POLITECNICO DI MILANO

School of Industrial and Information Engineering

Master of Science in Management Engineering

ENGAGING SENIOR ADULTS INTO HEALTHY AGEING THROUGH DIGITAL TECHNOLOGIES: AN EMPIRICAL INVESTIGATION OF THE INTENTION TO USE A PERSONALIZED VIRTUAL COACH FOR HEALTHIER LIFESTYLE BEHAVIOURS

Supervisor: Prof. Emanuele Lettieri

Co-Supervisor: Dott.ssa Marta Pinzone

Author:

Paloma Lumbreras de Mazarredo 896526

Academic Year: 2018/2019

Acknowledgements

I would first like to thank my supervisor, Prof. Emanuele Lettieri, who has supported me all throughout the project. It has been a pleasure to work with him; his motivation and enthusiasm made me enjoy learning and developing the project. I could not have asked for a better supervisor. I would also like to thank Marta Pinzone for her valuable advices.

In addition, I would like to thank my friends and my family for their affection and support, which I can always count on. Special thanks to my parents because they always give me advice to be not only a better person but also a better professional. They have always believed that I am capable of anything. You are the best.

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Abstract

English version

In response to the rapid ageing of the European population, the European H2020 project NESTORE was funded with the aim of developing and testing an innovative personalised coaching system to support healthy ageing by providing people with guidance for longer healthy life years.

The success of an intervention depends largely on its effectiveness and, just as importantly, on user acceptance. Given the limited research evidence about the adoption of virtual coaching tools, in particular for health-related purposes, the current study aims at exploring the factors influencing the intention to use NESTORE among the target population of the Spanish market (pilot site of the system).

To address the research question, a theoretical extension of the Technology Acceptance Model (TAM) was developed using TAM2 and HBM as its anchor. In order to test the research model, an online survey was conducted to collect first-hand opinions from the potential users of the service. The causal relationships between the constructs were analyzed with structural equation modeling (SEM).

Results reveal that respondents' intention to use NESTORE is determined by their IT literacy, which acts as the substitute for the system's perceived ease of use, and the system's perceived usefulness. IT literacy, subjective norm and image positively influence users' perception of the usefulness of a virtual coach for Healthy Ageing. Contrary to expectations, a positive attitude to life, higher levels of empowerment and higher health literacy do not have a positive effect on the system's perceived usefulness. Instead, higher levels of health literacy decrease it while attitude to life and empowerment do not have any effect.

A positive attitude towards life and users' subjective norm encourage them to have a higher IT literacy. In addition, a positive attitude to life leads users to be more empowered people and thus have higher levels of health literacy. Willingness to pay for NESTORE is determined by intention to use, image and subjective norm; which correspond with the system's functional and social perceived value.

Keywords: Technology Acceptance Model (TAM), virtual coach, persuasive technologies, structural equation modeling (SEM), Healthy Ageing.

Italian version

Il progetto europeo NESTORE, sviluppato in seno al pogramma H2020 della Unione Europea, è stato creato in risposta al rapido invecchiamento della popolazione europea. Tale progetto ha lo scopo di sviluppare e testare un innovativo sistema di coaching, con il fine di promuovere un invecchiamento salutare fornendo linee guida per mantenere un buono stato di salute negli anni.

Il successo di un'azione dipende in massima parte dalla sua efficacia e, nello stesso modo, della sua accettazione da parte degli utenti. Dato il numero limitato di evidenze riguardo l'adozione di strumenti di virtual coaching, in particolare quelli legati a scopi sanitari, questo progetto si prefigge lo scopo di esplorare i fattori che influenzano l'intenzione di utilizzare NESTORE tra la popolazione obiettivo del mercato spagnolo (sito pilota del progetto).

Per rispondere a questa esigenza, si è sviluppata un'estensione teorica del Technology Acceptance Model (TAM) utilizzando come base il TAM2 e il Health Behaviour Model (HBM). Un sondaggio online è stato condotto per raccogliere opinioni dei potenziali utenti, con lo scopo di testare il modello di ricerca. Le relazioni causali tra variabili sono state studiate attraverso un'analisi SEM (structural equation modeling).

I resultati hanno rivelato che la predisposizione degli utenti ad utilizzare NESTORE è determinata dall'utilità percepita e dal loro livello di alfabetizzazione digitale, usato per misurare la facilità d'uso percepita.

L'alfabetizzazione digitale, la "*subjective norm*" e l'immagine sociale influenzano positivamente la percezione dell'utilità di un *virtual coach* per promuovere un invecchiamento salutare. Contrariamente a quanto ci aspettavamo, un'attitudine positiva nella vita, un alto livello di coinvolgimento nella cura del proprio benessere (*empowerment*) e una forte alfabetizzazione alla salute non hanno effetti positivi nella percezione dell'utilità del sistema. Al contrario, un elevato livello di alfabetizzazione alla salute ha un effetto negativo, mentre l'attitudine positiva e l'*empowerment* non hanno nessun effetto.

Allo stesso tempo, un'attitudine positiva verso la vita e la "*subjective norm*" incoraggiano gli utenti a migliorare il proprio livello di alfabetizzazione digitale. Inoltre, questa attitudine positiva conduce agli utenti a essere piu proattivi e quindi ad avere un maggior livello di alfabetizzazione alla salute.

La volontà di acquistare NESTORE è determinata dall'intenzione di usarlo (relazionata all'utilità funzionale del prodotto), dall'immagine sociale e dalla "*subjective norm*" (legate all'utilità sociale del prodotto).

Parole-chiave: Technology Acceptance Model (TAM), virtual coach, tecnologie persuasive, structural equation modeling (SEM), invecchiamento salutare.

Executive Summary

In response to the rapid ageing of the European population, the European H2020 project NESTORE (Novel Empowering Solutions and Technologies for Older people to Retain Everyday life activities) was funded with the aim of developing and testing an innovative personalised coaching system to support healthy ageing by providing people with guidance for longer healthy life years.

Thanks to the use of mobile technology such as tangible objects and sensors, continuous real-time monitoring which enables contextualized and personalized feedback in a ubiquitous way is possible. Indeed, NESTORE is a multi-domain intervention in the form of a virtual companion that gives advice to help older adults to maintain the functional ability and their independence by promoting healthy behaviours. It addresses five crucial domains: physiological status, physical activity, social interaction, cognitive and emotional status and nutrition.

In this way, the project aims to sustain our society as well as our sanitary systems by shifting from treatment towards prevention of age-related diseases. In fact, older adults in good health may contribute to economic growth with their skills and experience; and pressure on the health care system would be reduced.

Given the limited research evidence about the adoption of virtual coaching tools, in particular for health-related purposes, the current study aims at exploring the factors influencing the intention to use NESTORE among the target population of the Spanish market (pilot site of the system).

Contextual and theoretical background

The European population is going through an ageing process caused by a simultaneous increase in life expectancy, a drop in fertility rates below replacement levels, and the ageing of post-war baby boomers. The labor force is expected to shrink while people aged 65 and over will almost double from 2010 to 2060. Moreover, it is also expected that the share of the oldest old (aged 80 and more) will rise gaining a substantial weight.

Life expectancy in the adulthood has increased significantly over the 20th Century and it is expected to be growing continuously. The added years of older age represent an opportunity; however, there is evidence which reveals that the proportion of lifetime without disease or impairment has been decreasing.

Health in older age changes in a complex and unpredictable way; there is a noticeable diversity at an individual level because the environment of the person and the behaviors adopted by the individual influence significantly on it. Contracting risk factors of common age-related diseases such as obesity and diabetes is in general related to sedentary lifestyles and inadequate diets. These problems could be reduced or prevented by embracing healthy habits as well as having access to better medical treatment and preventive measures.

In this regard, the World Health Organization introduced the concept of Healthy Ageing, whose aim is to enable people to be and do what they identify as important by maintaining their functional ability throughout their lives. It is worth noting that even if an individual's intrinsic capacity diminishes over time, the functional ability could be preserved to a large extent if the individual has access to additional functioning from a supportive environment.

With ever-growing access to smart sensing systems and its wide acceptance, the delivery of health-care through unobtrusive and portable technologies, which is known as mHealth, has emerged as a cost-effective solution. In this way, the individual is empowered to manage his or her own health and stay independent longer. mHealth has been shown to improve the quality and coverage of health care, increase access to health information and services, as well as promote positive changes in health behaviours to adopt an active approach to prevent age-related diseases. In this context, technological advances have given rise to virtual systems. These systems, also referred to as virtual coaches, are able to deliver tailored interventions that provide anywhere real-time feedback to have the highest potential impact on the user's decisions by leveraging on behaviour changing techniques. In connection with persuasive technologies, defined as "interactive computing systems designed to change people's attitudes and behaviours" (Fogg, 2003), virtual coaching has been related to the concept as it involves the use of technology to persuade people in changing their behaviour. Focusing on virtual coaching, a literature review of existing studies on e-coaching solutions for overall well-being has been conducted to provide a general view of their scope and main contributions.

Behavioural theories applied in the scope of virtual coaching include the Health Belief Model (HBM), Social-Cognitive Theory (SCT), the Theory of Reasoned Action (TRA), the Theory of Planned Behaviour (TPB) and the Trans-Theoretical Model (TTM). Attitudes, beliefs, expectations of future events and outcomes as well as cognitive variables are major determinants of behaviour change in health related behaviours. Nonetheless, other theories could be considered with this purpose.

The success of an intervention depends largely on its effectiveness and, just as importantly, on user acceptance. Even if technological solutions are powerful and sophisticated; they cannot improve lifestyle behaviours if they are not used. For that purpose, intention models have been widely used by information systems' (IS) researchers to explain and predict the determinants of user acceptance of new technologies. The most widely applied theoretical model in the IS field is the technology acceptance model (TAM) introduced by Davis in 1986.

TAM uses Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) as the main constructs that influence users' behavioral Intention to use a system (ITU). Extensions of the model have introduced new variables hypothesizing different relationships between key TAM constructs, PU and PEOU, and their possible antecedents. These extensions have provided a better explanation of user acceptance in different contexts and have been used to design correction actions. It is worth mentioning the most relevant ones: Venkatesh and Davis (1996) studied the antecedents of Perceived Ease of

Use (PEOU); Venkatesh and Davis (2000) introduced TAM2, a theoretical extension of the TAM that examines the antecedents of Perceived Usefulness (PU); Venkatesh (2000) included previous studies and provided a further understanding of the determinants of PU and PEOU; Venkatesh et al. (2003) formulated the Unified Theory of Acceptance and Use of Technology (UTAUT), a unified model that integrates elements across eight user acceptance models; Connelly (2007) presented The Persuasive Technology Acceptance Model (PTAM), an extension to TAM which is directly related to the topic at hand, virtual coaching tools; finally, Chen and Chan (2014) proposed the Senior Technology Acceptance Model (STAM) which aims to study user acceptance of gerontechnology.

However, only few studies exploring TAM concerned virtual coaching systems, in particular those for adopting healthy behaviours by older adults. Social influence appears to be a recurrent external variable in the adoption of new health-related technologies, especially by older adults, because users tend to rely on others' opinion such as family or healthcare professionals due to lack of knowledge about the system. Trust and data privacy related to the use of the system are also relevant concerns of the elderly population when approaching a new IT system; seniors are afraid to share their health data on digital devices. However, there is plenty of room for exploring many other variables based on the abilities, needs and preferences of target users that could better predict and explain user acceptance of virtual coaching systems for Healthy Ageing, as it is still an emerging health-related technological solution.

Research model and hypotheses

This study develops and empirically tests a theoretical extension of the Technology Acceptance Model (TAM) as a model of user acceptance of a virtual coaching system for Healthy Ageing. In order to improve the model, TAM2 and HBM were used as the anchor of the proposed model.

Given that mobile health technologies' adoption is also considered as health behaviour, only taking into account TAM constructs, which are based on the acceptance of computing tools for improving job performance, seemed to be inadequate to have an integrated perspective of users' acceptance of a health-related technology. With this purpose, some constructs presented in the Health Belief Model (HBM) were incorporated in order to address factors that make users adopt long-term health-promoting behaviours. Self-efficacy was designed to address both healthcare and technological domains. External cues to action were addressed as social influence; we used TAM2 to incorporate the constructs that represent such effect. Lastly, as the target population is the elderly, users' self-worth and engagement with life are key aspects that should be considered because they play a key role in people's behavior and activity during the late adulthood. Therefore, the proposed model incorporates six additional theoretical constructs that assess social influence (Subjective norm and Image), users' self-efficacy (IT Literacy and Health Literacy) and engagement to life (Empowerment and Attitude to Life) in order to better explain user intention to use a coaching system in

older adulthood. In addition, their impact on users' willingness to pay has been analyzed too; such construct was added as a consequential behavior of the TAM model.

Given that the system is in its early stage of development, potential users are not familiar with this type of technology and do not have hands-on experience using it; thus the Perceived Ease of Use of NESTORE could not be assessed. For this reason, Perceived Ease of Use construct has been replaced by IT Literacy (ITL) in the model due to two main reasons: users mainly rely on their own technology self-efficacy when evaluating the effort required in order to learn how to use a new technology; and the nature of NESTORE as the bundle of different technologies.

The basic TAM relationships between key constructs were assumed in the proposed model. These include the direct positive effect of PU and PEOU on Intention to Use and the positive influence of PEOU on PU. Particularly with regard to IT Literacy acting as the substitute for PEOU, it is related to the fact that IT knowledge and usage skilfulness is still considerably less in adulthood than among younger citizens. Many older adults are unfamiliar with new technologies and find difficulties in learning and using them, which may cause their rejection. In this vein, an easy-to-use system is normally understood as a system that has certain features and standards similar to those of familiar systems. Moreover, intuitive or easy-to-use systems allow users to perceive them as more effective because they easily make use of their full potential.

Health Literacy (HL) is defined as the ability to make sound decisions concerning health in everyday life. It has been assumed that individuals with high levels of Health Literacy would have a higher perception of the benefits of new health-related technologies, such as a virtual coaching system for healthy ageing. Moreover, Empowerment (E) refers to the active involvement in the attainment of health goals and taking care of individual well-being enhancing self-care behaviours and acquiring knowledge in order to increase control over the factors, decisions and actions that affect their health. Thus, it is expected that people that have high levels of health empowerment will easily perceive the benefits coming from an e-coaching system for healthy ageing than those that are not used to controlling the factors that affect their health. Also, according to the definition of health empowerment, we assume that empowered people will have higher health literacy levels as they will be constantly increasing their knowledge to manage their health effectively.

Besides that, Attitude to Life (ATL) represents users' satisfaction with life and individual self-worth. Both characteristics are related to the motivation to be active, have good health and learn about new things such as new advances in technology. Older people that have a positive attitude towards life are expected to have a higher IT Literacy as there is higher likelihood that those people generally put more effort to learn about new technologies. At the same time, using technology makes older people increase their perception of self-efficacy and, in this way, they tend to attribute additional gains to the use of the system perceiving it as more useful than those with a more negative sense of life. In addition, as a positive attitude to life leads to more active

lifestyles and to care about individual health, users that are engaged with life will tend to be more empowered people.

Subjective norm (SN) refers to the fact that people may decide to use the system if they believe that one of their referential or reliable person thinks they should. Also, users may perceive the system as more useful if there are people around him or her judge positively the use of such technology. Meanwhile, Image (I) is related to the utility derived from a product's ability to enhance social status within a social group. The increased power and influence resulting from the use of the system increases the Perceived Usefulness of it.

Willingness to pay (WTP) is assumed to be determined by Intention to Use, Image and Subjective norm. These relationships correspond with buyers' perceived value of a product that derives from its functional and social utility.

Control variables were included to increase the explanatory power: gender, age, education, residence, form of cohabitation and having any kind of chronic disease that affects everyday life. The intention to use the system is expected to be greater among the youngest masculine segments of the target population due to their higher interest in new technologies and because of having less age-related limitations. Moreover, those that live without any kind of support will be more likely to be interested in using a virtual coaching system to maintain their independence in the long term. The intention to use an innovative intervention such as NESTORE is expected to be higher in large cities, where highly educated people concentrate. It is also assumed that target users with chronic diseases, who are more aware of their health condition and need constant health care, will have higher intention to use the system because of related convenience.

Methodology

In order to test the hypotheses, a self-administered, non-experimental, cross-sectional and explanatory online survey was created in order to collect first-hand opinions from the potential users of the service. Also, through the questionnaire, it has been attempted to further explore the target population and its possible customer journey by collecting demographic and behavioural information about the users. The results obtained will complement the data collected through the desk analysis which has been done in previous studies.

The nine constructs in the theoretical model were measured with a total of 39 items. Most of the measurement scales and items adopted have been widely used and validated previously. Therefore, prior to developing measurement instruments, an extensive literature review was conducted in order to find such scales in extant studies which were then evaluated in terms of their validity and reliability through Exploratory Factor Analysis, particularly Principal Component Analysis (PCA), and Cronbach's alpha.

