See 6.4 for recent success stories on external funding initiatives

proposals and/or inspiring new or follow-up ones. The Database will therefore collect and organize all available information of granted projects that belong to the researchers involved in the program, taking into account the ipr of the authors.

Internal support will be given by at least the following parties:

- EU Office: support on the acquisition chain and project management;
- Novel T: support on Exploitation, IP, Patents and innovation/opportunity recognition and valorisation;
- LISA: support on the Data Management;
- Already existing events on funding acquisition (i.e. the Grants Week).

7. CREATING IMPACT

Impact can be created at several levels: **societal, technical and economic**. These are not separated but in general strongly connected. Eg. New technology has to be mature, to be introduced in the society and successfully implemented, whereas it is unlikely that without economic impact some party will put efforts in its marketing, sales and implementation.

7.1. Societal impact

The social impact of eHealth technology will be manifold, in particular:

- **Improved well-being through optimal coaching**: we will streamline and synchronize support functions, which will offer subjects access to holistic support in a cost-effective way.
- **Impact on carers and family members**: we will prolong the time individuals can live independently without any need for support from a family member or carer.
- **Reduction of hospitalization**: we develop new virtual coaching approaches that will motivate individuals to remain active and adopt a healthy lifestyle. In this way, subjects will reduce their risk for worsening of their chronic condition or occurrence of co-morbidities that lead to hospitalization.
- **Impact on Society**: One of the major impacts on the society as a whole will be the contribution to the wider adoption of monitoring and coaching services by citizens, as a result of the introduction of a novel more integrated and more cost-effective coaching paradigm. Additionally, improvement of personalized eHealth technologies has an impact on society by facilitating healthcare at distance, thereby contributing to sustained equal access to healthcare in areas of remote access.

7.2. Economic impact

The market of personalized care solutions is characterized and driven by three major trends, which are reshaping the business strategies of healthcare services providers and which are depicted in the following figure (from the European Council of Coaches Proposal):

- **Integration of wellness and healthcare services**: with the increasing focus on the needs of people with chronic conditions who require particularly services that support them in their selfmanagement and independent living, the difference between healthcare services and wellness services is diminished. The customers will demand a mixed set of services they can choose from, that is delivered by a single interface. This has a substantial impact on the business model, which may shift to multistakeholder models with more than one source for payment, like health insurance, local government and the customer.
- **Consumer driven services**: Healthcare services providers are increasingly focusing on the provision of personalized services, which are tailored to consumer needs. Rather than “one-size-fits-all” solutions, the new wave of healthcare services aims at putting subjects at the heart

of the services provisioning model, through adapting services to the subject's preferences and needs, which may change in due time.

- **Market growth driven by mHealth trends**: There is a clear trend towards mobile health, as smartphones and tablet-PCs are gradually becoming the preferred terminals and interface for the interactions between healthcare services providers and end-users.

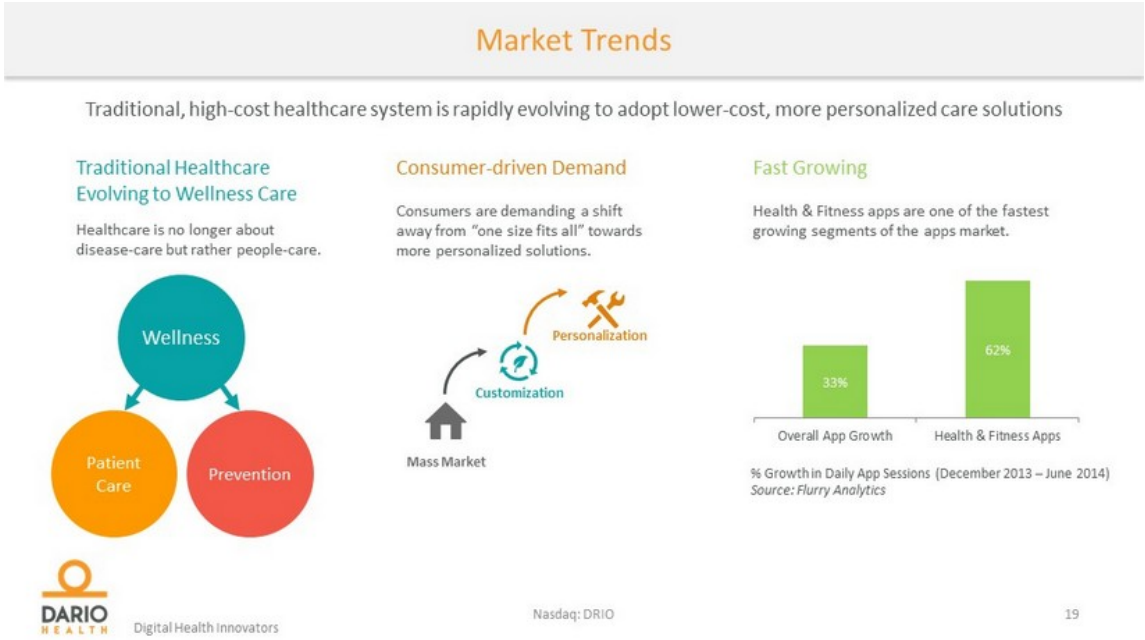


FIGURE 4: TRENDS IN (PERSONALIZED) HEALTHCARE SYSTEMS AND SERVICES.

Our ambitions are highly aligned with all the above listed trends, as it enables integrated personalized services, which will be delivered to the users through mobile devices. Furthermore, our program will be introducing novel care services delivery models for monitoring and virtual coaching services, as it emphasizes the involvement, collaboration and coordination of multiple stakeholders, which cater for different (complementary) aspects of the users' healthcare status, including cognitive, mental, functional and well-being aspects. Therefore, it has a high potential impact for healthcare services providers, as it will enable them to introduce new disruptive healthcare models.

7.3. Technological & Scientific Impact

Beyond the technological development that will stem from the introduction of new monitoring and coaching paradigm (e.g., opportunities for innovative mobile apps), the program will have a significant scientific impact in the main research areas of the program, including new holistic approaches for sensing, embodied conversational agents, data driven decision support and coaching systems, human machine interactions for persuasive interactions and more. A major challenge will be to balance robustness, accuracy and non-intrusiveness of the various interactions as these should be offered at the same time. This pushes existing technologies to their limits and asks for moving several techniques from the realm of lab environments to real-life, less constrained settings. A major objective of the program is to open new horizons in the wider uptake and use of these technologies in pragmatic settings, which could give a significant boost to other applications that benefit from these technologies like self-service applications, gaming, smart home deployments and more. This will have a major technological and scientific impact, which will be quantified in terms of scientific improvements over the state-of-the-art. A project portfolio will be created ranging from a focus on scientific and technology development, towards clinical trials and

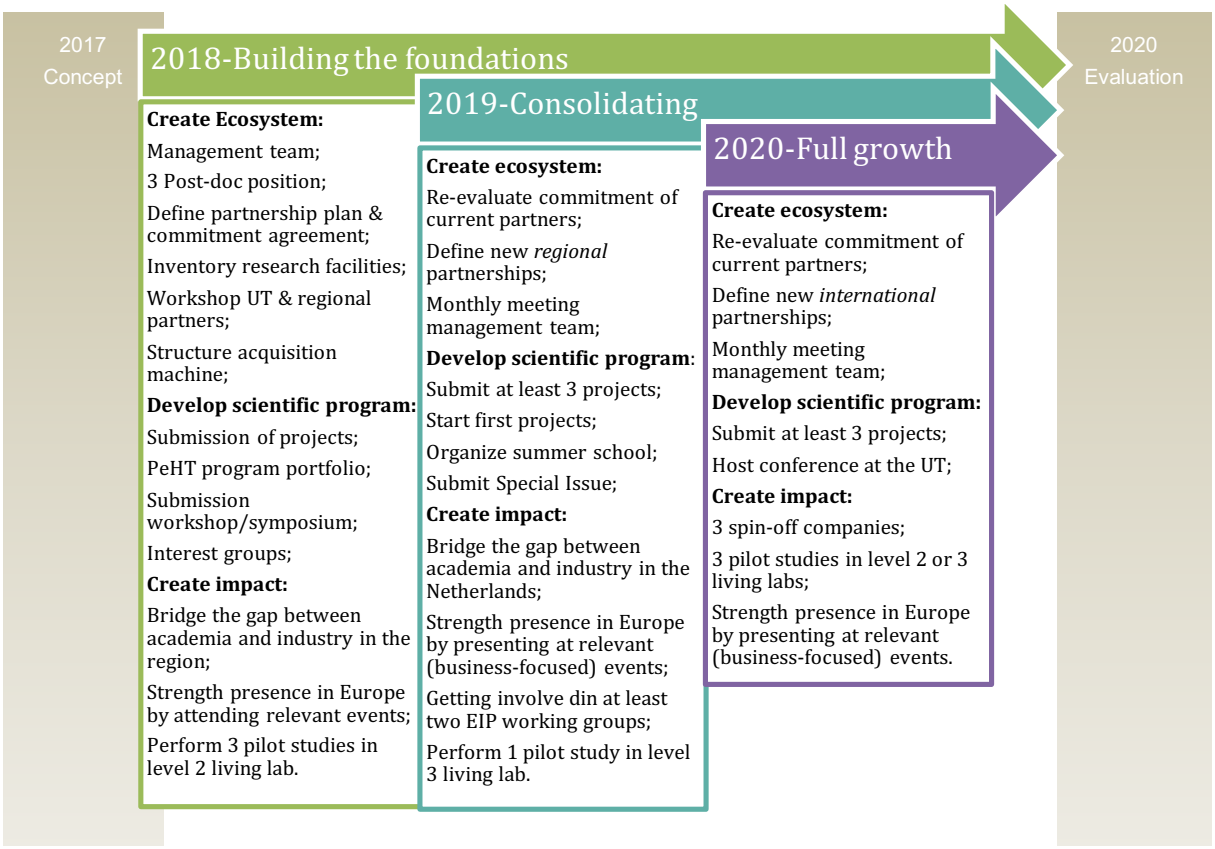
implementation trajectories in clinical practice, as illustrated in figure x. The creation of such portfolio pipeline will enable continuous flow of products, services and ideas towards the clinical practice, creating substantial societal and economic impact. Actions to realise this impact, will be embedded in the roadmap.

8. THE ROADMAP

8.1. Approach

The eHealth Technology program is defined for a period of 5 years. After 3 years the program will be reviewed and based upon the results the roadmap for the next two years will be defined. In this document, the roadmap for the first three years will be specified. Each year a detailed activity plan will be developed and agreed with the partners. Main aspects for the roadmap are:

1. **Creating the Ecosystem**, involving a close and fruitful collaboration between the participating groups, their linkage to the outside world and the creation of a state of the art infrastructure with excellent labs, the acquisition machine and
2. **Develop the scientific program**, creating a portfolio of projects covering the whole translational chain with strong interactions between the different stages of research and development activities
3. Create **impact** in terms of societal, technical and economic impact.



8.2. 2017 – Defining the Concept

In 2017 the following activities have been/are carried out:

- The core UT research groups have been identified through several meetings with potentially interested groups in joining the Personalised eHealth Technology programme;
- A **workshop** has been organized at the DesignLab in October 2017, following the concepts of *design4people4community* to bring together interested people from the UT core partners (see Section 7.2.2), to identify synergies and define the priorities for research;
- A **website** is being designed that facilitates the community building, information exchange and dissemination of the work developed within the programme;
- The **supporting organization** and **underlying infrastructure** was designed and people assigned to create the acquisition machine.
- The strategic plan of the Personalised eHealth Technology program was defined.

8.3. 2018 – Building the foundations

In 2018 the following activities are foreseen:

- Create the *ecosystem activities*:
  - Define **management team** of the program;
  - Monthly **meetings** with the management team;
  - Support the Personalized eHealth Program with 3 dedicated **Post-Doc** positions;
  - Define a **plan** for new structural partnerships with relevant stakeholders;
  - Define **commitment agreement** between partners;
  - Enhance the infrastructure in support of research, scholarship, and creativity by making an **inventory** of all research facilities (material and living lab) available within the programme.
  - Organize **workshop** with UT community and external (un-)structured partners to define paths for each one of the main topics identified in the first workshop;
  - Define the **acquisition machine** and structure the support given to proposal writing when at least two partners of the Personalized eHealth Technology program are involved.
- Develop the *scientific program*:
  - **Submission** of the first national and international projects, with the support of the acquisition machine, building on the results of the workshop that took place in October 2017;
  - Strength position of the UT as epicentre for personalising ehealth technology research and expertise, by **collecting** and **making visible** available on- and offline a portfolio of projects, education courses and initiatives at UT within the program.
  - Strength position of the UT as epicentre for personalising ehealth technology research and expertise in the scientific community by submitting a **workshop/symposium** to a high ranked conference (e.g. PervasiveHealth2019)
  - Specific interest groups will be defined within the core UT partners, e.g. wearables and future engineering.
- Create *impact*:
  - Introduce the Personalised eHealth Technology research program to technology and service companies in the *region*, with the aim to create partnerships and define new collaboration agreements, bridging the gap between academia and industry in the industry;
  - Organize an event with companies and researchers interested to define common strategies for collaboration to transfer the academic knowledge to the market;
  - Actively attend a European Innovation Partnership-Active and Healthy Ageing meeting to strength the position of the eHealth Technology program in Europe;

- Actively attend the European event of the Healthcare Information and Management Systems Society (HIMSS) to strength the position of the Personalised eHealth Technology program in Europe;
- Perform three pilot studies in a large clinical population of the technology developed within the Personalized eHealth Technology program connected with the level 2 Living Lab.