The survey was conducted between December 2018 and February 2019 through the online survey tool *Survey Monkey*. Online participants were reached with the help of

Spanish associations such as *Sociedad Española de Cirugía Ortopédica y Traumatología* (SECOT) and *Fundació Salut i Envelliment*; and Third Age Universities such as Comillas Pontifical University (ICADE) and University of Navarra.

Results

We obtained 251 responses with a 75% of completion rate. However, after conducting data screening and validity checks only 196 responses were used for the data analysis. The research model was transferred into a structural equation model (SEM) to analyse the causal relationships between the constructs. The SEM Builder of STATA 14 was used for this purpose. The level of significance was set at 0.05.

The results show that the model has a good fit as the five indicators that were considered largely comply with the prescribed acceptable ranges: the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), the Root Mean Square Error of Approximation (RMSEA) and the Standardized Root Mean Residual (SRMR).

The research model explains 66% of variance of the intention to use NESTORE and 62% for willingness to pay for NESTORE. The coefficient of determination is 0.99, which confirms that the model explains to a great extent the overall variance. The measurement model construct validity was verified with the computation of Confirmatory Factor Analysis (CFA), composite reliability (CR) and average variance extracted (AVE). Results obtained from the path analysis present direct and indirect effects supporting most of the hypotheses that were raised; except for the direct positive effect of ATL and E on PU. Contrary to expectations, higher health literacy did not have a positive effect on the perceived usefulness of the system. Instead, it can subtly influence the user's perceived usefulness by decreasing it. None of the demographic variables had any significant influence on intention to use except age.

Additionally, a qualitative analysis of the survey data was conducted. It can be argued that the sample population is not completely satisfied with its own weight and would potentially be more inclined towards solutions to keep or lose weight; namely those related to physical activity and nutrition domains. In this sense, elders seem to care about their physical wellbeing first. Cognitive ability is the second concern in the ageing process while nutrition seems to be their third main interest. However, a significant proportion of respondents stated to not monitor their physical activity or their nutrition, but to play memory games. Therefore, there is need to promote an active approach among seniors; thus, it denotes an opportunity for the diffusion and success of a virtual coaching system for Healthy Ageing.

Senior adults rely especially on their general practitioner and mass media in order to obtain information about healthy lifestyles and disease prevention. Family and friends result to be their alternative sources of information. Among them, health care professionals are considered the most reliable source followed by family and friends. Surprisingly, even though people typically rely on mass media such as radio and television to find information, it is not considered reliable at all.

The adoption of health-related technologies is still very low among seniors. Few of the respondents are familiar with the concept and benefits of coaching and just over a third of them declared to have used an application to control or to support their lifestyle. Among those only about half of them still use it because the other half did not perceive the intervention as useful as they thought or found out that its functionalities were too trivial. The first week of usage of an intervention results to be the most important period to engage the user; generally he or she decides to stop using it within that time span.

Half respondents consider that the best way to acquire the product would be through the Statutory National Health System (SNS), while a considerable percentage considers that health insurances, which are voluntary and supplementary to the SNS, should provide it. The system distribution was contemplated to be done in pharmacies, medical stores or directly sent by the Health System to citizens. Most potential consumers seem to not be willing to pay much for their wearable devices but for the service of the system.

Theoretical and managerial contribution

This work can be considered as additional evidence of proving the usefulness of the extended TAM in the healthcare field. IT Literacy, acting as the substitute for Perceived Ease of Use, has been found to positive influence the intention to use a virtual coaching system for Healthy Ageing as well as its Perceived Usefulness.

Moreover, this research provides additional contribution in the field of virtual coaching for Healthy Ageing. This type of technology is only weakly known and there are not many studies examining the factors that determine its adoption among the elderly population. Given that the system would impact in everyday life and particularly on our overall health, this study highlights the importance of considering factors aside from the technology's high-tech features. User acceptance of virtual coaching tools for Healthy Ageing should account for individual attributes of the target population, thus age-related health and ability constructs. In this vein, HBM together with TAM was verified to be applicable in explaining users' engagement in long-term health-promoting behaviours. Besides that, developers of virtual coaching systems should design awareness-raising, targeted practical interventions and educational courses to increase awareness of the existence and benefits of virtual coaching.

With regard to the negative effect of Health Literacy on Perceived Usefulness, it could be explained by the fact that people with high levels of health literacy have developed their own strategies and facilities for managing their health. These users may try to avoid the additional investment of changing their daily routine and could devalue the usefulness of an e-coaching system by considering its functionalities to be trivial or not sufficiently effective to contribute to their health goals.

It is worth noting the significant influence of Image on both Perceived Usefulness and Willingness to pay. Potential users' decision to use and buy a virtual coach for Healthy Ageing may not be fully grounded on the system's primary function of promoting health but on fashionable trends. Communication campaigns should be developed in

order to raise the prestige associated with system use. According to the survey results, mass media would be the appropriate channel to deliver them.

According to results, marketing strategies should target the younger segment of older adults with low levels of health literacy Developers should contact medical practitioners and design the business strategy taking into account their major role as first and most reliable source of information about healthy behaviours among the elderly population.

Consideration should also be given to policy implications, in particular ethical issues. The system should avoid discrimination in favour of older adults with higher technological education and income than the average Spanish older adult. In this sense, the system should be universal, that is, inclusive and with an egalitarian approach.

Limitation and future research

Demographic characteristics of participants could pose challenges to generalize the results to the whole Spanish population. Participants were, to a great extent, younger than 80 years old and men vastly outnumbered women. Also, the sample represents largely older adults with higher education and income than the average Spanish older adult. Besides, the questionnaire was required to be filled in online, which restricts respondents to older adults that already have a greater tendency to use technology than the average older adult. Future research should encompass a larger randomized sample by collecting responses using paper format questionnaires and apart from the online survey to obtain information from people with low levels of IT Literacy or with functional limitations that make them unable to complete a survey in digital format.

Another limitation of the current research has been the limited knowledge about the technology studied and, in particular, about the existence of health interventions for healthy ageing based on a virtual coach. For this reason, answers about the system perceived usefulness and intention to use could not fully reflect respondents 'perception of the real system, which were based on a definition provided in the questionnaire.

In the long term, a longitudinal research should be conducted to analyze the effect of "experience" on the model. Some constructs that influence over the intention to use a coaching system for Healthy Ageing might not be considered. It could also be of interest studying the effect of Trust, Result Demonstrability and Resistance to Change, among other variables.

1. Investigation area

This study arises in the context of the NESTORE project, which is part of the European Union's Horizon 2020 research and innovation programme. Its aim is to tackle the social and demographic challenge faced by most EU countries, the rapid ageing of their population, by developing and testing an innovative personalized coaching system to help the elderly population live longer in good mental and physical autonomy. In this way, it aims to sustain our society, as well as our sanitary systems.

In the scope of digital solutions for healthy ageing promotion, traditional coaching by human coaches such as physical therapists and clinicians can be quite expensive and only possible at infrequent and often random moments. By using a virtual companion, most individuals would benefit from opportunistic coaching, interventions that occur at the time and place when it is needed instead of when possible. Also, digitisation means that coaching can be made scalable; a digital coaching application, once it is developed, can be replicated at virtually zero cost.

Thus, this age-friendly and innovative systems can be considered as part of the Silver Economy, defined by the European Commission as ''all types of goods and services for older adults and an ageing population, including extending the working life, volunteerism, and active citizenship of older people''. It supports people with self-care or self-management by providing tailored advices, with the expectation that such assistance will increase the extent to which people can be self-reliant (Kamphorst, 2017). The potential target population of the project is characterized by two main attributes: older adults aged 60+ that have good health condition, which also includes people with mild chronic conditions.

However, it should be taken into account that no suitable or effective solution will have any impact or effect if it is not used. Currently, the adoption of virtual coaching systems among adults aged 60 or over is still challenging (Carroll et al. 2017). A systematic literature review on technology acceptance in older adults found that concerns regarding the technology, expected benefits of the technology, alternatives to technology, and social influence are important considerations for the elderly population (Peek et al., 2014). Mobile health (mHealth) technologies must represent a clear benefit to them and fit with their goals, expectations, and lifestyles. Independence, understanding, and visibility were identified as facilitators to adopt such technologies whilst complexity, limited usability, and ineffectiveness as barriers (Kruse, Mileski, & Moreno, 2016). Little evidence is provided through specific studies on the intention to use a virtual coaching system in the health domain, and even less for the ageing population. Besides, many of them concentrate on devices for critical disease management (Cajita et al., 2017).

Given that the intervention belongs to the healthcare domain, the adoption of such system should be also considered as long-term health-promoting behaviour and not only as the adoption of a new technology. In addition to this, only a few existing systems have been developed based on the needs and preferences of the ageing population. In

addition, acceptance, usability, feasibility and validity of such systems for the ageing population are not well documented.

The EU Countries in which NESTORE will be developed are: Italy (pilot site), Spain (pilot site), the Netherlands (pilot), Austria, Finland, Estonia, France, Germany, and United Kingdom. A desk-based analysis has been conducted for each country in order to define the actual ecosystem where NESTORE system is going to be developed, to provide insights on the number of potential users and their profiles.

In order to supplement the information collected with the desk analysis, an empirical research was conducted to further study the Italian market, which was selected as the first pilot site in which to test the system. A survey was distributed in 2018 with the aid of Grey Panthers, an Italian web-based news outlet that has been active since 2008 on healthy ageing issues. They collaborated in the finalization of the questionnaire and its dissemination. As a result of the study, a theoretical model about the intention to use NESTORE was developed.

In order to improve the proposed theoretical model and create a more comprehensive questionnaire, the present study was intended on the basis of the Spanish market, which is the second pilot site of the system. In this way, the new and enhanced questionnaire will be distributed in every target country and results obtained will be able to be compared. Through the model, motivators that lead potential users to adopt the system will be determined and, similarly, different contextual features such as the culture and the type of sanitary system of every EU countries will be highlighted in the results.

1.1. Research objective

Given the limited evidences on the topic, the current study aims at exploring the factors influencing the intention to use NESTORE, a virtual coaching device for well-being and healthy ageing purposes. The system is under development and, thus, potential users do not have direct experience using it. The Technology Acceptance Model (TAM) proposed by Fred Davis (1989), which takes Perceived Usefulness and Perceived Ease of Use as proximal antecedents of the intention to use a technology, together with the TAM2 and HBM have been taken as the anchor for the theoretical model proposed in the current study.

The present work aims at developing and testing an extension of the TAM, by investigating the role of users' cognition (Health Literacy and IT Literacy); social environment (Subjective norm and Image); and engagement with life (Attitude to Life and Empowerment) on the intention to use a virtual coach for healthy ageing.

In that connection, cognition is related to users' self-efficacy in both the technological and sanitary fields. In this vein, it has been taken into account that even though the digital divide that runs between those aged 55 or older and the younger generations has been decreasing over the years, the Internet use is still considerably less in adulthood than among younger citizens. Many older adults are unfamiliar with new technologies

and find many difficulties in learning and using them which may cause their rejection. For this reason, the influence of age-related limitations in accepting a new technological system has been examined. Moreover, it has been analysed the influence of having different levels of Health Literacy, intended as the ability to make sound decisions concerning health in everyday life. Based on previous studies, it has been assumed that there is a relationship between Health Literacy and the adoption of healthy behaviours, and thus, it should be studied.

With regard to social environment, both Subjective norm and Image are examined as important influencers on the intention to use. Subjective norm refers to the influence coming from people around the user that may lead him or her to adopt the system even if they are not themselves favourable toward using it. This could happen because those people are seen as important referents or because the use of the technology is judged positively. Meanwhile, Image is related to the utility derived from a product's ability to enhance social status within a social group.

Lastly, engagement to life encompasses Empowerment and Attitude to Life. Empowerment implies an active involvement in the attainment of health goals and the caring of individual well-being. In this sense, it is considered relevant when it comes to determining the intention to use a virtual coach for adopting healthy behaviours. Besides that, Attitude to Life represents users' satisfaction with life and individual self-worth. User's willingness to be active may lead the individual to be willing to have good health and learn about new things such as new advances in technology.

Therefore, the main purpose of the present work is to identify the constructs or motivators that lead potential users to use and pay for a virtual coach to promote healthy ageing such as NESTORE; with which to create a sustainable business model for the product.

2. Contextual and theoretical background

This chapter aims to present the project NESTORE and the context of the present study. In this vein, it explains the problem of an ageing population in Europe, including its main causes. In the following sections the importance of having good health in older age and the approach of the World Health Organization (WHO) to develop and maintain the functional ability, which is known as Healthy Ageing, are explained.

Moreover, the need of a shift from treatment towards prevention of age-related diseases has resulted in the emergence of innovative solutions that enable the ageing generation to stay healthy and independent as long as possible. These health-related technologies are presented as part of mobile health (mHealth), which is an aspect of electronic health or eHealth that focuses on the delivery of health care services via mobile communication devices.

mHealth services such as smart phone apps and exercise platforms have been used to conduct behavioural change and help users, in particular older adults, achieve predefined health goals (improve diet, increase physical activity, change sedentary behaviours…). In this context, technological advances have given rise to virtual systems. These systems, also referred to as virtual coaches, are able to transform health goals into strategies and to deliver tailored advices and feedbacks to the user by leveraging on behaviour changing techniques.

Thus, the two last sections are conceived to present virtual coaching, behaviour changing techniques and its current state of the art in its development and applications. In addition, a comprehensive analysis of technology acceptance models that assess intention to use will follow in order to select the most suitable ones to be exploited in the empirical study.

2.1. NESTORE

The European H2020 project NESTORE (Novel Empowering Solutions and Technologies for Older people to Retain Everyday life activities) was funded with the aim of developing and testing an innovative personalised coaching system to support healthy ageing by providing people with guidance for longer healthy life years.

It consists of a multi-domain intervention for older adults in the form of a virtual companion that gives advice to help users maintain their well-being and their independence. It provides coaching in five crucial domains: physiological status, physical activity, social interaction, cognitive and emotional status and nutrition. As a coach, NESTORE proposes activities according to the user's personality, punctual needs, preferences and moods, taking into account environment, current situation and health status. Simultaneously it generates motivation to take care of one owns health and to preserve well-being.

By leveraging ICT social connectivity, the NESTORE system operates through tangible objects and sensors, as well as software and apps enabling monitoring and coaching.

The system is composed of a system of sensors able to monitor the different key parameters of the user to deliver advice and coaching by leveraging algorithms of decision support logic that make use of the sensor data and additional self-reported data. The companion is embodied in a smartphone or an intelligent tangible object such as a tablet and makes use of a *chatbot* (an artificial intelligence software that can simulate a conversation) to interact with the user. Unobtrusive wearable devices such as a smartwatch are worn by the user in order to collect real-time data and monitor daily activities to give feedback and offer a personalized service. Currently the system is under development and its final design has not been decided.

Figure 1: Graphic overview of NESTORE

The project consortium includes research institutes, universities and industry experts. It is composed of 16 partners from 8 European countries: Belgium, Italy, Netherlands, Romania, Spain, Switzerland, and United Kingdom. This H2020 project will run for three years with a total EU budget of € 4,977,000 under grant agreement No. 769643.

2.2. Population ageing in Europe

The European population is going through an ageing process caused by a simultaneous increase in life expectancy, a drop in fertility rates below replacement levels, and the ageing of post-war baby boomers. As a result, population growth is slowing down while

population ageing accelerates causing a deep demographic transformation in the age composition of European population.

The age composition of the European population is changing significantly. The most pronounced changes are predicted in the share of old-age and working-age groups of the population. The labor force, which includes people between 15 and 64, is expected to shrink by nearly 42 million over the next 50 years. This means a significant decline in the share of the working-age population from 67 % in 2010 to 56.2 % in 2060. Meanwhile, people aged 65 and over will almost double from 87.5 million (17.4 % of the total population in the EU-27) in 2010 to 152.6 million in 2060 (29.5 % of the population in the EU-27). There will be an intensive population ageing until 2030. However, this trend is expected to continue at a lower intensity until 2060. Moreover, it is also expected that the share of the oldest-old (aged 80 and more) will rise from 5 % to 12 %.

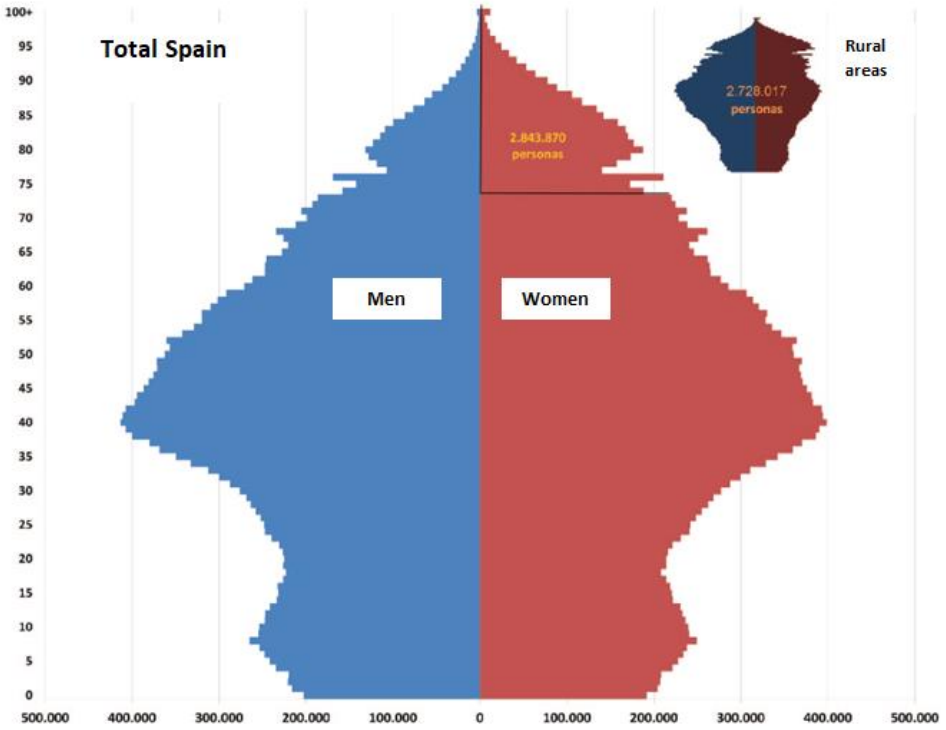
Currently, Germany (17.3 million), Italy (13.4 million), United Kingdom (11.7 million) and Spain (8.7 million) are the European countries with a higher number of older people according to data of 2016. In relative terms, Italy is the country with the highest proportion of old adults, 22% of the population belongs to this age-group.

Figure 2: Percent distribution of 65+ European populations. Europe, 2016 (Source: EUROSTAT. Elaboration: European Commission)

If we focus on Spain, in 2017 elder people aged 65 or older (8.764.204 inhabitants) accounted for the 18.8% of the Spanish population (46.572.132 inhabitants); however, the share is expected to increase in the future, according to the National Statistics Institute (INE). It is predicted that Spanish 65+ population will come to represent the

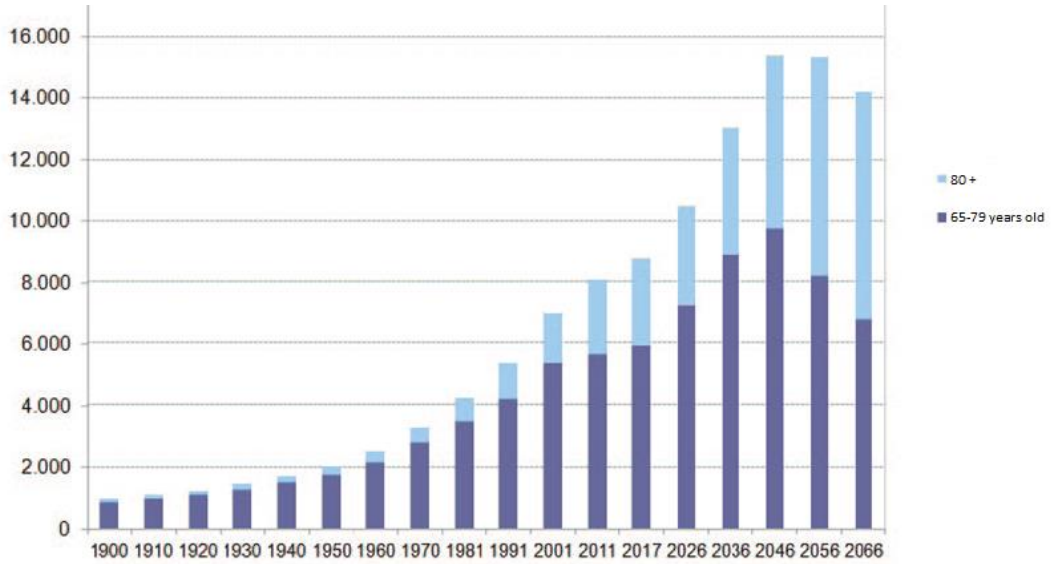
24.5% in 2029 and the 38.7% in 2064. As in Europe, it is also expected that the share of the oldest old (aged 80 and more) will rise gaining a substantial weight.

Figure 3: Spanish population pyramid and Spanish rural population pyramid, 2017 (Source: INE. Elaboration: Envejecimiento en Red)



Looking carefully at the population pyramid, it can be seen that there is a shortage in number of births that is caused by the Spanish Civil War (1936-1939), which is related to those aged 75 approximately. The following generations have led to a sharp demographic increase.

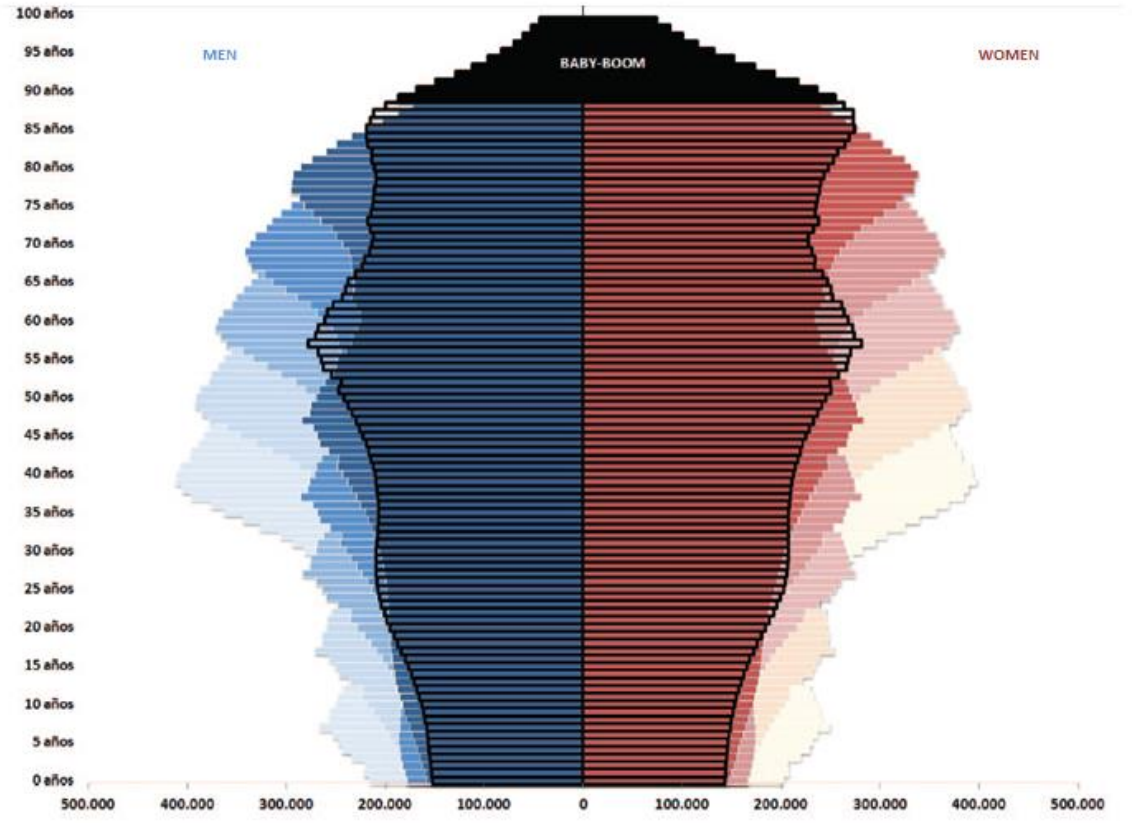
Figure 4: Population (in thousands) trends in Spain, 1900-2066 (* Real data from 1900 until 2017; forecasts from 2026 until 2066. Source: INE/ INEBASE. Elaboration: Envejecimiento en Red)



Post-war baby-boomers

The Spanish baby-boom took place between 1958 and 1977. During those years, around 14 million children were born. It is projected that the major increase in the elderly population will occur in the 30's and 40's decade with the arrival of the baby-boom generation retirement and ageing.

Figure 5: Population projection by age and gender, 2016-2066 (Source: INE. Elaboration: Envejecimiento en Red)



Life expectancy

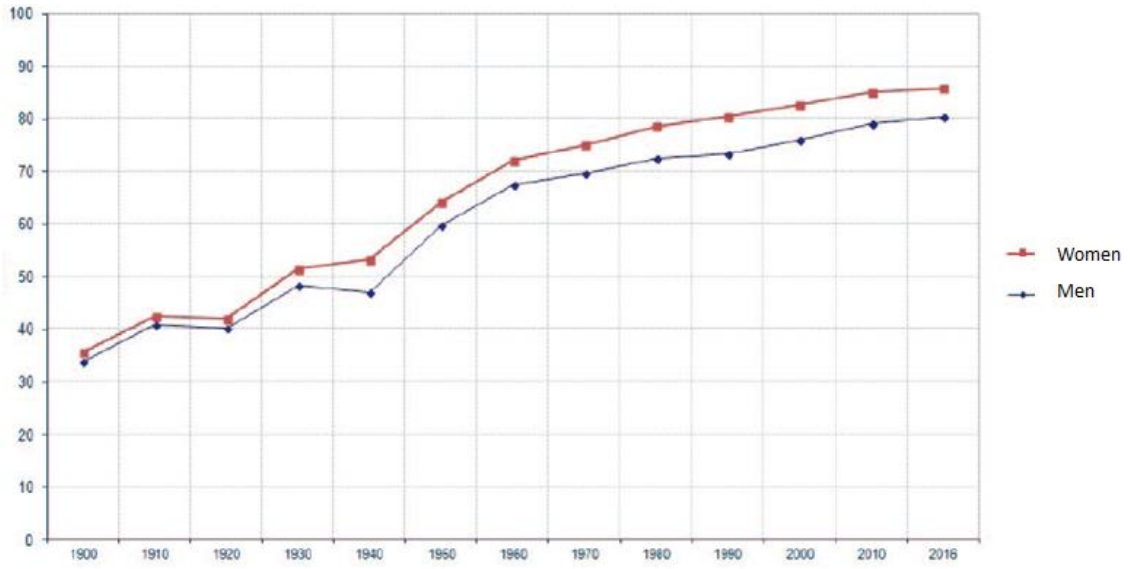
Life expectancy has increased significantly over the 20th Century. This has been caused thanks to a decrease of mortality, in particular at younger ages during childhood and childbirth, which is the reflection of the development and improvement of sanitary and economic conditions as well as lifestyles. This rise can be also seen in life expectancy of older adults which has been followed by demographic and social changes, particularly in developed countries, and the opportunity to maintain and extend quality of life during ageing.

Concerning life expectancy at birth in Spain, since 1908 it has increased by 38.9 years and 42.8 years for men and women, respectively. In relative terms, this change represents an increase in years of lifetime of 96.3% for men and 101.3% for women.

Nowadays, according to data published by INE in 2016, Spanish women life expectancy at birth stands at 85.5 years, whereas men's lifespan stands at 80.3 years. Spanish life

expectancy is among the highest in Europe and worldwide; additionally, it is expected to be growing continuously.

Figure 6: Life expectancy at birth by gender, 1900-2016 (Source: 1900-1998, INE. "Anuario estadístico de España 2004". 2000-2016. INE. "Tablas de mortalidad de la población de España". Elaboration: Envejecimiento en Red)



With regards to the elderly, men have extended by 80.7% their years of life and women by 106.8%. Henceforth, it is in the adulthood were the increase in life expectancy has been notorious.

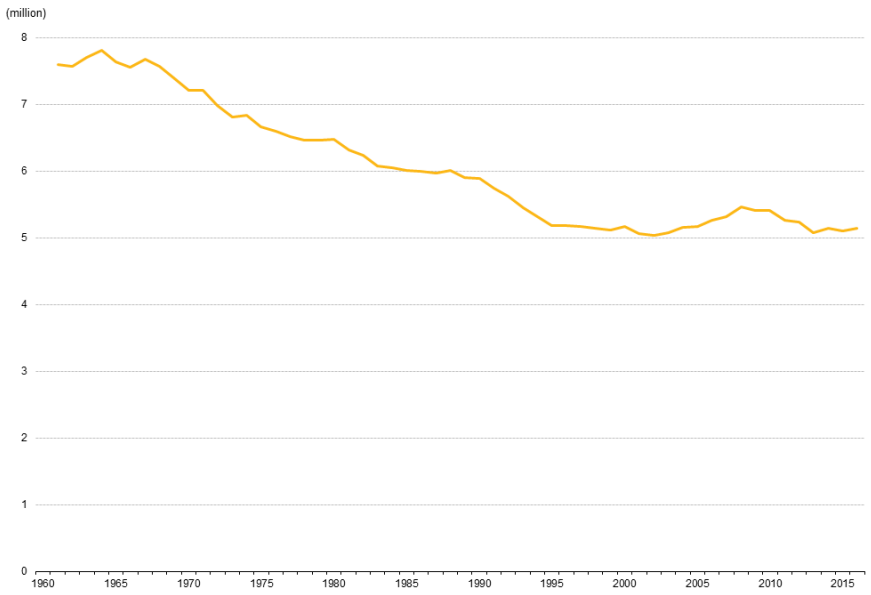
Figure 7: Life expectancy over 65 years old by gender, 1900-2016 (Source: 1900-1998, INE. "Anuario estadístico de España 2004". 2000-2016. INE. "Tablas de mortalidad de la población de España". Elaboration: Envejecimiento en Red)

Fertility rates

In the second half of the 20th century, fertility rates in many countries were more than 5 children births per woman. Over the last 50 years the global fertility rate has halved and globally the average woman has fewer than 2.5 children nowadays.

In Europe, the number of births has been steadily declining since the mid 60's. Since 2013, the number of live births has been kept almost constant (5.1 million live births) which explains the slowdown in the population growth.

Figure 8: Number of live births, EU-28, 1961-2016 (Source & Elaboration: EUROSTAT)



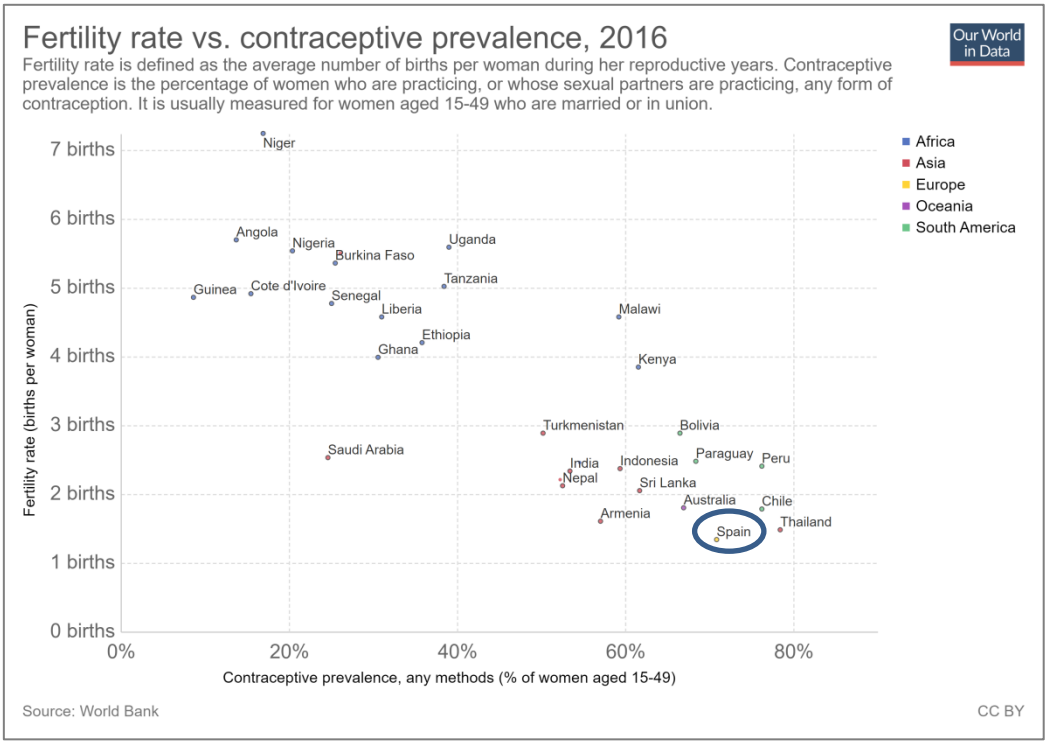
Among the EU Member States, the average children born for every woman are 1.55. In 2016, the lowest fertility rates were recorded in Spain and Italy: both recorded 1.34 live births per woman in childbearing age.

Currently, Spanish fertility rate has declined even more down to 1.27 live births per woman. The economic crisis has provoked the migration of a lot of Spaniards in search of jobs abroad. The result is that, since 2012, Spain's population has been shrinking (James Gallagher, 2018) (Ashifa Kassam, 2017).

The empowerment of women in society through education, labor force participation, and strengthened women's rights, the increased well-being and status of children, opportunities for family planning through greater access to contraception, fewer deaths in childhood and increased economic prosperity are the main reasons of the decline in fertility rate (Roser, 2017).