8.4. 2019 – Consolidating

- Create the *ecosystem activities*:
  - Re-evaluate commitment of the partners;
  - Monthly meeting with the management team;
  - Establish *regional* partnerships
- Develop the *scientific program*:
  - Submit at least three projects resulting from collaboration between partners of the program;
  - Initiate the first projects resulting from the Personalized eHealth Technology program;
  - Organization of a **summer school** on Personalized eHealth Technology to bring the early career researchers to the University of Twente;
  - Submit a proposal for a **Special Issue on Personalized eHealth Technology** to a journal in Q1 of healthcare technology (e.g. International Journal of Medical Informatics and Journal of Biomedical Informatics).
- Create *impact*:
  - Introduce the Personalised eHealth Technology research program to technology and service companies in *the Netherlands and in the whole Europe*, with the aim to create partnerships and define new collaboration agreements, bridging the gap between academia and industry in the industry;
  - Getting involved in at least two working groups of the European Innovation Partnership to strength the position of the Personalised eHealth Technology program in Europe;
  - Present at the European event of the Healthcare Information and Management Systems Society (HIMSS) to introduce the Personalised eHealth Technology program in Europe also in the business paradigm;
  - Perform **one pilot study** in a large clinical population of the technology developed within the Personalized eHealth Technology program connected with the level 3 Living Lab.

8.5. 2020 – Full growth

- Create the *ecosystem activities*:
  - Re-evaluate commitment of the partners;
  - Monthly meeting with the management team;
  - Establish *international* partnerships.
- Develop the *scientific program*:
  - Host a high ranked conference/workshop on eHealth at the University of Twente;
  - Submit at least three projects resulting from collaboration between partners of the program;
  - Organization of a **summer school** on Personalized eHealth Technology to bring the early career researchers to the University of Twente;
  - Submit a proposal for a **Special Issue on Personalized eHealth Technology** to a journal in Q1 of healthcare technology (e.g. International Journal of Medical Informatics and Journal of Biomedical Informatics).
- Create *impact*:
  - Three new **spin-off companies** resulting from the collaboration between partners within the Personalised eHealth Technology research program;

- Perform **three pilot studies** in a large clinical population of the technology developed within the Personalized eHealth Technology program connected with the level 2 or 3 Living Labs.
- Present at the European event of the Healthcare Information and Management Systems Society (HIMSS) to strength the position of the Personalised eHealth Technology program in Europe also in the business paradigm.

9. FINANCES

The eHealth Technology program is defined for a period of 5 years. After 3 years the program will be reviewed and based upon the results the roadmap for the next two years will be defined. Therefore, the budget has been calculated now for a period of three years starting from January 2018.

The requested personnel for the activities defined in the roadmap involves:

- **Boegbeeld, hoogleraar** during 3 years, one day per week
- **Program manager** (senior postdoc) 0.6 fte for 3 years, who will work especially on the community building, dissemination.
- **3 Postdocs** as the glue to start and facilitate collaboration between the three main, core disciplines, each of them supervised from two core disciplines. They are the main drivers of the scientific program and the impact part
- PhD's will be funded by externally funded joined proposals
- Support from supporting staff will be obtained from EU office, Mira.

Costs are estimated to be per year

Description	Personnel	Other cost	Total
2018	247.680	35.000	282.680
2019	250.219	25.000	275.219
2020	252.783	20.000	272.783

Personnel costs have been calculated by D.Gimenez Miras (financial projectmanager EWI).

Functie	fte.	Jaren*			Totale projectkosten
		Jaar 1	Jaar 2	Jaar 3	
Junior Postdoc	1,0	€ 57.600	€ 58.190	€ 58.787	€ 174.577
Junior Postdoc	1,0	€ 57.600	€ 58.190	€ 58.787	€ 174.577
Junior Postdoc	1,0	€ 57.600	€ 58.190	€ 58.787	€ 174.577
Senior Postdoc	0,6	€ 41.280	€ 41.703	€ 42.131	€ 125.114
Hoogleraar	0,2	€ 33.600	€ 33.944	€ 34.292	€ 101.837
Totaal	**3,8**	**€ 247.680**	**€ 250.219**	**€ 252.783**	**€ 750.682**
*Indexatie 2,5 %					

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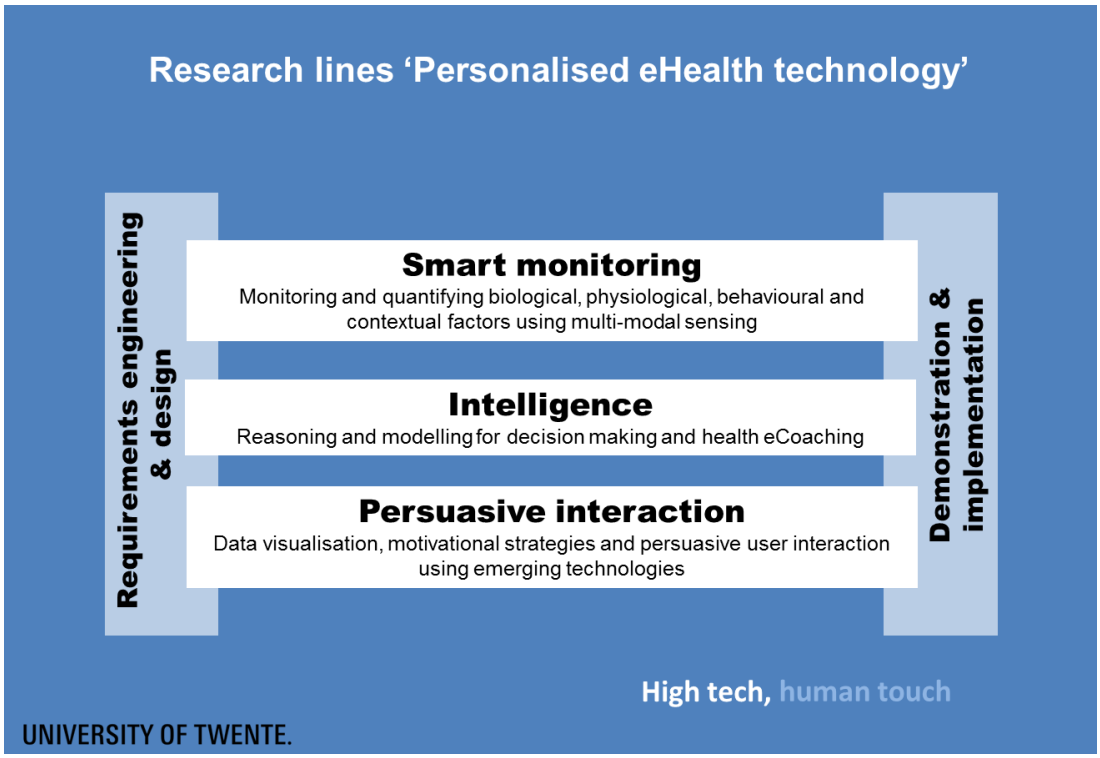
ANNEXES

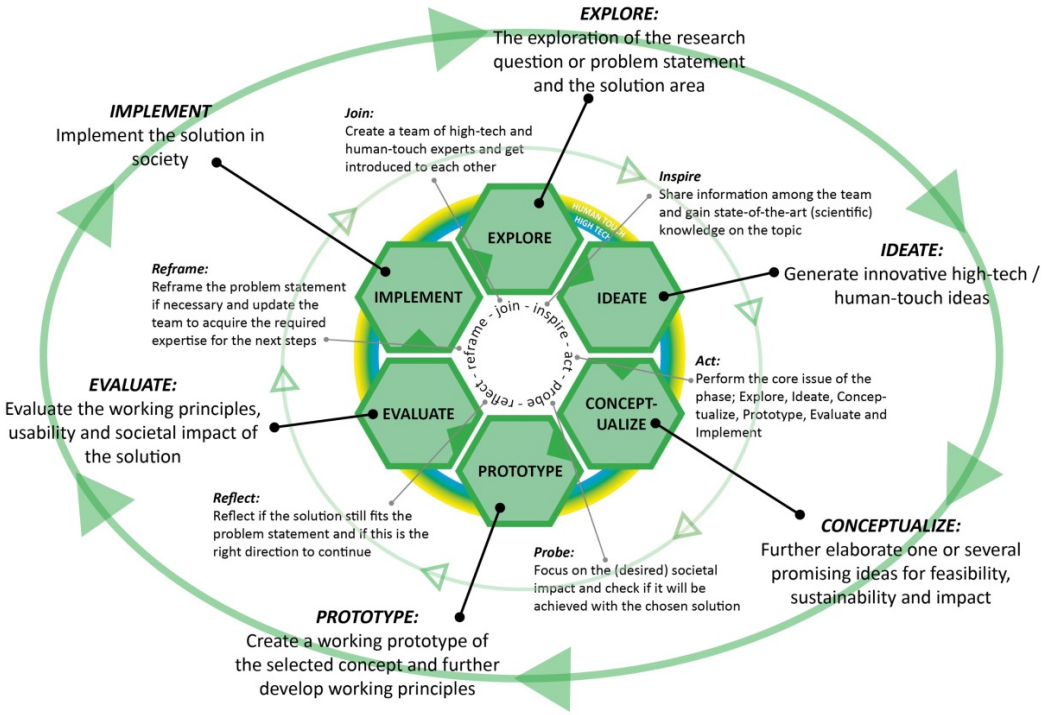
Annex 1. The research program

The five key research areas that need to be mastered in order to deliver successful Personalised eHealth solutions are listed in the figure below:



In order to shortly illustrate these five research lines, we define a high level, typical personalised eHealth scenario and quickly highlight the defining features of these five elements. A typical eHealth scenario revolves around a patient or user group suffering from a chronic condition. The goal is to develop a tool that can help the user self-manage his condition, or prevent/delay the condition from arising, thus limiting his dependency on professional healthcare.

Research line: Requirements and Design



Requirements engineering has been defined as “all the activities devoted to the identification of user requirements, analysis of the requirements to drive additional requirements, documentation of the requirements as a specification, and validation of the documented requirements against the actual user needs” (Saiedian & Dale, 2000, p. 420). For the context of personalised eHealth technology, these activities should cover functional design, as well as the development of associated care protocols or service models. Where in the past, health technologies were often developed with a technology-centered approach, nowadays these technologies cannot be created without the involvement of prospective end-users and other stakeholders. One method that has incorporated this vision is the approach and methodology of the University of Twente Design Lab that is created in their strive towards science2design4society.

1. With all the gathering and use of personal health data, generating requirements and designs for privacy-abiding technology will be a must. Current functionalities and interfaces that allow patients to control their health data are extremely difficult or unusable. Requirements engineering activities must enable the development of easy to use, understandable features that allow for full control over personal health data, as gathered and used by personalised ehealth technologies;
2. In a development process, a technology-push, needs and wishes of end-users and stakeholders, and, last but not least, creativity must be combined in order to create cutting edge health technology that also adds value. Now, one of these approaches is often leading, and therefore, new requirements elicitation methods must be developed that combine the approaches. For example, one can think of gamifying requirements elicitation sessions.
3. Many new personalised eHealth development processes start with engineering requirements anew, while similar studies on the same disease or the same kind of technology have already been conducted. Somehow, we do not learn from others’ efforts. Developing a taxonomy for classifying requirements for eHealth, and subsequently creating a platform for distributing them should enable a huge gain in efficiency while engineering requirements.
4. The issue of ‘trust’ will become more and more important in the coming years. When do I trust a health advice that is generated by a technology? What makes me (dis)trust the

output of personalised eHealth technology? Answers to these questions will be crucial for developing an application that can count on high end-user acceptance. But at the moment, our knowledge of the coming about and workings of trust with respect to personalised eHealth technology are very limited.

5. Requirements often need to be gathered from a group of diverse people that are geographically dispersed and difficult to get together. Therefore, online tools need to be developed and validated that allow for online requirements elicitation, but that do foster the same atmosphere as can be created in face-to-face meetings. Such tools are in use currently to explore further deployment.

Research line: Smart Monitoring and Multi-Modal Sensing

All things start with sensing, gathering the required information to obtain a quantitative holistic picture of the health and status of the individual person. It is not our intention to develop sensors, but looking for collaboration with the sensor program at UTwente and use state of the art sensing technology commercially available. As shown in figure 2, we aim at obtaining relevant information at both the biological, physiological and behavioural functioning.

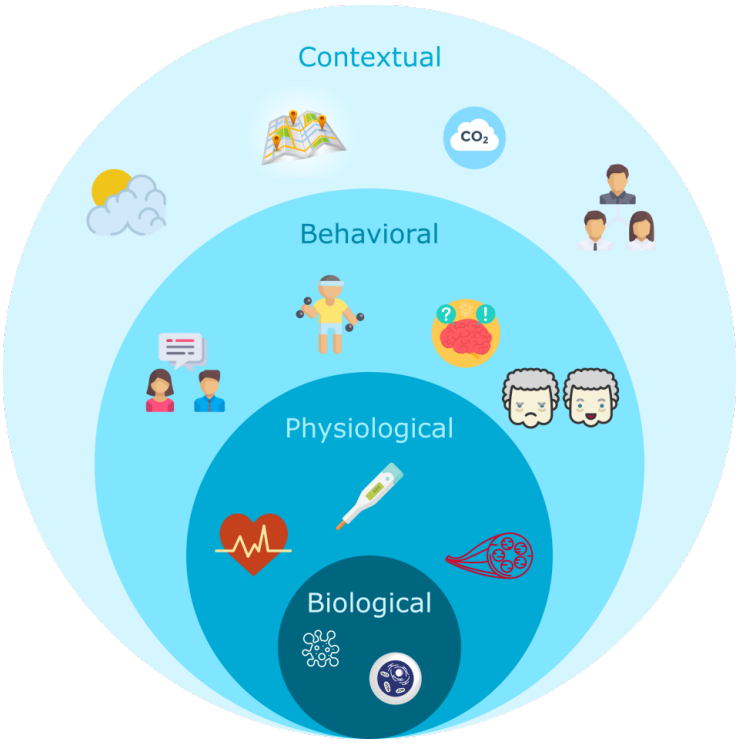


FIGURE 5 - LAYERS OF SENSING.