1. Empowerment of women: Increasing education is leading to a declining number of children per woman because having a child is considered a question of opportunity costs and education. Better educated women see a higher "price" they have to pay for having children. Moreover, the increasing labor force participation of women is a second aspect of women's rising empowerment in society. As women increasingly participate in the labor market their opportunity costs for having children are rising so that they seek to have fewer children. As women decide to have fewer children and are increasingly participating in the labor market they have yet more reason to have fewer children.

2. Family planning: All active efforts to choose actively the number of children a woman or a family wants. Use of contraceptives as well as counseling by experts reduces the gap between the desired and the actual number of children. Better education can increase the understanding and acceptance of contraceptive methods and the ability to use contraception effectively.



3. Infant mortality: In an environment with high child mortality women will give birth to more children than they want to ensure against the loss of children.

4. Increasing prosperity and structural transformation of the economy: Richer countries are healthier and better educated. "*New products and new lifestyles in the growing metropolitan societies created by the Industrial Revolution expanded choices. Wealthy families responded by consuming more of these new products and services instead of producing children.*"

2.3. Health at older ages

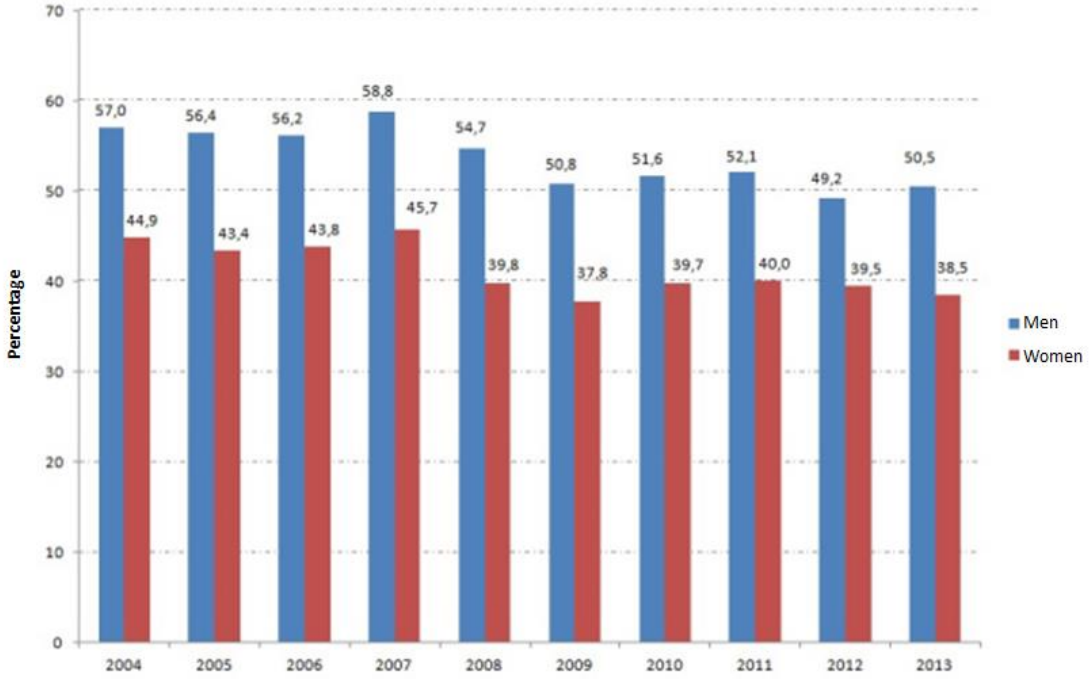
The increase in life expectancy allows individuals to live longer. However, there is evidence which reveals that the proportion of lifetime without disease or impairment has been decreasing, in particular among women (Gu, Gomez-Redondo, & Dupre, 2015).

If the added years of older age are lived in good health, population ageing would contribute to society in many ways as they would have few limits to accomplish everyday jobs. It has been shown that the prevalence of severe disability and functional

limitations among the elderly has been declining in wealthy countries over the recent decades. In general, most of the health problems of older age are the result of chronic diseases (World Health Organization, 2015). However, mental illness and nervous system illness have been increasing with respect to chronic and degenerative diseases (Gómez Redondo, García González, & Faus-Bertomeu, 2014).

Focusing on healthy years lived after becoming 65; the difference between men and women is noteworthy. Indeed, in this time-span the probability to be affected by health-related risks increases, as confirmed by the World Health Organization (WHO). Men live 52.3% of life years in good health whilst women only the 40.4%.

Figure 9: Life years lived in good health with respect to life expectancy at the age of 65 by gender, 2004-2013

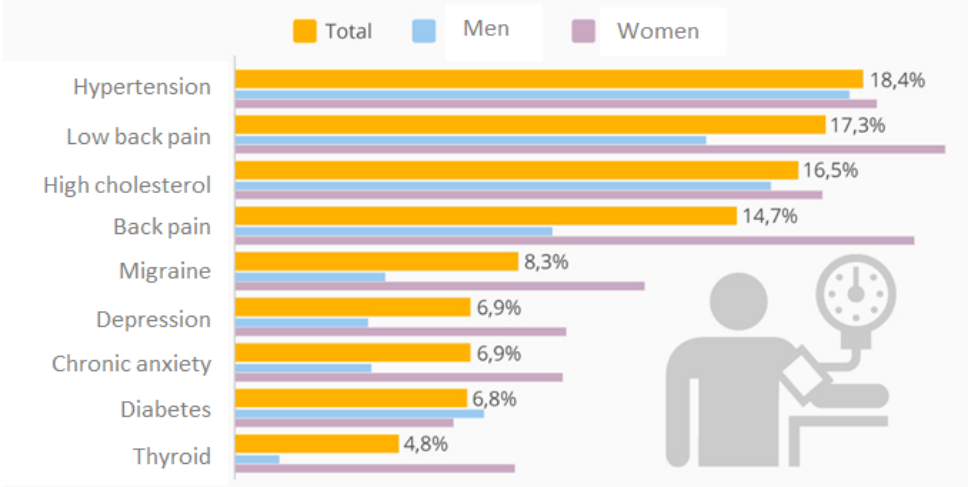


WHO, in its 2015 report on ageing and health, affirms that the dynamics of health in older age are random and complex since there is a noticeable diversity at an individual level. Physical and mental functionalities' changes can evolve in many different ways among individuals. Indeed, a disease can be easily controlled for one person while it may require multiple treatments for another. Moreover, physiological changes are strongly influenced by the environment (e.g. economic situation, attitudes, social norms) and behaviors adopted by the individual.

Multimorbidity, which is the risk of contracting more than one chronic disease at the same time, is more likely to occur in the adulthood. When this happens, it is very difficult to assess the individual effects on health of each disease due to the interaction between them that causes a greater impact than the sum of individual effects (Marengoni, et al., 2011).

The most common diseases that Spanish citizens suffer are hypertension in first place (18.4%), hypercholesterolemia (16.5%), low back pain (14.7%) followed by migraine, depression, chronic anxiety and diabetes (approximately 7% each of them).

Figure 10: Common diseases in Spain 2014, people over 15 years old (Source: INE, Ministerio de Sanidad, Servicios Sociales e Igualdad. Elaboration: Statista)



Obesity and diabetes are two important issues among the elderly. In fact, in Spain 52.7% of the adult population (18+) in 2014 was overweight. Both problems are more accentuated with age as sedentary lifestyles and inadequate diets increase the risk of developing diabetes. This fact is proved as three out of four 65+ year old that suffer from diabetes are overweight and have sedentary lifestyles.

Figure 11: Proportion of adults with obesity by sex and age in Spain, 2014 (Source: INE: European Health Interview Survey, 2014. Elaboration: CSIC)

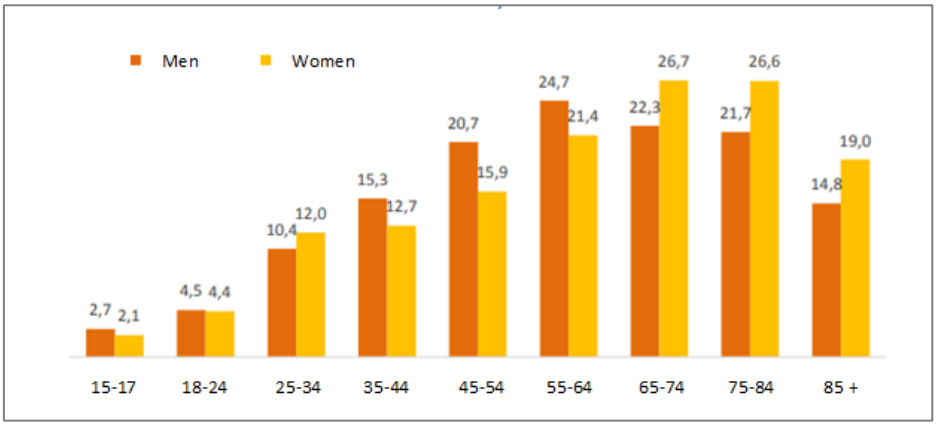
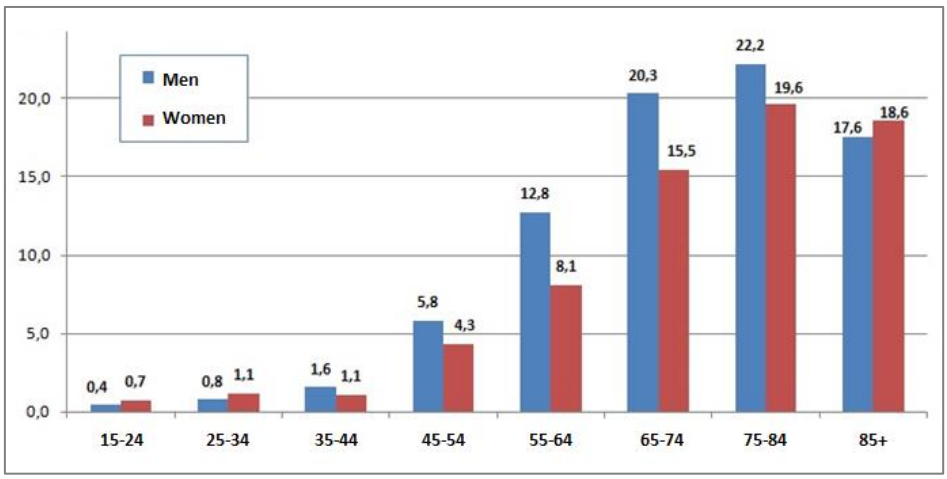


Figure 12: Percent distribution of Spanish citizens with diabetes by age and gender in 2014 (Source: INE/INEBASE. European Health Interview Survey, 2014. Elaboration: CSIC)



The promotion of healthy habits, better medical treatment and preventive measures, as well as improvements in education and living conditions, can delay or prevent these problems. Therefore, embracing healthy behaviours and a proactive approach to maintain a sufficiently good health condition over the entire lifetime, becomes fundamental. The Europe 2020 strategy for a smart, sustainable and inclusive growth emphasizes the need to promote a Healthy Ageing.

2.4. Healthy Ageing

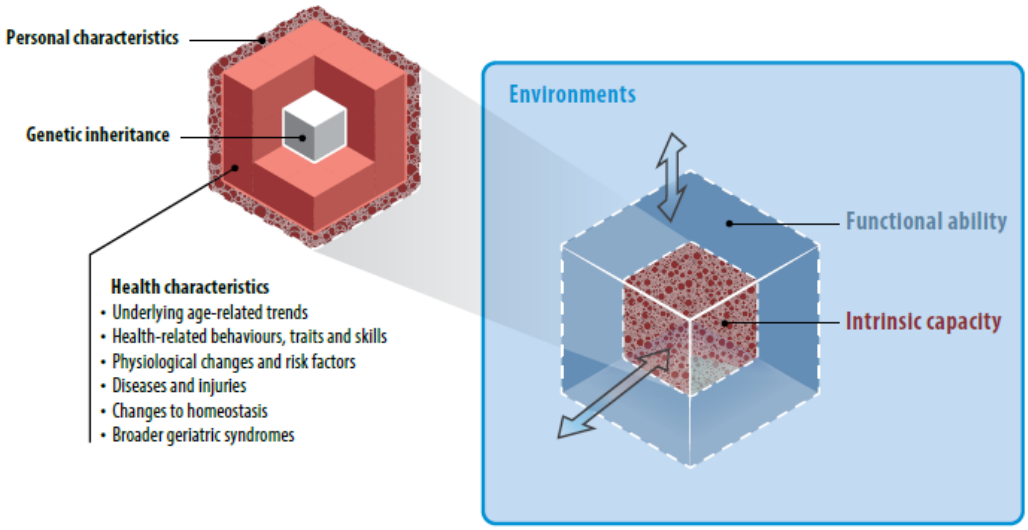
Healthy Ageing entails enabling people to be and do what they value throughout their lives. Healthy Ageing does not require a disease-free state; indeed, many older adults have one or more health conditions that, if well controlled, they have little influence on their wellbeing (WHO). Valuable state conditions differ among individuals and change throughout life (Carstensen, 2006). Things that older people identify as important include having a role in society, having social relationships, being independent, being able to make own decisions and feeling safe.

Healthy Ageing is defined as "the process of developing and maintaining the functional ability that enables wellbeing in older age"; according to the definition stated by the WHO in the World report on ageing and health in 2015. In this regard, the WHO has appointed the decade from 2020 to 2030 as the Decade of Healthy Ageing (WHO).

Functional ability refers to important health-related attributes for older people: the ability to meet basic needs, to learn, grow and make decisions, to be mobile, to build and maintain relationships and to contribute to society (WHO). As stated before, the main goal of Healthy Ageing is to preserve functional ability.

As explained in the WHO's World report on ageing and health, functional abilities are made up of the intrinsic capacity of the individual, environmental characteristics and the interaction between them.

Figure 13: Healthy Ageing components (Source: World Health Organization 2015)



Intrinsic capacity refers to the genetic inheritance, health and personal characteristics such as mental and physical capacities (e.g. ability to walk, think, see, hear and remember). These attributes can be affected by health characteristics such as physiological risk factors, diseases, injuries and age-related changes. Personal characteristics such as sex, ethnicity, occupation, educational attainment, gender or wealth also influence the intrinsic capacity.

Furthermore, *environments* include home (attitudes and values), community (people and their relationships) and broader society (health and social policies) in which individuals inhabit. Being able to live in environments that support and maintain the intrinsic capacity and functional ability is fundamental to Healthy Ageing.

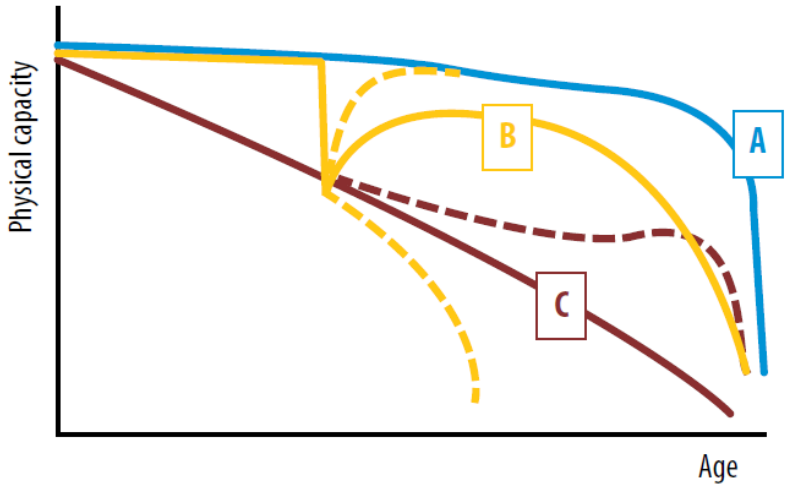
Older adults in good health could contribute to economic growth with their skills and experience by remaining as a resource to their families, communities and economies. In fact, 2012 was proclaimed the European Year for Active Ageing and Solidarity between Generations. Its main goal was inter alia to demonstrate how older people can contribute to the economy and society.

As a constructive response to population ageing, reforms of social protection systems, particularly pensions, health care and long term care arrangements should be conducted. These overhauls were postulated by the Stockholm European Council in 2001.

Trajectories of Healthy Ageing

Intrinsic capacity and functional ability follow different trajectories throughout life. They are the result of continuous interaction between individuals and the environments where they spend their life. There is not a common trajectory for every elder due to the complexity and diversity of the ageing process at an individual level (WHO, 2015).