As illustrated in the figure, the challenge of the sensing is to obtain a holistic view on the functioning of the person in his/her context. This will involve several layers of the sensing, ranging from the sensing of biological and physiological processes, up to more behavioural aspects involving social, cognitive aspects, subjective experiences on health and wellness and contextual information to support a proper interpretation of the health and wellness aspects. The sensor data characteristics are basically very different in their characteristics, not only in their scales but also with respect to their sampling rates. Feature engineering will be a great challenge to create homogeneous longitudinal datasets that enable further analysis.

Research line: Reasoning and Intelligence for Decision Making and Coaching

Somewhere on the digital path from sensor data to meaningful information is a thin line where we draw the border between "smart monitoring" and "reasoning and intelligence". Without attempting to provide a formal distinction, in this research line we are dealing with (i) *high level semantically meaningful concepts*, (ii) *deriving information post-hoc from multiple data sources*, and (iii) *defining fluent models of users or context*.

The raison d'être for a reasoning and intelligence component is to bridge the semantic gap between the information provided by *sensing* and required for *user interaction*. Without this component, a personalised eHealth tool could, for example, display a user's measured steps on a screen – information from sensing is directly used in the user interaction. When the same tool aims to provide a motivational advice, the gap between what is sensed and the information needed becomes too large and an intelligence/reasoning component becomes necessary.

In recent years, reasoning has become an integral part of personalised eHealth solutions and has played a major role in eHealth research at the University of Twente, driven by a large number of (inter)national research projects (e.g. MobiHealth, IS-ACTIVE, MobiGuide, PERSILLAA, eLabel), resulting in key publications (Hermens et al., 2014), and a number of completed PhD projects, e.g. (Tabak, 2014; op den Akker, 2014; Klaassen, 2015). In this body of work, there is an emerging trend in shifting from single-domain reasoning towards a more holistic approach in which fusion of multiple-domain data is becoming increasingly important.

Major challenges in the area of reasoning and intelligence are related to the single-domain to multi-domain shift. Additional challenges lie in keeping up with the increasing amount of data that becomes available, and the needed level of robustness of the solutions required for a world in which personalised eHealth solutions are more and more embedded into daily life. We define the five major challenges for the coming five years below:

- Creating holistic models that allow us to understand the intricate complexities of interactions between physical, cognitive, social, emotional, and environmental parameters in relationship to the person's health or wellbeing goals;
- Defining and constructing models of users or health status in ways that foster interoperability in a rapidly digitizing environment;
- Designing the digital mind of the coach of the future – paving the way for truly natural and personalised interactions between virtual coaches and users;
- Creating open, collaborative platforms for the collection, storage, and analysis of large scale heterogeneous multi-modal data;
- Keeping up with the rapidly advancing technologies in the area of data science, deep learning and artificial intelligence in order to make optimal use of the wealth of data collected.

Research line: Persuasive Interaction

If we know what the user needs, can unobtrusively monitor the user's health and behaviour, and can support by intelligent clinical decision making and generating coaching strategies, we will still not be successful in actually changing the user's behaviour. We need to persuade the end users in a motivating, understandable and engaging manner to enable behaviour change in health and wellbeing. For this, we should 1) turn the data into meaningful variables reflecting health, social, cognitive and emotional status 2) motivate the user to convey to the coaching provided and 3) engage the user to actually use and adhere to the emerging technologies. The persuasive interaction line deals with *developing the right persuasive tools for the specified users, on emerging interaction devices, translating the desired intentions into successful persuasive interaction strategies.*

Persuasive design can increase adherence by introducing persuasive elements to eHealth applications to engage end users (e.g. through gamified elements). The aim is to improve adherence and to better engage patients and professionals in using the application, thereby facilitating underlying treatment objectives. Moreover, applying persuasive design strategies could enable to sustain engagement for a prolonged time, which is specifically needed for long-term behaviour change. As such, in this body of work, combining social sciences with persuasive technologies is an upcoming field of research for enabling behaviour change among patients and professionals. In particular persuasive profiles will be developed using (big) data to develop data driven persuasive coaching modules (projects Monitoring &Coaching BMS). Additionally, steering strategies can be used to lead the individual into a certain behaviour without noticing. In more concrete, while persuasion has a strong focus on modifying the attitude and mindset, steering strategies focus on modifying the behaviour of the user directly. Looking at gamified applications, steering can be achieved by incorporating game mechanisms that *require* certain behaviours to proceed in the game, *insist* users to use certain behaviours, or even *entice* users into the desired behaviours in more indirect ways (van Delden et al., 2017).

Such approaches have been an important part of personalised eHealth technologies developed and researched in several (inter)national projects of the University of Twente. For example, the AIRplay project, which incorporated social motivation and goal-setting strategies in a gamified app and interactive playground, to support self-management of children with asthma and to promote their physical activity in a fun and unobtrusive manner. MAGGY, a mobile gaming environment for elderly people, to promote physical activity behaviour using a cross-word inspired app on a smartphone, and PERSSILAA, in which a persuasive game layer was developed on top of an online web-portal and screening instrument for frailty. Furthermore, persuasive interaction plays a major role in completed and ongoing PhD projects (e.g. van Delden, 2017; de Vette, 2018) and have resulted in numerous publications and (e.g. Klaassen et al., 2017; Tabak et al., 2015; de Vette et al., 2016).

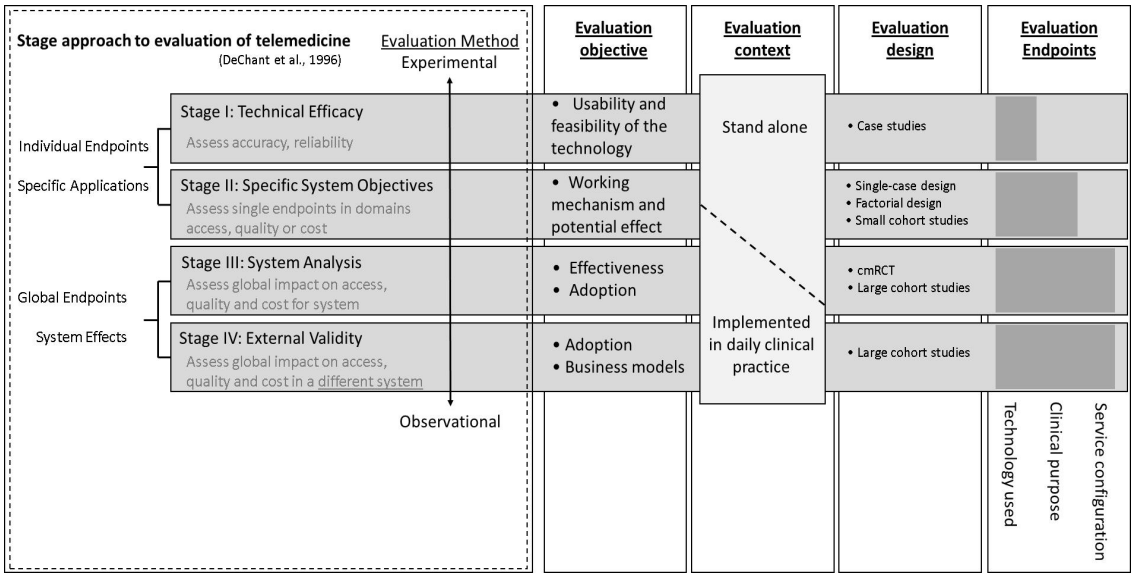
The research line is timely: In this emerging scientific field of applying persuasive technologies in healthcare, a clear knowledge-base for designing persuasive interactions is so far lacking. On the other hand, developments of the emerging technologies (like immersive virtual reality) reach maturity for application at larger scale. The research is multidisciplinary and cross-border, as such evidence would lead to new scientific insights in the application of persuasive technology in behavioural, medical and technical science. In this light, we define the following key challenges for this line of research:

- Derive fundamental knowledge-base for device- and technology-agnostic personalised user interaction and persuasive communication;
- Design and develop efficient and usable interactive tools using emerging technologies such as virtual reality, holograms, and future interactive technologies;
- Create persuasive and steering interaction strategy models to understand the interaction between motivation strategies for behaviour change and persuasive strategies for engagement and adherence;
- Create persuasive profiles, using data and real-time strategies (Just in time adaptive interventions to change behaviour);
- Develop methods to link the personal preferences, besides attitude or different physical capabilities, of any target group into a specific model for persuasive interaction design.

Research line: Demonstration, Evaluation and Implementation Studies

This research line concerns the integration of building blocks into end-to-end applications and their implementation in daily care. To be useful in daily practice user studies are essential during the whole period of development. One of the common pitfalls with this user studies is that they often only start after an extensive period of development and almost immediately focus on testing the

effectiveness in traditional randomized controlled trials and in addition outcome is measured as point of time estimations. However, user studies need to be performed from the early beginning on, the methodologies and endpoints of the study must grow with the maturity of the technology and the power of the data needed for the separate building blocks (sensing and user interaction) should be expanded to increase the power of and by this the evidence gathered from the evaluation studies. Kosterink designed a framework that links the methodology of evaluation to the maturity of the technology which will be used as starting point.



Evaluation framework for eHealth Technology

Our experience has taught us that it is not the technological application that makes the success but the way how the technological applications enable the user in managing his health; what is the additional value for the individual person. As such we have to look beyond the technology here. Using technology for health purposes, the assumption that patients will self- management their health asks behavioural change for the users. Developing strategies starting from this for user acceptance and adoption are needed. Next to this, technologies to be used in daily practice mean that different stakeholders are involved, that costs and benefits are in most cases are shared different among the stakeholders. In order to come to successful implementation these cost and benefits should be researched for the total ecosystem and each of the stakeholders within this. Based on the insights gained here new value and financing stream and by this value based health care be developed.

The key challenges here are:

- Development of iterative evaluation approaches, testbeds and methodologies that fit the iterative design approach and grow with the maturity of the technology
- Development of automated new outcome criteria coming from the sensing and end user interaction modules
- Research into implementation scenarios and behavioural change strategies to ensure real uptake in by users in daily practice

- Development of business modelling methods and tools that give insight in the revenues and costs for the whole pallet of stakeholders involved as well as for each of them involved, separately

Annex 2. National Funding options for Personalised eHealth Technology

Relevante routes NWA

Gezondheidszorgonderzoek, preventie en behandeling

Een nieuwe kijk op gezondheid, met aandacht voor verschillen tussen mensen en een betere aansluiting bij hun persoonlijke beleving, is noodzakelijk om de zorg toekomstbestendig te maken.
https://vragen.wetenschapsagenda.nl/route/gezondheidszorgonderzoek-preventie-en-behandeling

Meten en detecteren: altijd, alles en overal

Door meten tot weten. Onder dat motto groeit onze behoefte aan detailinformatie. Die groei stelt echter eisen aan de benodigde instrumentatie, aan de interpretatie van meetgegevens en aan communicatie, perceptie, en eigendom van meetresultaten.
https://vragen.wetenschapsagenda.nl/route/meten-en-detecteren-altijd-alles-en-overal

Personalised medicine: uitgaan van het individu

Precies de juiste en voldoende zorg voor elke individuele patiënt. Met een optimaal resultaat, een minimum aan bijwerkingen, tegen minimale kosten, zo dicht mogelijk bij huis. Dat is in het kort het ideaalbeeld van personalised medicine.
https://vragen.wetenschapsagenda.nl/route/personalised-medicine-uitgaan-van-het-individu

Sport en Bewegen

Bewegen en sport zijn in de hele levensloop belangrijk. Baby's beginnen met leren bewegen; kinderen hebben sport en spel nodig om zich lichamelijk en geestelijk te ontwikkelen; volwassenen bewegen om fit te blijven en welvaartsziekten op afstand te houden; ouderen blijven bewegen omdat het hen helpt langer vitaal te blijven, en daarmee langer zelfstandig en zelfredzaam. En sommige mensen ontwikkelen hun beweegtalent tot topsporter.
https://vragen.wetenschapsagenda.nl/route/sport-en-bewegen-3

Relevant roadmaps Topsector HTSM

Healthcare. Mensgerichte nano-elektronica, embedded systems en mechatronica ten behoeve van preventie, diagnostiek, interventie en therapie, nulde- en eerstelijnszorg en thuiszorg; en enabling technologies voor gezondheidszorg.
https://www.hollandhightech.nl/nationaal/innovatie/roadmaps/healthcare

Security. Bescherming van de veiligheid van personen en maatschappij, zowel bij geweld als door crises en rampen. Met technologie in de domeinen system-of-systems-oplossingen, cyber security en sensoren.
https://www.hollandhightech.nl/nationaal/innovatie/roadmaps/security

Embedded Systems: Geïntegreerde hardware/software-systemen die intelligentie, besluitvorming en mogelijkheden toevoegen aan hightech producten, welke economische bedrijvigheid en kwaliteit van leven verhogen.
https://www.hollandhightech.nl/nationaal/innovatie/roadmaps/embedded-systems

Advanced Instrumentation. Systemen en technologie voor het meten van straling, licht en deeltjes; bepaling en controle van plaats, beweging en trilling; management, verwerking en interpretatie van big (sensor) data.

https://www.hollandhightech.nl/nationaal/innovatie/roadmaps/advanced-instrumentation

Relevant roadmaps Topsector LSH

Knowledge and innovation agenda LSH 2018-2021
https://www.health-holland.com/public/downloads/kia-kic/knowledge-and-innovation-agenda-2018-2021.pdf

3 Homecare & self-management. Developing, assessing and implementing technologies, infrastructure and services that promote life span, i.e. individuals' abilities to live and function independently and to manage their own health, care and daily functioning, adequately helped by intelligent decision-support agents, technology and, when necessary, by healthcare professionals.

8 Health technology assessment, individual functioning & quality of life. Development of methods and knowledge for health technology assessments in which the impact of health innovations on individual functioning and quality of life, cost-containment, and productivity is assessed.

PPS-toeslag regeling RVO

Een publiek-privaat samenwerkingsverband, bijvoorbeeld tussen een bedrijf en een universiteit, kan in aanmerking komen voor de PPS-toeslag regeling van RVO. Een samenwerkingsverband bestaat minimaal uit een onderzoeksinstelling en een ondernemer. Om voor de toeslag in aanmerking te komen, moet een private partij (dat kan ook een ANBI-instelling zijn) een private bijdrage leveren. Daarnaast moet het project uit fundamenteel onderzoek, industrieel onderzoek, experimentele ontwikkeling of een combinatie daarvan bestaan. En er moet sprake zijn van een concrete samenwerking. Het mag niet om contract onderzoek gaan en het IP is in principe eigendom van de universiteit. Als een ANBI-instelling de private financier is, dan is het alsnog nodig dat er minimaal 1 ondernemer bij het samenwerkingsverband betrokken is.

PPS-projecttoeslag

De hoogte van de PPS-projecttoeslag is 25% van de (cash) private bijdrage aan onderzoeksinstellingen. Voor de eerste € 20.000 euro private bijdrage geldt een verhoogd percentage van 40%. Die eerste € 20.000 mag ook een in natura private bijdrage aan de onderzoeksinstelling zijn (bijvoorbeeld als de onderzoeksinstelling een apparaat van een bedrijf mag gebruiken, dan kan de waarde van de gebruiksuren opgevoerd worden als in natura private bijdrage). De hoogte van de private bijdrage moet wel in een samenwerkingscontract vastliggen, ook de in natura bijdrage.

De bijdrage van ANBI's algemeen nut beogende instellingen is gemaximeerd: voor alle aanvragen om TKI-toeslag of PPS-toeslag samen is een jaarlijks plafond van € 75 miljoen. RVO verleent de aanvragen met ANBI-bijdragen op volgorde van volledige aanvragen totdat dit plafond is bereikt.

Voorwaarden

De voorwaarden voor de PPS-projecttoeslag voor samenwerkingsverbanden zijn de volgende:

- Het project duurt maximaal 10 jaar;
- Het project draagt bij aan de Nederlandse kennisinfrastructuur;
- Het project is een samenwerkingsverband, geen contract onderzoek;
- De private bijdrage mag niet worden opgevoerd als 'grondslag' voor PPS programmatoeslag;

- De projecttoeslag moet helemaal worden ingezet in het aangevraagde project, gedurende de
- looptijd van het project.

Subsidiabele kosten en de maximale steunintensiteit

De subsidiabele kosten zijn:

- personeelskosten: onderzoekers, technici en ander ondersteunend personeel voor zover zij zich met het onderzoeksproject bezighouden;
- kosten van apparatuur en uitrusting voor zover en zolang zij worden gebruikt voor het project. Wanneer deze apparatuur en uitrusting niet tijdens hun volledige levensduur voor het project worden gebruikt, worden alleen de afschrijvingskosten overeenstemmend met de looptijd van het project, berekend volgens algemeen erkende boekhoudkundige beginselen, als in aanmerking komende kosten beschouwd;
- kosten van gebouwen en gronden voor zover en zolang zij worden gebruikt voor het project. Wat gebouwen betreft, worden alleen de afschrijvingskosten overeenstemmend met de looptijd van het project, berekend volgens algemeen erkende boekhoudkundige beginselen, als in aanmerking komende kosten beschouwd. Wat gronden betreft, komen de kosten voor de commerciële overdracht of de daadwerkelijk gemaakte kapitaalkosten in aanmerking;
- kosten van contractonderzoek, kennis en octrooien die op arm's length-voorwaarden worden gekocht bij of waarvoor een licentie wordt verleend door externe bronnen, alsmede kosten voor consultancy en gelijkwaardige diensten die uitsluitend voor het project worden gebruikt;
- bijkomende algemene kosten en andere operationele uitgaven, waaronder die voor materiaal, leveranties en dergelijke producten, die rechtstreeks uit het project voortvloeien.
- Maximale steunintensiteit: Voor fundamenteel onderzoek: 100%, Voor industrieel onderzoek 50% , Voor experimentele ontwikkeling 25% van de subsidiabele kosten

Waar kan men indienen?

Een PPS-projecttoeslagaanvraag kan ingediend worden bij een TKI of direct bij RVO. Voor een indiening direct bij RVO dienen de totale projectkosten minimaal 2 miljoen Euro te bedragen.

PPS-programmatoeslag

Als er geen gebruik gemaakt wordt van projecttoeslag, kan de private bijdrage van een bedrijf/ANBI-instelling in een project opgevoerd worden bij een TKI als grondslag. Het TKI geeft de grondslag op bij RVO en ontvangt 25% programmatoeslag over deze grondslag. Deze reservering van 25% kan het TKI weer investeren in onderzoek en ontwikkeling. De werkwijzen van de verschillende TKIs variëren maar vaak is het zo dat de TKIs de programmatoeslagen teruggeven aan de instellingen waar de grondslag is gegenereerd. Universiteiten bijvoorbeeld, kunnen voor hun reserveringen bij een TKI projectvoorstellen indienen. De opbouw van de grondslagen en de aanwending van de reserveringen worden centraal geadministreerd en georganiseerd op de UT.

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Annex 3. European funding opportunities & Upcoming European calls

EU funding for projects in the field of health are available in various EU initiatives such as:

- Connecting Europe Facility
- 3rd Health programme, and
- Horizon 2020 – especially in the Societal Challenges pillar

The **Connecting Europe Facility** (CEF) is a key EU funding instrument to promote growth, jobs and competitiveness through targeted infrastructure investment at European level. It supports the development of high performing, sustainable and efficiently interconnected trans-European networks in the fields of transport, energy and digital services. CEF investments fill the missing links in Europe's energy, transport and digital backbone. The CEF benefits people across all Member States, as it makes travel easier and more sustainable, it enhances Europe's energy security while enabling wider use of renewables, and it facilitates cross-border interaction between public administrations, businesses and citizens. In addition to grants, the CEF offers financial support to projects through innovative financial instruments such as guarantees and project bonds. These instruments create significant leverage in their use of EU budget and act as a catalyst to attract further funding from the private sector and other public sector actors.

Since January 2014, INEA is the gateway to funding under the CEF. INEA implements most of the CEF programme budget, in total €27.4 billion out of €30.4 billion (€22.4 billion for Transport, €4.7 billion for Energy, and €0.3 billion for Telecom). The CEF is divided into three sectors: CEF Energy, CEF Transport and CEF Telecom that includes calls for eHealth solutions

The third **EU health programme,** is the main instrument the European Commission uses to implement the EU health strategy. It is implemented by means of annual work plans which set out priority areas and the criteria for funding actions under the programme. The total budget for the programme is € 449.4 million. The programme has 4 overarching objectives. It seeks to:

- Promote health, prevent diseases and foster supportive environments for healthy lifestyles taking into account the 'health in all policies' principle,
- Protect Union citizens from serious cross-border health threats,
- Contribute to innovative, efficient and sustainable health systems,
- Facilitate access to better and safer healthcare for Union citizens.

The third pillar of the **Horizon 2020** initiative responds directly to the policy priorities and societal challenges identified in the Europe 2020 strategy[4] and aiming to stimulate the critical mass of research and innovation efforts needed to achieve Union's policy goals.