Figure 14: Hypothetical trajectories of physical capacity (Source: World Health Organization 2015)

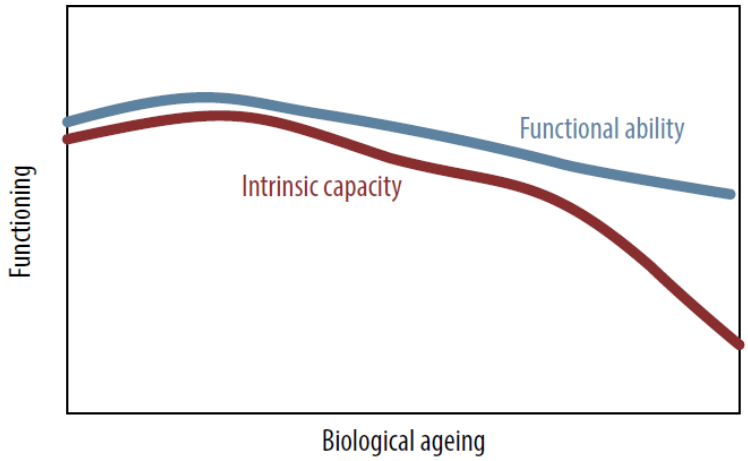


Taking physical capacity as an example, three hypothetical trajectories which could be related to three different individuals have been projected in Figure 14. All three trajectories begin in middle age and see the person die at around the same age.

However, each individual enjoys different levels of physical capacity in the following years of life. In stroke style, alternative trajectories for individuals B and C have also been reflected.

In trajectory A, intrinsic capacity remains high until the end of life; it represents the optimal trajectory. Ideally, everybody should experience the same physical capacity progression as this individual. In the case of individual B, the trajectory is similar to A until a point where there is a sharp decline followed by some rehabilitation and then a gradual deterioration. Alternative trajectories represent the possibility or lack of access to health services. Lastly, individual C suffers a continued decline in function. By adopting healthier behaviours or having access to medication this individual might be able improve his physical capacity resulting in a more positive trajectory.

Figure 15: Trajectories of functional ability and intrinsic capacity at a population level (Source: World Health Organization 2015)



In spite of diversity, general trends at a population level can be observed. However, even at a population level there could be significant differences in these average trajectories of intrinsic capacity.

It is worth noting that even if an individual's intrinsic capacity diminishes over time, the functional ability, which is the ability to do the things that matter to him, could be preserved to a large extent if the individual has access to additional functioning from a supportive environment. Thus, the environment could enable functional ability to be greater than might be possible through intrinsic capacity alone.

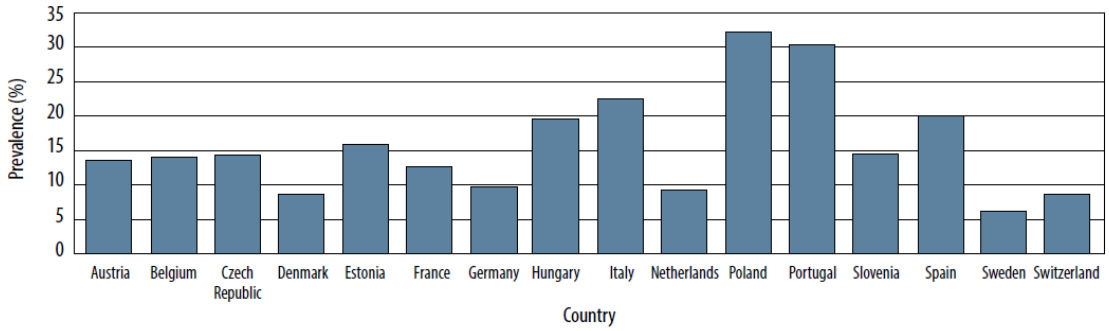
Key behaviours that influence Healthy Ageing

Embracing a healthy lifestyle can reduce or prevent contracting risk factors as well as delay and reduce the age-related diseases. Healthy behaviours focused on physical, social, and cognitive activities such as regular exercise and an adequate nutrition can help to maintain the intrinsic capacity and the autonomy, in particular in the adulthood. According to the World Health Organisation's (WHO) report on ageing and health, it is

recommended to develop strategies that engage people when they still have a high and relatively stable functional capacity.

For example, it is proven that inactivity is the fourth leading cause of death worldwide (Kohl, et al., 2012). There is a 50% reduction in the relative risk of developing functional limitations among those reporting regular physical activity as it affects mental and physical capacity (Paterson & Warburton, 2010; Tak et al., 2013). Regular exercise decreases the risk of adverse health conditions such as cardiovascular disease, diabetes or cancer and increases life expectancy (WHO, 2010). It is also associated with low self-esteem, anxiety, depression, and cognitive decline (Murtagh et al. 2015).

Figure 16: Age-adjusted prevalence of physical inactivity in people aged 60 years and older, by COUNTRY (Source: Survey of Health, Ageing and Retirement in Europe, 2013 (SHARE))



Despite the fact that, in general, it is widely known that unhealthy behaviours that could be avoided can result in harm to human health, their prevalence in many countries makes it necessary to foster health promotion. The proportion of the population meeting recommended levels falls with age. As an illustration, data analyses from SAGE and the WHO World Health Survey suggest that around one third of 70–79-year-olds and one half of people aged 80 years or older fail to meet basic WHO guidelines for physical activity in older age (World Health Organization, 2015). For the coming decades, there is a societal goal to maximise the number of people who experience positive trajectories of ageing explained above.

Furthermore, increasing life expectancy together with decreasing fertility rates is reducing the number of economically active persons per pensioner, putting more pressure on the health care system. Thus, a shift from treatment towards prevention of age-related diseases is needed. It is in this context in which the development of innovative solutions that enable the ageing generation to stay healthy and independent as long as possible emerges. Health-related technologies can support the individual to maintain the intrinsic capacity or delay its decline to stay independent longer and empower him to take care of his own health.

Unobtrusive technologies, like smartphones, are well suited for the delivery of interventions that provide anywhere real-time feedback to increase uptake of the intervention over time. In order to maximize the adoption of these technologies, tailored solutions to individual functional levels are needed.

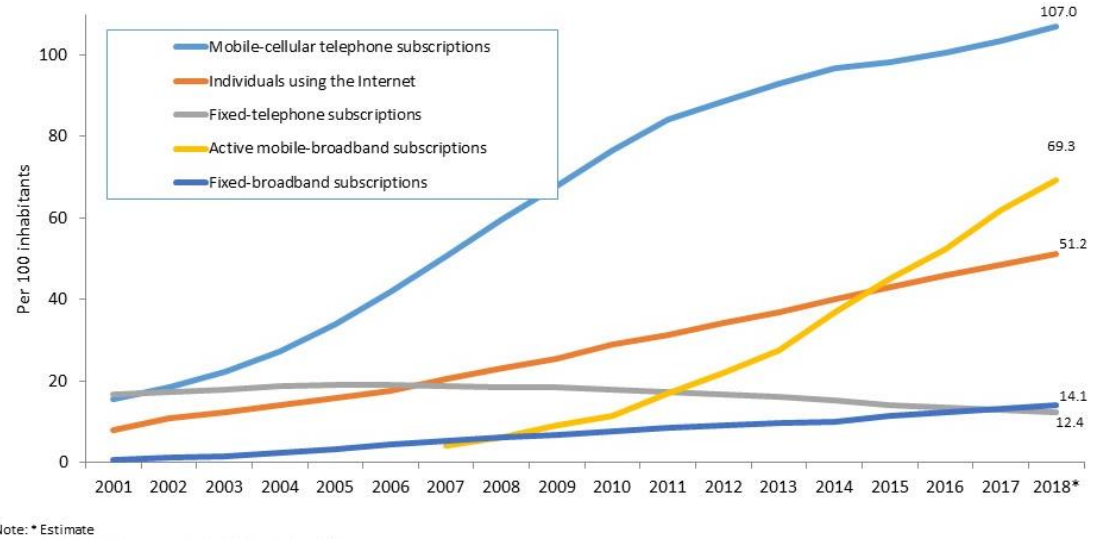
2.5. Mobile Health Technology and Services

Mobile health, or mHealth, is an aspect of electronic health or eHealth that focuses on the delivery of health care services via mobile communication devices (World Health Organization, 2011). According to the Global Observatory for eHealth, it is defined in the WHO mHealth report as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices".

mHealth is based on the use of mobile technology, such as smartphones and smartwatches, wireless devices and sensors that are intended to be worn, carried, or accessed by the person in their everyday life. Moreover, because of their portability, they can allow a continuous real-time monitoring and provide contextualized and personalized feedback in a ubiquitous way (Free et al., 2010; Terry, 2010). Mobile technologies act as two-way devices, creating and consuming information making them an ideal system for pervasive and supportive social computing (Helbostad J. , et al., 2017).

Health-related behaviours and habits in the form of information about physical, psychological, emotional, and environmental states can be derived and understood through algorithms that make use of the sensor data and additional self-reported data (Kumar, et al., 2013). In this way, it enables consumers to manage their health through cost-effective solutions (Noel et al., 2004). mHealth has been shown to improve the quality and coverage of care, increase access to health information, services and skills, as well as promote positive changes in health behaviours to adopt active and healthy ageing preventing age-related diseases and chronic conditions.

Figure 17: Global ICT developments, 2001-2018* (Source: ITU World Telecommunication/ICT indicators database)

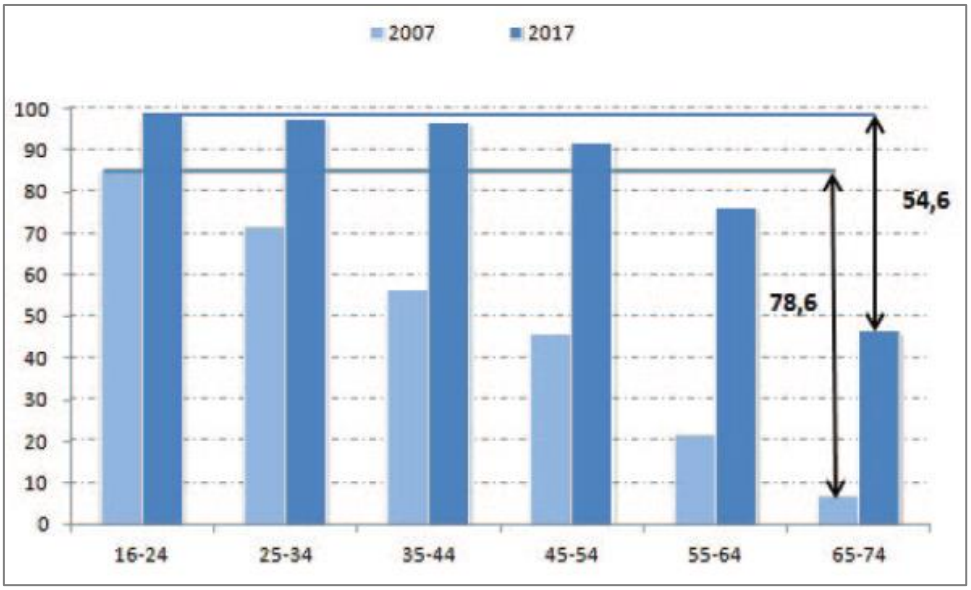


With ever-growing access to smart sensing systems and its wide acceptance, there is an enormous potential for the development of mHealth services (Kool et al. 2014). According to ITU, it was estimated that at the end of 2018 that 51.2% of the global

population was using the Internet. In developed countries, the percentage of population using the Internet has grown at a steady pace, from 51.3% in 2005 to 80.9% in 2018. Mobile access to basic telecommunication services is becoming ever more predominant. While fixed-telephone subscriptions continue to decline with a penetration rate of 12.4% in 2018, the number of mobile-cellular telephone subscriptions is greater than the global population (Albertini, M.; Gehner, M., 2018).

However, there is a digital divide which runs between those aged 55 or older and the younger generations. The Internet use is considerably less in adulthood than among younger citizens. Studies comparing young and older adults' use of smartphones conclude that there are five distinct human factors where older adults are different from their younger counterparts: learning time, speed of performance, error rate, retention over time, and subjective satisfaction (Holzinger & Searle, 2007). Among those who are 65-74 years old, men access the Internet to a greater extent than women. In 2007, 7 out of 100 elders used to access the Internet.

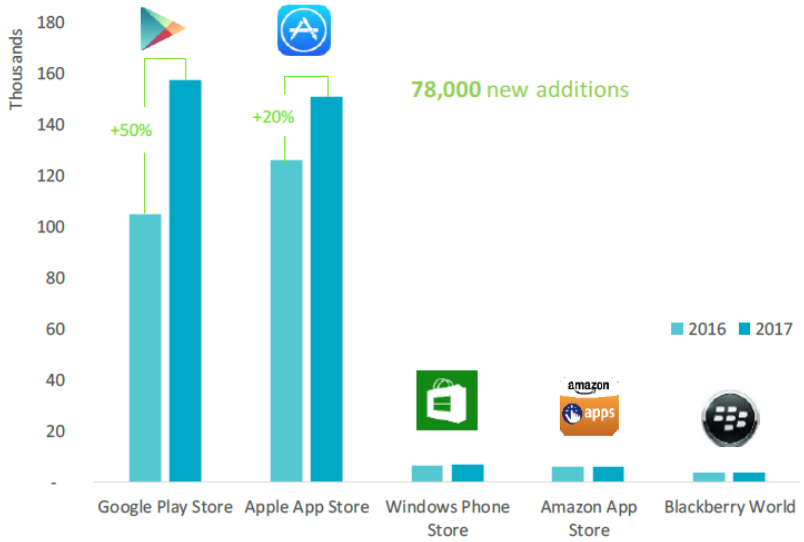
Figure 18: Percentage of people that have used the Internet in 2007 and in 2017 by age groups (Source: INE: "Encuesta sobre Equipamiento y Uso de Tecnologías de la Información y Comunicación en los hogares 2007 y 2017")



Nowadays, according to data collected in 2017, the figure is closer to 47 (Envejecimiento en Red, 2017). This increase in usage has been more pronounced among women. As depicted in the previous graph, the digital divide has been decreasing over the years, and many older adults are already familiar with technologies.

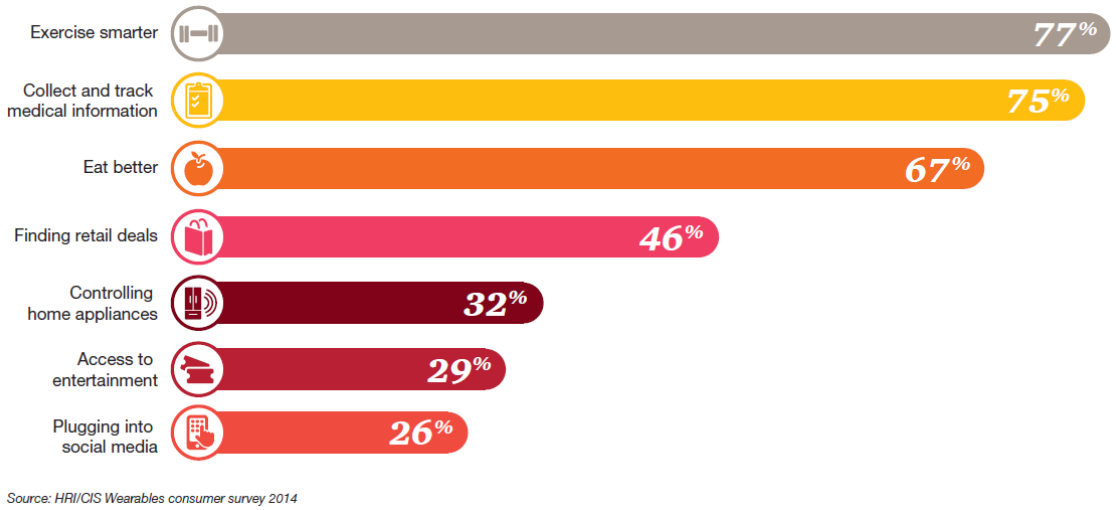
Within the framework of mHealth, the development and use of mobile health applications is rapidly growing. In 2017 there were 325,000 eHealth apps available in App Stores which equated to approximately 3.7 billion app downloads (Pohl, 2017).

Figure 19: Number of eHealth apps displayed in App Stores (Source: Research2Guidance -eHealth App Developer Economics study 2017)



With respect to smart wearable devices, many consumers believe wearables can dramatically improve their health, according to a national survey of US consumers conducted by PwC in 2014. However, consumers have not embraced health wearable technology in large numbers but they are interested. Their biggest hesitations are price, privacy and concern that they won't actually use it (Bothun, D.; Lieberman, M., 2016).

Figure 20: Preference in information received from wearable technology (Elaboration: PWC)



Source: HRI/CIS Wearables consumer survey 2014

However, there is still much to be done. It has been proved that a multiple-behavior intervention is relatively more effective compared to single-behavior interventions (Clark et al., 2002). Unfortunately, most applications are one-dimensional, meaning that they address one function only, such as physical activity applications. Besides, it has been proven that multi-component interventions are more effective than standalone app interventions (Krebs, Prochaska, & Rossi, 2010).

Furthermore, apps and other systems have not been strongly based on psychological theories of behaviour change making them unsuitable or less effective (Bort-Roig et al.,

2014; Webb et al., 2010). In this respect, a recent systematic review of the efficacy of interventions that use a variety of smart phone apps and exercise platforms to improve diet, physical activity and sedentary behaviour sustained with modest evidence the usability of app-based interventions (Schoeppe, et al., 2016).

Only a few existing systems have been developed based on the needs and preferences of the ageing population. Thus, acceptance, usability, feasibility and validity of such systems for the ageing population are not well documented.