The **Health, demographic change and wellbeing challenge** aims to keep older people active and independent for longer and supports the development of new, safer and more effective interventions. The initiative pursues three main objectives:

- Improve our understanding of the causes and mechanisms underlying health, healthy ageing and disease, improve our ability to monitor health and to prevent, detect, treat and manage disease;
- Improve the decisional process in terms of prevention and treatment offer, test and demonstrate new models and tools for health and care delivery

[4] https://ec.europa.eu/info/strategy/european-semester/framework/europe-2020-strategy_en

- Contribute to the sustainability of health and care systems.

According to the draft version of the 2018-2020 Work Programme, funding for the upcoming three years will be canalized into the following areas:

- Better Health and care, economic growth and sustainable health systems
  - Personalized medicine
  - Innovative health and care industry
  - Infectious diseases and improving global health
  - Innovative health and care systems – Integration of care
  - Decoding the role of the environment for health and well-being
- Digital transformation in Health and Care
- Trusted digital solutions and Cybersecurity in Health and Care

A complete overview of upcoming **calls for proposals under the "Health, demographic change and wellbeing" challenge – for the period 2018 – 2019 (text of the call available in a draft version) is given in annex 3.**

The Overview of upcoming calls for proposals under the "**Health, demographic change and wellbeing" challenge – for the year 2020 (text of the call not available)** can also be found in **annex 3.**

In addition to the previously mentioned funding opportunities, it is important to mention here other three components of the H2020 that can be relevant for the eHealth Technology program, and namely:

- the Marie Sklodowska Curie Actions (MSCA) under the First Pillar (Excellent Science)
- the Future and Emerging Technologies (FET) initiative under the First Pillar (Excellent Science)
- the ICT calls under the Second Pillar (Industrial Leadership)

The **MSCA** aim at supporting the career development and training of researchers – with a focus on innovation skills – in all scientific disciplines through worldwide and cross-sector mobility. For this, the MSCA provide grants at all stages of researchers' careers, from PhD candidates to highly experienced researchers, and encourage transnational, intersectoral and interdisciplinary mobility. In particular, the Innovative Training Networks calls support competitively selected joint research training and/or doctoral programmes, implemented by European partnerships of universities, research institutions, and non-academic organisations.

The research training programmes provide experience outside academia, hence developing innovation and employability skills. ITNs include industrial doctorates, in which non-academic organisations have an equal role to universities in respect of the researcher's time and supervision, and joint doctoral degrees delivered by several universities. Furthermore, non-European organisations can participate as additional partners in ITNs, enabling doctoral-level candidates to gain experience outside Europe during their training.

The **FET** aim is to turn Europe's excellent science base into a competitive advantage. FET actions are expected to initiate radically new lines of technology through unexplored collaborations between advanced multidisciplinary science and cutting-edge engineering. In particular, the FET Flagships support ambitious, large-scale, long-term, science-driven, goal-oriented, roadmap-based research initiatives tackling grand challenges in S&T. They are expected to provide transformational impact on science, technology and society, lead to novel innovation clusters in Europe and facilitate alignment of national and regional research efforts.

The draft FET Work Programme for 2018 – 2020 includes a "Preparatory Actions for new FET Flagships" call to prepare new candidate FET Flagship(s) on, among others, the topic: "Disruptive ICT to Revolutionise Healthcare: New technologies and approaches aiming at a paradigm shift to prevention and treatment of diseases". This includes in particular methods to use patients' genetic make-up to provide individualized prevention and treatment, nano-medicine approaches including novel uses of biosensors, organ-on-a-chip technologies, radically new technologies for drug development, precision medicine, regenerative medicine and biofabrication techniques to replace human cells, tissues and whole organs.

The second pillar of H2020 aims to speed up development of the technologies and innovations that will underpin tomorrow's businesses and help innovative European SMEs to grow into world-leading companies.

Overview of upcoming calls for proposals under the "Health, demographic change and wellbeing" challenge – for the period 2018 – 2019 (text of the call available in a draft version):

2018	International flagship collaboration with Canada for human data storage, integration and sharing to enable personalised medicine approaches
2018 – 2019 - 2020	Actions in support of the International Consortium for Personalised Medicine
2018	Data integration and data-driven in-silico models for enabling personalised medicine - a European standardization framework
2019	Regenerative Medicine: from new insights to new applications
2018	Innovation platforms for advanced therapies of the future
2019	Mining big data for early detection of infectious disease threats driven by climate change and other factors
2019	Demonstration pilots for implementation of personalized medicine in healthcare
2019	Big data and Artificial Intelligence for monitoring health status and quality of life after the cancer treatment
2018	Adaptive smart working and living environments supporting active and healthy ageing
2019	Large scale implementation of digital innovation for health and care in an ageing society
2018	Exploiting the full potential of in-silico medicine research for personalised diagnostics and therapies in cloud-based environments
2018	Prototyping a European interoperable Electronic Health Record (HER) exchange
2019	Scaling up the univocal Identification of Medicinal Products
2019 – 2020	Digital health and care services

2019	Large Scale pilots of personalised & outcome based integrated care
2018	Supporting investment in smart living environments for ageing well through certification
2019	Support for the large scale uptake of open service platforms in the Active and Healthy Ageing domain
2018	Support to further development of international cooperation in digital transformation of health and care
2018	Digital health and care services – support for strategy and (early) adoption
2019	Smart and Healthy living at home
2018	Toolkit for assessing and reducing cyber risks in hospitals and care centres to protect privacy/data/infrastructures
2018	Raising awareness and developing training schemes on cybersecurity in hospitals

Overview of upcoming calls for proposals under the "Health, demographic change and wellbeing" challenge – for the year 2020 (text of the call not available):

2020	Personalised early risk prediction, prevention and intervention
	International cooperation in digital solutions and robotics for independent living
	Accelerating the uptake of in-silico methods for testing medicines with dermatological use
	Digital health and care services
	Support to eHealth Innovation ecosystems in Europe
	Support for European eHealth Interoperability roadmap deployment
	Scaling up innovation for active and healthy ageing
	Supporting deployment of eHealth in developing countries for better health outcomes
	The smart hospital of the future
	Demonstrating the potential and benefits of a European Digital Health Infrastructure for Personalised Medicine

Overview of upcoming relevant calls for proposals under the ICT Work Programme:

2019 - 2020	Robotics in Application Areas

2019 – 2020	Robotics Core Technology
2018 – 2019	HPC and Big Data enabled Large-scale Test-beds and Applications
2019	Advanced 5G validation trials across multiple vertical industries
2019	EU-Taiwan 5G collaboration
2018- 2020	Interactive Technologies
2018 – 2020	Artificial Intelligence
2018	Robotics – Digital Innovation Hubs (DIH)
2019	Digital Platforms/Pilots Horizontal Activities
2018	Cloud, IoT and AI technologies (EU – Korea joint call)
2018	Advanced technologies (Security/Cloud/IoT/BigData) for a hyper-connected society in the context of Smart City (EU – Japan joint call)