Mobile Health Technologies for older adults

mHealth interventions can be divided into those aimed at disease management and those aimed at health behavioural change (Free, et al., 2013). Several mobile phone applications and mobile phone text message interventions within disease management have been developed and tested in clinical studies, such as diabetes control (Quinn et al., 2011), depression treatment (Bexelius et al., 2010; Van de Ven et al., 2012) and adherence to medication (Lester, et al., 2010).

Behavioural change interventions, which have been developed particularly for older people, allow changing the behaviour of individuals and help them to achieve predefined goals. They include smoking cessation (Free, et al., 2011), increase social interaction (Muñoz et al., 2015), reduction of calorie intake by use of personal digital assistant for diet and exercise (Burke et al., 2011; Boh et al., 2016), and mobile phone application interventions to increase physical activity levels (King et al., 2008; Klein et al., 2015). Additional technological advances have given rise to virtual systems. These systems, also referred to as virtual coaches, are able to transform them into strategies and to deliver tailored advices and feedbacks to the user by leveraging on behaviour changing techniques.

Indeed, the last version of smartphones and wearables incorporate sensors and functionalities like accelerometers, GPS, microphones and cameras that make them suitable means to deliver e-coaching solutions. Extant studies on the effectiveness of such systems show a sharp increase starting from 2005 (Orji and Moffatt 2016), demonstrating the growing interest of the academic world on this new topic.

Virtual coaching systems have been demonstrated to be a powerful instrument in motivating, stimulating and persuading users towards targeted behaviours, in particular in the Healthy Ageing domain (Hamari et al. 2014).

2.6. Virtual coaching

Due to the lack of a precise understanding of what constitutes an e-coaching system and how e-coaching systems differ from other types of behavior change interventions, it is difficult to provide a unique definition of virtual coaching (Kamphorst, 2017). There is need for a more precise description of e-coaching systems. To this end, it is important to first understand the concept of coaching which constitutes its founding pillar.

Unfortunately, there are many approaches to the concept of coaching. All of them are appropriable for different situations; with very little consensus about which one is the right one. Goal-oriented approach seems to be the most suitable definition. It is consistent with the concept of e-coaching, in which the system contributes in helping the individuals to use and exploit their resources in better achieving their goals. According to Grant (2006 p. 153), "coaching is essentially about helping individuals regulate and direct their interpersonal and intrapersonal resources to better attain their goals". The aim is to help the user to identify and form well-crafted goals used to develop an effective action plan. The role of the coach is to stimulate ideas and action and to ensure that the goals are consistent with the user's main life values or vision of his or her lifestyle, rather than working on helping the client to adjust her values and beliefs. In this conception, coaching is essentially about raising performance and supporting effective action.

Building on the results of two integrative literature reviews of diverse publications, it can be assumed that some features are common to the full range of coaching approaches.

According to Ives (2008), even if goal-oriented approaches differ on the role of the coach and on the objective of coaching, both share common features in the coaching process: it is based on a systematic process designed to facilitate change, whether cognitive, emotional or behavioural; it is intended for a non-clinical population; an individualized, tailor-made approach; aims to encourage users to assume charge of their life; it is based on awareness and responsibility; it involves a collaborative and egalitarian relationship, rather than one based on authority; it creates a relationship within which the user agrees to be responsible for the choices he makes; it is designed to access the inner resourcefulness of the client, and built on her wealth of knowledge, experience and intuition and it focuses on the achievement of a clear stated goal, rather than problem analysis.

On another note, in accordance with Ives' findings, Bartlett II et al. (2014) identify the following common features of coaching: creation and establishment of a collaborative relationship that supports individuals by establishing clearly defined goals and using a systematic process that is solution focused. Important components to the process are action plans, intervention strategies, communication (discussion, questioning, listening), and feedback. The desired result of an executive coaching engagement is for the learner to arrive at a point where self-reflection allows for self-evaluation and self-correction. Further, executive coaching benefits individual's performance and effectiveness. Executive coaching may result in behavior changes, enhance development, provide the learner with skills/tools primarily used for improving interpersonal relations, and facilitate continued learning.

To put it simply, Kamphorst (2017 p. 3) provided in his work a summary of the main features and defines narrowly the concept: "coaching is an ongoing process between two parties who have a collaborative relationship that focuses on creating opportunities

for improving self-understanding, increasing self-monitoring, and supporting people's plan-making in order to improve goal striving".

The information technology revolution has transformed the way in which people interact with the world and do everyday activities, including coaching. Virtual coaching or e-coaching has arisen as the result of the entrance of coaching into the digital world. As stated by Banos & Nugent (2018), this computing area uses intelligent systems, called e-coaches, that exhibit abilities similar to those of their human counterparts: sensing (observing, listening, questioning), learning (acquiring knowledge, understanding), actuating (reasoning, clarifying, advising) and predicting a user's behaviour to provide tailored and effective guidance to reach an individual's goal.

Virtual coaching has been defined in many ways. Without having achieved any consensus on a unique definition, some approaches of the concept and applications are presented below with the aim to create a global vision.

In 2002, Clark and colleagues (2002) developed the SENIOR project based on coaching calls. The e-coaching goal was to enhance and encourage motivation for change by assisting the individual in resolving ambivalence, and by matching the style and content of the call with the person's degree of readiness for change. Providing information and advice is generally avoided unless it is solicited by the individual.

Bickmore, Caruso, & Clough-Gorr (2005) designed a coaching system that was defined as "a relational agent that plays the role of an exercise adviser designed to be used by older adults to motivate them to walk more". They made use of a relational agent, a computational device designed to build long-term social-emotional relationships with users using simulated face-to-face conversations, in order to conduct an effective health behavior change.

An additional perspective is also provided by Fasola and Mataric (2012) that introduced virtual coaching as social agents that can interact, engage and motivate the user in his personal tasks.

Warner (2012, p.24) characterized e-coaching systems as pedagogical agents that provide "questions to coachees and responses based on coachees' entries or selections". Pedagogical agents are typically defined as having life-like animated interfaces whereas with e-coaching, it is perfectly possible to be coached solely by voice, text or through other interfaces. Moreover, Warner's specification of the system's level of sophistication is too broad to precisely identify a system as an e-coach.

In their work, Callejas and colleagues (2014) identify the virtual coaching system as a conversational agent that embodies a coach that has the main function to support the individual. The authors state that the agent could be developed as a mobile application coupled with sensors able to provide meaningful advices.

In connection with persuasive technology defined as "interactive computing systems designed to change people's attitudes and behaviors" by (Fogg, 2003), virtual coaching has been related to the concept as it involves the use of technology to persuade people in changing their behavior. For example, Lin and colleagues (2006) addressed virtual coaching as cost-efficient, personalized and computerized interventions that are delivered "just in time", whenever and wherever they can have the highest potential impact on decisions. These techniques incorporate persuasive computing techniques and represent ubiquitous ways to promote behavior change. In the same vein, Albaina and colleagues (2009) developed a persuasive virtual coach named Flowie. Oinas-Kukkonen and Harjumaa's (2009) persuasive system design (PSD) model describes such persuasive technologies that are expected to positively influence health behavior change De Oliveira and colleagues (2010) also developed a mobile persuasive social game, *MoviPill*, based on tailored persuasive technology to shift the focus from a human activity that we are not typically good at, to an activity that we tend to be good at and enjoy. In this way, personalized user motivation and engagement were the main pillars to change users' behaviour. The Dutch Rathenau Institute published an advisory report in which the notion of "e-coaching system" is understood as a system able to collect data, analyze it, determine a plan of actions while also give persuasive advices (Kool, Timmer, & Van Est, 2013). As with Warner, this last characterization is considered to be a very vague and nonspecific definition as it covers a wide variety of systems.

Consistent with the above, Klein and colleagues (2014) and Van Wissen (2014) characterized e-coaching systems as behaviour change support systems (BCSSs). This term was coined by Oinas-Kukkonen (2010, p.6) and defined as "an information system designed to form, alter or reinforce attitudes and behaviours". In later work, Oinas-Kukkonen (2013) affirmed that these systems focus on the positive experiences of users and seek to motivate and engage with them regularly over an extended period of time. To achieve this purpose, repeated interactions between the user and the BCSS are required; in this way, the outcome of the interaction (the user's behaviour) will directly affect the feedback that the system gives to the user.

Finally, Kamphorst (2017 p. 5) provides in his work a comprehensive definition of e-coaching stating that "an e-coaching system is a set of computerized components that constitutes an artificial entity that can observe, reason about, learn from and predict a user's behaviours, in context and over time, and that engages proactively in an ongoing collaborative conversation with the user in order to aid planning and promote effective goal striving through the use of persuasive techniques."

As can be noted from the above, in the last years the concept of virtual coaching as an instrument for behaviour change has become very popular. Many studies have focused on understanding their effectiveness for this purpose.

2.6.1. Main features and system structure

Bart A. Kamphorst (2017) proposed a set of features reflecting the minimum requirements to classify a behavior change system as an e-coaching system.

1. Social ability: establish and maintain a collaborative relationship between user and system.
2. Credibility: perceived by the user as having expertise and thus, being trustworthy.
3. Context-awareness: stimulate ideas and action according to the situation and the user's life values.
4. Learning abilities: build up and maintain a personalized relationship with the user (ask pertinent questions, give tailored feedback and offer personalized advice).
5. Measure and process different data streams: base its questions and recommendations on information collected by sensors, direct user input, but also measurements of physical activities, mood self-reports, sleeping patterns, etc.
6. Proactiveness: initiate interactions in with the aim of stimulating action or reflection whenever they can have the highest potential impact on decisions. The prediction of user behavior is vital.
7. Operate on a model of behavior change: adopt behavior change techniques in order to be successful in supporting behavior change as a coach.
8. Coaching planning: guide its user in a process of future-directed intention formation in order to support users in setting themselves up for behavior change success.

These requirements can be used as a checklist to integrate relevant coaching capabilities in systems under development or to determine them in already implemented systems. However, the relations among these requirements are not explicit.

According to Ochoa and Gutierrez, (2018), those features could be split into two major concerns: the system structure and its e-coaching mechanisms. In this way, the design of virtual coaching systems is easily executed by taking both affairs into account.

System structure

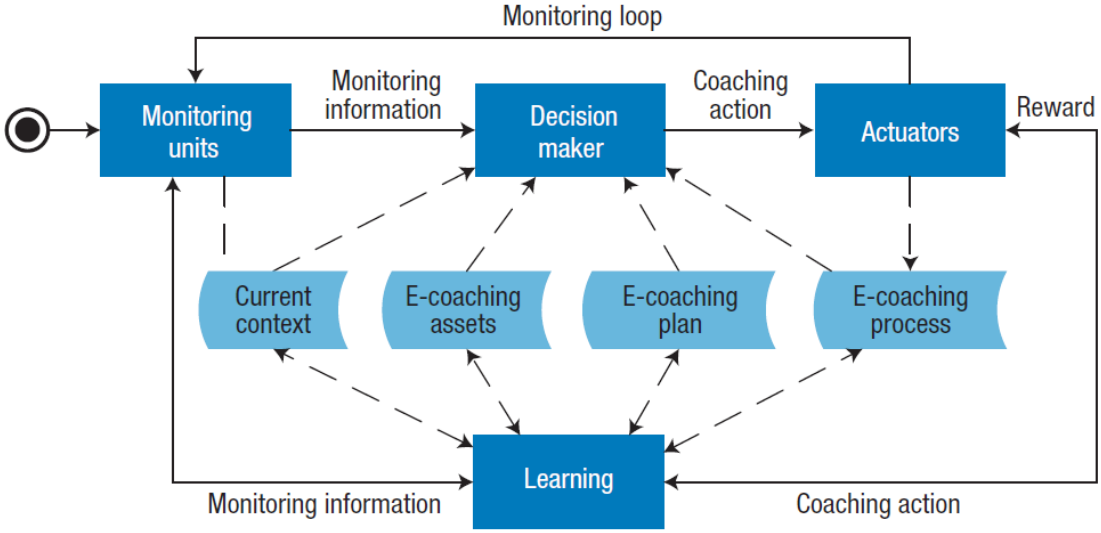
The system structure determines the set of features that these systems must necessarily have in order to conduct a coaching process, regardless of its purpose (e.g. context awareness, decision making, and self-adaptation). This structure organizes the system in terms of functional components and supporting data.

The four major activities of the e-coaching processes are monitoring, decision making, persuasion/awareness, and learning.

The monitoring unit controls context variables and events, and detects relevant changes in the current context. It informs both the decision maker and the learning unit. The

decision maker uses this input to determine whether an e-coaching action is required, when and how to persuade the user to do something or to make the user aware of a situation. It takes into consideration the available e-coaching assets and e-coaching rules to determine the most suitable action that will lead the user to achieve the final goals, which are established in the e-coaching plan. The actuator performs the coaching actions, which can be persuasive or reflective. Persuasive actions motivate behavior change using explicit actions, whereas reflective actions provide awareness information that can be accessed on demand by the user. The learning unit improves the knowledge available by estimating the impact of each coaching action and determining the need to trigger a new action if the action is ineffective. It also delivers intrinsic or extrinsic rewards with the aim of keeping the user engaged with the coaching process. The feedback obtained from each action is recorded in the e-coaching process which establishes the sequence of actions and rewards delivered to the user in the future.

Figure 21: Conceptual model of an e-coaching system (Source: Ochoa and Gutierrez, 2018).



E-Coaching mechanisms: Health Behaviour Models

According to Ochoa and Gutierrez (2018), the e-coaching mechanisms are focused on determining how to properly use the available resources to conduct the e-coaching process in an effective way, taking into account personal characteristics of the user and the coaching domain. In order to promote behavioural change, people need to keep motivated over time. This requires the use of behavioural change theories as the basis for delivering tailored motivation and feedback, particularly relevant to older adults. For that purpose, an e-coaching system must operate on an appropriate theoretic framework of behaviour change in order to transform the collected data into meaningful actions (Rhodes, Fishbein, & Reis, 1997).

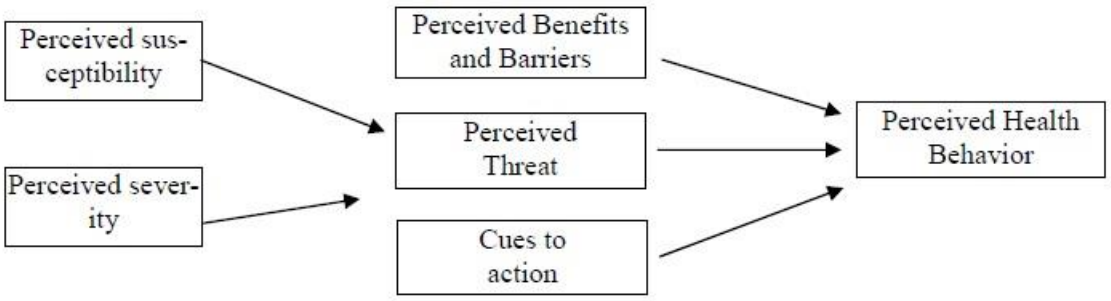
There are a variety of mechanisms that stand behind the functioning of virtual coaches which consist of psychological theories and techniques designed to support the user to change his behaviour and achieve the desired goal depending on the context (Cabrita et

al., 2018; Redding et al., 2000; Bort-Roig et al., 2014; Rabin & Bock, 2011). However, as stated by Yardley et al. (2016) there is little knowledge about the most effective behaviour change models to be implemented, long-term effectiveness of coaching interventions and long-term behaviour change adherence determinants. Besides that, Fanning et al. (2012) affirms that it is worth considering that much can be added to current theoretical models of behaviour change so that they are better suited to design mobile interventions and interpret results. Unfortunately, few studies have yet been conducted in which persuasive technology has been applied specifically at the elderly user group for Healthy Ageing.

Theories such as the health belief model (HBM), social-cognitive theory (SCT), the theory of reasoned action (TRA) and planned behaviour (TPB) focus on cognitive variables as part of behaviour change. Attitudes, beliefs, and expectations of future events and outcomes are major determinants of health related behaviour. Unlike the others, the transtheoretical model (TTM) is based on a stage perspective; people move through different stages of change on the basis of perceived advantages and disadvantages of behaviour (Prochaska & DiClemente, 1983). This section reviews different models of health behaviour change used or suitable for Healthy Ageing purpose as an overview, not an in-depth comparison.

The Health Belief Model, HBM (Rosenstock et al. 1966) is one of the oldest models used to inform behaviour change interventions. The original Health Belief Model included only four constructs: perceived susceptibility or vulnerability in developing the condition, perceived severity of the consequences of the condition, perceived benefits of reducing the threat of the condition, and perceived barriers for effectively preventing the condition. Cues to action refer to events or strategies that increase one's motivation. Subsequently, a number of other constructs were added to the model such as self-efficacy. Health behaviour change is viewed as the result of a rational assessment of the balance between the hurdles to and benefits of action.

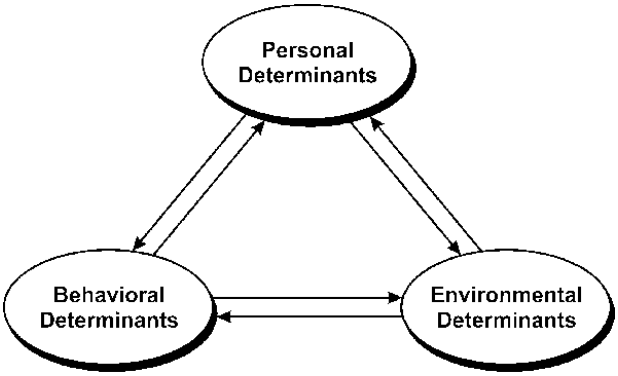
Figure 22: Health Belief Model, HBM (Rosenstock et al. 1966)



The Social Learning Theory or Social Cognitive Theory, SCT (Bandura A. , 1999) has been widely applied to health behavior with respect to prevention, health promotion, and modification of unhealthy lifestyles for many different risk behaviors. This theory states that expected outcomes based on knowledge of health risks and benefits of action are a prerequisite to change. Human capacities such as self-efficacy and self-regulation

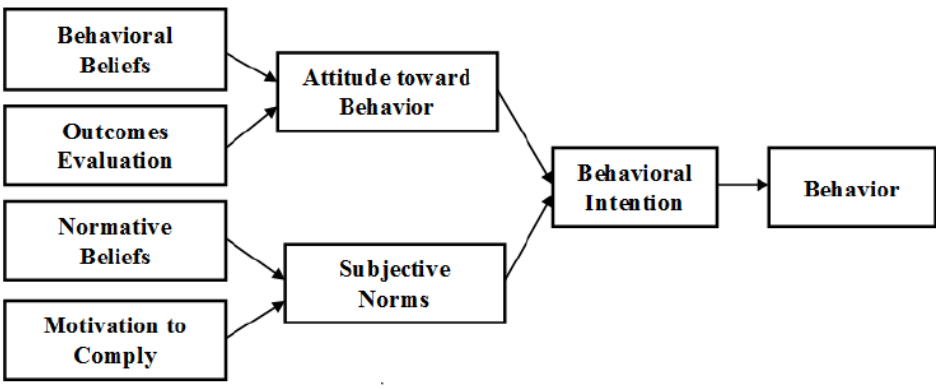
play a crucial role in triggering change (Bandura A., 2004). Self-efficacy is defined as the perception of the individual about his or her capability to perform the required task and to achieve the defined goals (Bandura, 1997) if the individual has low self-efficacy, he will not be willing to change the current behaviour. Other determinants of behaviour are perceived facilitators and barriers to conduct the change process. This theory proposes that behaviour change is accomplished if people perceive that they have control over the outcome, that they are capable to attain the defined goals and that there are few external barriers to execute the behaviour.

Figure 23: Social Cognitive Theory, SCT (Bandura 1999)



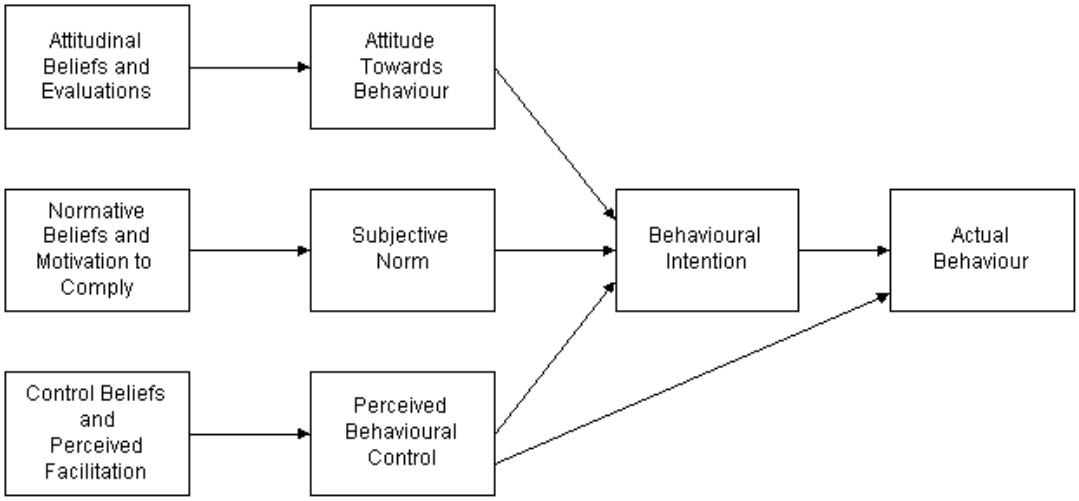
The theory of reasoned action, TRA (Fishbein & Ajzen, 1975) assumes that a person's intention to perform a particular behaviour is both the immediate determinant and the single best predictor of any behaviour under voluntary control (Sutton, 1997). Individual behavioural intention is determined by two key factors: attitude and subjective norm. Attitude includes the individual's positive or negative feelings and evaluations about consequences of performing the target behaviour whilst subjective norm represents individual perceptions of social pressures coming from others that are important to the person (e.g. family, friends or work colleagues) with regard to his or her behaviour and the motivation for a person to comply with others' wishes. The authors argue that other variables besides those described above can influence the behaviour only if such variables influence attitudes or subjective norms. A meta-analysis examining this theory found that it could explain approximately 25% of variance in behaviour by behavioural intention alone, and slightly less than 50% of variance in intentions (Sutton, 1997).

Figure 24: Theory of Reasoned Action (TRA)



The Theory of Planned Behaviour, TPB (Fishbein & Ajzen, 1975) is an extension of the TRA, in which it is assumed that behaviour are always voluntary and the impacts of past behaviour on current behaviours are not taken into account. Recognising this, the authors extended the theory to include a new construct: behavioural control. 'Behavioural control' represents the perceived ease or difficulty of performing the behaviour and is a function of control beliefs (Sutton, 1997); conceptually it is very similar to self-efficacy. Behavioural control is assumed to have a direct influence on intention (Sutton, 1997). Meta-analyses examining the TPB have found varied results regarding the effectiveness of the theory's components (Hardeman et al. , 2002).

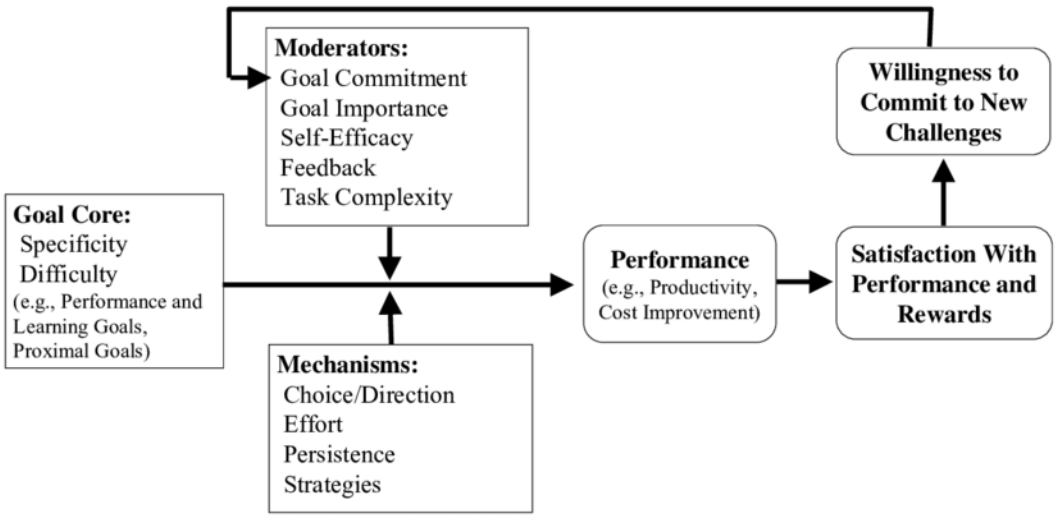
Figure 25: Theory of Planned Behaviour, TPB (Fishbein & Ajzen, 1975)



According to the Goal Setting theory (Latham & Locke, 1991; Strecher et al., 1995; Locke & Latham, 2002), motivation is crucial for the success of behaviour change interventions that promote general well-being. This is accomplished by setting long-term and short-term achievable goals in combination with the delivery of performance feedback and rewards. Goal-setting encourages a person to try harder and for longer periods of time, with less distraction from the task.

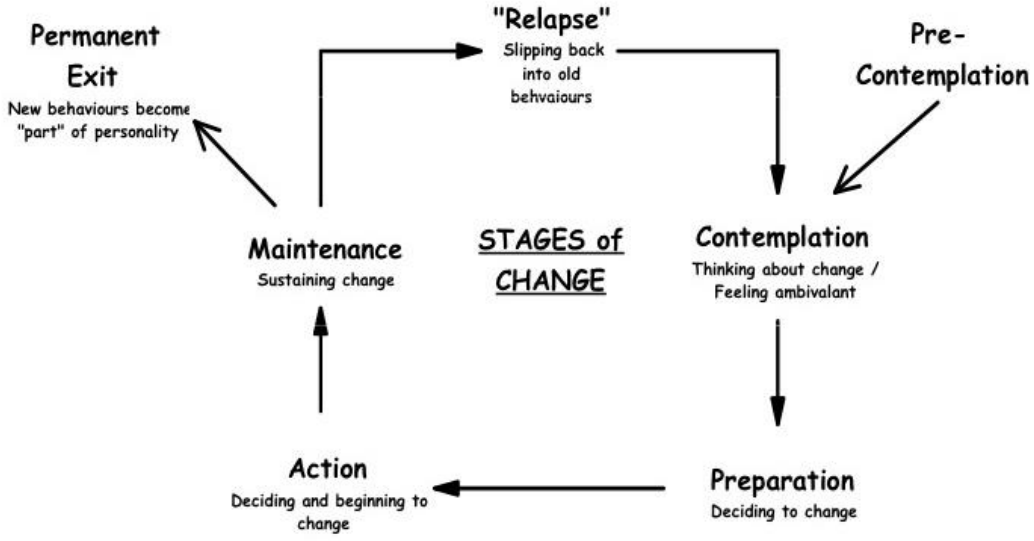
Goals have been shown to be most effective when they are important to the individual, when they are realistic, when the individual can see his progress, and when he receives positive feedback as progress toward his goal is made (Munson & Consolvo, 2012; Locke & Latham, 2002). However, setting a goal does not automatically instill motivation to achieve the goal if the goal conflicts with other goals. There are a number of studies based on goal setting to change health-related behaviours by adopting healthier lifestyle habits (Consolvo et al., 2008; Epstein et al., 1982; Martin, et al., 1984; Baron & Watters, 1982).

Figure 26: Goal setting theory (Locke and Latham 1991)



Differently from the previous models, the Self-Determination theory or the Transtheoretical Model, TTM, (Prochaska & Di Clemente, 1983; Prochaska et al., 1992) argues that individuals change their behaviour gradually, by advancing along a series of steps of a defined process of behaviour change through which the individual understands his current behaviour and mature the idea of a change. These steps vary from pre-contemplation in which individuals have not realized the need for change, to termination in which the new behavior has become so habitual that there is no longer any danger of relapse.

Figure 27: Transtheoretical Model, TTM, (Prochaska and DiClemente 1983)

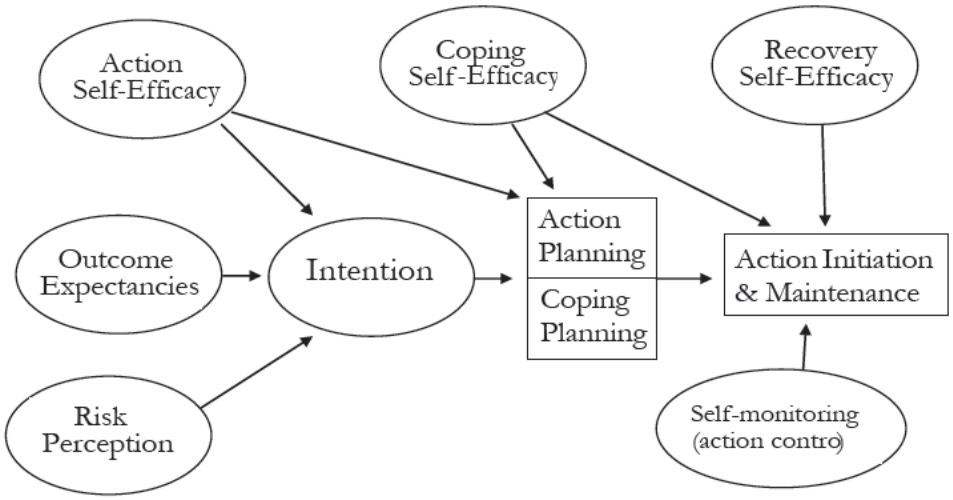


It takes into consideration the motivations that lead an individual to undertake a corrective action. It defines two types of motivation: the extrinsic motivation, which refers to the motivation that pushes an individual to reach the desired outcome, and intrinsic motivation, which is linked to the pleasure that an individual's experiences in performing the journey to reach the goal. Virtual coaches that use this theory will therefore educate the coachee towards a new behaviour leveraging on his awareness

(Prochaska & DiClemente, 1983) and letting the individual perform the activities suggested by the coaching system with pleasure (Ryan & Deci, 2000). TTM-based tailored interventions have been found to outperform best practice intervention programs. (Prochaska et al.,1993, 2001; Velicer et al., 1999). Further, the TTM has been successfully used in several intervention studies in the areas of nutrition and exercise behavior change (Dallow & Anderson, 2003; Marshall & Biddle, 2001; Riebe, et al., 2005).

Finally, the Health Action Process Approach (HAPA) consists of various psychological constructs (risk perception, outcome expectancies, self-efficacy, intention, action planning, and action control) and a mediator mechanism that is based on two processes: goal setting and goal pursuit (Schwarzer, 1992; Schwarzer, 2008). In the HAPA, three types of self-efficacy are distinguished: action self-efficacy, maintenance self-efficacy and recovery self-efficacy (Schwarzer & Luszczynska, 2015). Action self-efficacy refers to the situation in which an individual does not yet act, but develops a motivation to do so. Maintenance self-efficacy represents optimistic beliefs about one's capability to cope with barriers that arise during the maintenance period. Recovery self-efficacy addresses the experience of failure and recovery from setbacks. Action self-efficacy tends to predict intentions, whereas maintenance self-efficacy tends to predict behaviors. HAPA suggests a distinction between preintentional motivation processes that lead to a behavioral intention, and postintentional volition processes that lead to actual behavior. Before changing their habits, people need to become motivated.

Figure 28: Health Action Process Approach, HAPA Model (Schwarzer, 1992, 2008).



Recently, Ritterband et al. (2009) developed a behavior change model for Internet-based interventions. Given the similarities of these platforms with mHealth interventions, it might be suitable to guide virtual coaching but it has not still been tested.

These are just a few examples of the behavioural theories that can be applied in the scope of virtual coaching. Nonetheless, other theories could be considered with this purpose. As Riley and colleagues (2011) highlighted in their study, current theories do

not account for the dynamic interaction between user experiences and the coaching system.

To sum up, Lentferink and colleagues (2017) conducted a literature review of automated healthy lifestyle interventions with the aim to identify key components in the application of different theories that contribute to the coaches' effectiveness on health outcomes. These key features are the following:

- ✓ setting short-term goals to eventually reach long-term goals;
- ✓ personalization of goals;
- ✓ praise messages;
- ✓ reminders and suggestion;
- ✓ provide feedback based on how well the user changed behavior;
- ✓ and self-tracking to observe progress toward defined goals.

2.6.2. Related work: Virtual coaching systems for Healthy Ageing

An increasing number of smart, ubiquitous sensing technologies are being developed all over the world to coach and encourage people to adopt healthier and more responsible behaviors, providing them with timely personalized information and support. However, despite the proliferation of ICT solutions for personalized behavior change, there is still no easy way to provide older adults with integrated coaching services.

In the following, a brief summary of the scope and main contributions of existing studies on e-coaching solutions for overall well-being is provided. These papers have been classified according to four crucial human domains:

- Physical activity
- Nutrition
- Social interaction
- Cognitive ability and emotional status

According to Konsolakis and colleagues (2018) most of the studies focus on interventions of physical activities and nutrition, while there are only a few for modifying cognitive and social behaviour.

Physical activity

The majority of works studying virtual coaching applications for wellbeing report examples related to the physical activity domain. The use of inertial sensors such as accelerometers enable to easily monitor activity levels in real-time. Although pedometers' accuracy may be volatile, they are widely used due to their effectiveness in motivating individuals to adopt a more active lifestyle (Maitland, et al., 2007).

Bickmore, Caruso, & Clough-Gorr (2005) designed *Laura*, an animated conversational agent which behaves as a virtual exercise advisor to encourage older adults to increase daily number of steps. With this aim, participants wear a pedometer which tracks their

daily activity level so that the system provides feedback on their progress. The agent engages the user in conversation, provides educational information about walking for exercise and negotiates goal setting with users in a personalized way.

Houston (Consolvo, Everitt, Smith, & Landay, 2006) is a coaching system made of a mobile phone application and a pedometer which seeks to encourage opportunistic physical activities other than walking. In other words, the coaching tool aims to persuade participants to incorporate activities into their everyday life to increase their overall level of physical activity. Personal feedback and social influence are used to increase awareness and to encourage them.

Game-based coaching technologies have become popular to encourage physical activity. *Fish'n'steps* (Lin et al., 2006) consists in a social computer game to encourage adults to walk. It links a player's daily foot step count to the growth and emotional state of an animated virtual character, a fish in a fish tank. Additional incentives such as social dynamics are part of the coaching intervention. A cooperative framework, which is represented by a fish tank shared by various participants' fish, shows the progress of each fish which can affect the entire fish tank. Each fish tank constitutes a team of players that competes against other teams of players for being the best and healthiest fish tank. Team members share an anonymous chat application to have the opportunity to interact.

Likewise, Albaina et al. (2009) developed a virtual coaching system called *Flowie* that encourages seniors to walk more. Similarly to *Fish'n'steps*, it uses a flower as a metaphor to create motivation and awareness of activity levels. In the form of the flower's growth and emotional state, the daily number of steps is mapped. As well as *Fish'n'steps*, it consists of a pedometer-driven intervention with wireless connectivity with a touch-screen photo frame. The results of the study confirmed that the use of a virtual coach increases the acceptability of the system and the motivation of people to change their activity patterns. In both studies, players seem to empathize with the virtual coach and cultivate a strong internal locus of control through care of pets or plants (Langer & Rodin, 1976), thereby creating intrinsic motivation.

Moving in the same direction, the *UbiFit Garden* (Consolvo, et al., 2008) was created in order to monitor and encourage regular physical activity. It reflects activity levels and goal attainment with the representation of a garden (a flower for each activity performed and a butterfly upon goal attainment) as the phone's wallpaper. In contrast to the previous, the target user group of the study was young adults, from 25 to 35 years old.

Some years after, *GoalPost* and *GoalLine* (Munson & Consolvo, 2012) prototypes of coaching systems were developed to increase overall physical activity and add variety to exercise routines. They used goal-setting, reminders, rewards, self-monitoring and social influence in order to meet defined goals.

Bickmore et al. (2013) designed an automated exercise coach for older adults and analyzed its acceptance. They created it from the already existing *FitTrack* (Bickmore & Picard, 2005) coaching tool by adapting it for the elderly population.

Simultaneously, King et al. (2013) developed and tested three game-based applications to motivate adults just under 60 years old to become less sedentary and more active with the ultimate aim of achieving a sustained behaviour change. The applications delivered personalized goal-setting, real-time feedback, social support, positive re-enforcement and encouragement making use of social influence and competition between users.

Further contributions came from Callejas and colleagues (2014) who presented a conversational agent that acts as a coach and was developed as a mobile running application. The system suggests the users exercise plans and discusses results at the end of each activity session.

FitBit is currently the leading global wearables brand and a well-known coaching system that targets different age-groups with tailored solutions. Fitbit Health Solutions offer customized health coaching through a digital health coaching mobile app that drives healthy behavior change. With this platform, people have access to a highly scalable coaching model based on data-driven feedback and predictive algorithms. Asynchronous communications like text exchanges have proven to be highly effective in driving better outcomes, because it integrates well the coaching experience into daily life. It is composed of wireless devices connected to smartphones or computers. Fitbit tracks real-time information about exercise, food and sleep as well shows progress as charts and graphs to keep users motivated. In case of physical activity, it assigns a virtual flower to each user that grows accordingly to their recent activity level. The coaching system empowers members with data, motivation and assistance to reach their goals as well as it rewards users for achieving goals, such as step count milestones.

Although there are plenty of examples of virtual coaching applications in this domain, there is modest evidence about their effectiveness. Despite this fact, reviews such as the one done by Orji and Moffatt (2016) provide an idea of the effectiveness of virtual coaching. In particular, the results of their work show that 75% of physical activity interventions analyzed resulted to be effective.

Nutrition

There may be fewer examples of virtual coaching systems that focus entirely on the nutrition domain for the elderly population compared to the physical activity domain.

The work by Ali et al. (2012) explored the use of a touch screen interaction in developing an educational nutritional package for elderly. The educational package results to be helpful in providing an education on nutritional and healthy lifestyle as participants started to be careful in choosing meals and modified their daily meals.

Nutrihealth (Salim, Ali, & Noa, 2017) is a mobile application designed for the elderly. It implements persuasive techniques to increase user engagement and behaviour change in healthy diet by suggesting menus and monitoring calories intake.

As well as in the case of physical activity interventions, games are becoming a popular way of persuading individuals to engage in healthy dietary habits. For example, *OrderUP!* was presented in the Second International Conference of Persuasive Technology in Palo Alto (April 2007). It consists in a game in which the user plays the role of a restaurant owner and must serve the customer a balanced set of foods, allowing him to maintain a high health level.

Currently, there are some coaching tools which address the nutrition domain in the market. *MyFoodPhone* is a nutrition coach who promotes healthy eating habits by keeping track of food intake and giving personalized feedback. It consists in a camera-phone food-journaling feedback service which links individuals with virtual nutrition coaches and advisors as explained in its website. It allows tracking and evaluating progress by logging biometric data (e.g. weight, BMI, blood pressure).

Besides one-dimensional interventions, the promotion of healthy eating habits is easily found in multi-behavioural interventions. For example, in the work of Clark and colleagues (2002) a multi-behavioural health promotion intervention aimed at increasing the consumption of fruit and vegetables among the 60 and older adults is proposed. Reports and coaching calls were used to encourage the user.

Todd & Sasi (2006) presented a virtual companion designed as an intelligent system that engages in conversations with the user and monitors daily activities. It tackles different domains and in the case of healthy nutrition gives dietary suggestions as health reminders and nutritional education.

Social interaction

Despite evidence of the significant relationship between isolation and morbidity in the elderly, this population neglects the wellbeing implications of prolonged social isolation and loneliness, the affective response to social isolation. For this reason, addressing such issues in older adults represents an important opportunity for pervasive and affective computing technologies. These intelligent systems provide users long-term assistive companionship, social support such as facilitating social connectivity and aid people to develop or maintain social skills.

Mival et al. (2004) used AIBO, a robotic dog, in the UTOPIA project (Usable Technology for Older People: Inclusive and Appropriate) to provide artificial companionship for older adults. Morris (2007) created a system constituted by a set of sensors and ambient devices with a display function to support the social interaction of the person. The author states that in this particular research behavioural metrics

collected by the sensors are translated into meaningful feedbacks that can motivate adults to change their social behaviours.

Burns et al. (2011) developed the *Mobilyze!* system to target depression by detecting user's location and emotional states, such as sadness, happiness, anger and anxiety. These conditions are detected through sampling data from the accelerometer, GPS, Bluetooth, Wi-Fi, ambient light and phone usage analytics. It is based on Gravenhorst et al.'s (2015) findings about depressed patients.

Cornejo et al. (2013) studied the system *Tlatoque*, a client of Facebook running on situated displays that provide the elderly ambient awareness of their relatives' location to strengthen their family social network. These systems can assist the integration of the elderly to their social networks.

Furthermore, virtual assistive companions which are known as embodied conversational agents (ECAs) have been successfully used in health interventions, especially for older users aged 65 and above (Bickmore & Picard, 2005; Bickmore et al., 2005). Relational agents (Bickmore T. , 2003), a particular type of ECA, provide companionship and the perception of social support by its mere presence, through social interaction and by providing a wide range of social activities that it can conduct with the elder, such as game play. Moreover, they help elders to stay connected with friends and relatives via electronic communication and deliver proactive prosocial behavior change interventions to establish and maintain friendships. Conversational agents can directly intervene on loneliness, depression, and other mood disorders through talk therapy too.

In this regard, Vardoulakis et al. (2011) investigated the use of an agent to provide social support and wellness counselling to older adults. It consisted of a remote-controlled agent installed in homes of older adults.

Ring et al. (2013) developed a conversational agent-based system to provide social support and healthy behavior advice to isolated older adults in their homes for an extended period of time. The agent proactively starts conversations to engage elders in brief chats for social support and build a sense of companionship. Also, the agent motivates users to increase physical activity, such as walking, to help combat stress and symptoms of depression.

Cognitive ability and emotional status

Cognitive main functions are memory, language, perception, visuospatial processing, attention, thinking and judgement. Cognitive sensing is possibly the most challenging task since smartphone sensors are not able to directly measure cognition-related processes which severely compromise multiple aspects of people's everyday life. However, it can be monitored by assessing the performance at specific tasks that allow for early diagnosis of cognitive disorders and decline (Schmidt, Collette, Cajochen, & Peigneux, 2007). Despite the relevant technological progress, current unobtrusive

measurements focus on a single cognitive ability and are not able to provide a comprehensive overview of the cognitive state comparable to clinical tests. As stated by Siewiorek and colleagues (2012) relatively to the well-being of a person, "one important application domain for virtual coaches is assisting individuals whose own cognitive capabilities have been impaired due to natural aging, illness or traumatic injuries".

Morris (2007) presented a system design for the elderly that consists in a system of sensors and ambient devices intended to prevent cognitive regression, among other purposes.

Wohlfahrt-Laymann et al. (2018) in their work present *MobileCogniTracker*, a digital tool for facilitating momentary, seamless and ubiquitous clinically-validated cognitive measurements to track cognitive behavior. The proposed tool develops digital cognitive tests in the form of multimedia experience sampling questionnaires, which can run on a smartphone and can be scheduled and assessed remotely. The tool further integrates the digital cognitive experience sampling with passive smartphone sensor data streams that may be used to study the interplay of cognition and physical, social and emotional behaviours. The authors conveyed the desire to integrate the proposed tool into innovative e-coaching solutions as to facilitate not only the autonomous tracking but also the prevention and intervention of cognitive impairments.

Recently, commercial apps, known as brain games, have been developed to prevent, assess and treat cognitive disorders. For example, *Tapbrain* (Kang, Choi, & Lee, 2016) is a serious game of thirteen mini-games to stimulate brain exercise and prevent dementia. The objective of *Tapbrain* is to stimulate cognitive brain functions by targeting triggers that stimulate the brain and also that induce physical movements. *Sea Hero Quest* (2017) is a mobile game-based application that evaluates cognitive functioning by analyzing the user's spatial navigation skills. *Lumosity* (2017) is an app consisting of several mobile games assessing the functioning of different cognitive abilities (e.g. improve memory, increase focus) while engages users to stimulate brain learning and processing. *MindMate* (2017) is another mobile gaming application that aims to empower older adults by stimulating the user's cognitive abilities through problem-solving and memory-training activities and, thus, improve their brain health. It uses self-reporting methods to keep track of daily activities.

In the Taxonomy of serious games for dementia made by McCallum & Boletsis (2013) a list of preventive games for cognitive health is presented: *Brain Age, Big Brain Academy, Posit Science, CogniFit, Complete Brain Workout* and *SmartBrain Games* along with some other brain games already explained.

Multi-behavioural interventions

It is important to investigate multiple-behavior interventions in health promotion research, as their potential impact on public health may be superior compared to single-behavior interventions. This is due to greater results coming from the interaction

between the interventions' effect and from the sum of the interventions' independent impact on specific domains.

In general, healthy lifestyle goals are based on the World Health Organization's recommendations. In case of physical activity and nutrition, individuals should perform at least 30 minutes of moderate physical activity every day and consume at least five servings of fruit and vegetables, respectively.

The Study of Exercise and Nutrition in Older Rhode Islanders (SENIOR) Project (2002) is a multi-behavioral health promotion intervention for older adults to encourage them to exercise more and increase fruit and vegetable consumption. Similarly, Gasser et al.'s (2006) assess in their study compare the usage and acceptance of a healthy lifestyle coaching tool to increase physical activity and improve nutrition habits with a traditional with a web-based equivalent. Both systems base goals on WHO recommendations.

BeWell+ (Lin, et al., 2012) is the next generation of the *BeWell* (Lane, et al., 2011) smartphone wellbeing app, which monitors and promotes improved behavioral patterns along the physical, social and sleep dimensions. The application prioritizes resources to those dimensions of behavior that the individual is currently struggling with a more accurate assessment and immediate feedback to create awareness and promote change in individuals. Just like *UbiFit Garden,* the system provides feedback in the form of an animation that is rendered as an ambient display on the smartphone's lock-screen and wallpaper, making it visible to the user whenever the user glances or interacts with their smartphone. In this way, users easily understand the consequences of their actions enabling them to make appropriate changes in their behavior and more informed choices going forward.

A 2014 study on a diabetes prevention intervention program with the YMCA looked at the effects of health-coaching in relation to exercise, tracking and managing food intake. It found that those paired with a tracking coach had a 58 percent reduction in their risk compared to those treated with medication at 31 percent. Moreover, the effect was greater if participants were 60 or older at the beginning of the study; their reduction was 71 percent (Adams, Hebert, & Mcvey, 2016).

Baskar and colleagues (2017) introduced a prototype system for personalized digital coaching that consists of a mobile application that guides the user in the daily activities ensuring the well-being of the user in the physical, social as well as cognitive dimensions.

The European Personalising Health and Care project *PreventIT* (2016–2018, grant agreement number 689238) developed and tested a coaching system. The tool enables early identification of risks for age-related functional decline and stimulates behavioural change in young older adults (aged 60–70 years) in order to adopt a healthy, active lifestyle in the context of Healthy Ageing. In the project, an integrated system of a

smartphone and a smartwatch is used as the frontend technology. The multi-behavioural tool allows older people to self-assess the risk of functional decline, proposes individually-tailored interventions, gives feedback through motivational messages and allows for social interaction between participants with the possibility for team competition and comparison of one's own results with those of others.

The Council of Coaches (2018) was recently presented as a radically new virtual coaching concept based on multiple virtual coaches, each specialized in their own domain, which form together a personal council that fulfills the needs of older adults in an integrated way. Users select the number of coaches according to their own plans to go for a healthier lifestyle. In this concept, coaching takes the form of an open conversation in which virtual characters interact with each other and with the user to inform, motivate and discuss about health and well-being related issues (e.g. physical, cognitive, mental and social well-being). The Council of Coaches concept allows keeping the dialogue forward when the user's initiative of interacting with the system is low. The presence of multiple coaches allows for approaches in which coaches either apply separate coaching strategies at the same time or join together in applying one strategy. It also allows for the introduction of new coaches when their expertise is required, coaches can be added as modules (Op den Akker, et al., 2018).

Schoeppe, et al. (2016) did a systematic review about the efficacy of using app-based interventions to change health behaviours with the aim to improve daily diet, avoid sedentary behaviours and thus, prevent diseases. Unfortunately, results provided modest evidence about their effectiveness. However, multi-behavioural interventions seemed to be more effective than standalone app interventions.

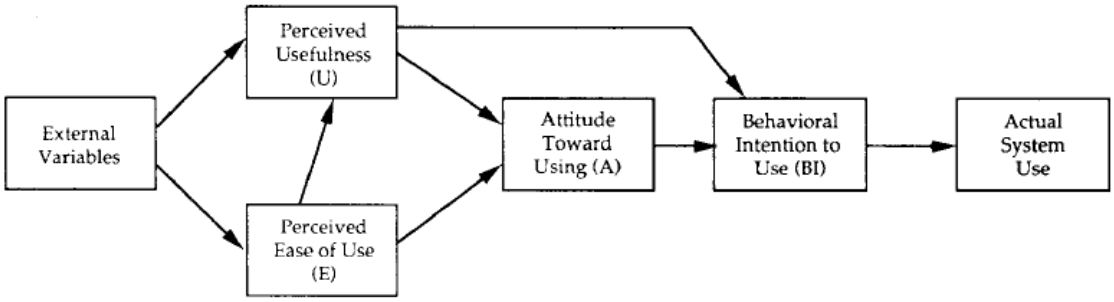
2.7. Extant technology acceptance models

The success of an intervention depends largely on its effectiveness and, just as importantly, on user acceptance. Even if technological solutions are powerful and sophisticated; they cannot improve lifestyle behaviours if they are not used.

In an attempt to adopt a proactive attitude towards this problem, there have been many approaches to identify features of a system and user's characteristics that influence the willingness to use such system. For that purpose, intention models from social psychology have been widely used by information systems' researchers. Foremost among these is Fishbein & Ajzen (1975) theory of reasoned action (TRA), which has been proven to be successful in predicting and explaining behaviors across different domains. In 1986, Davis introduced an adaptation of TRA specifically tailored for modeling user acceptance of information systems (IS), the technology acceptance model (TAM), which continues to be the most widely applied theoretical model in the IS field (Lee & Larsen, 2003). The goal of TAM is to provide an explanation and prediction of the determinants of computing technologies acceptance and their impact on internal beliefs and attitudes. In this way, IS developers can take them into account in order to

increase the acceptability of the system and its related business success (Davis, 1986; Davis, 1989; Davis, Bagozzi, & Warshaw, 1989; Davis,1993).

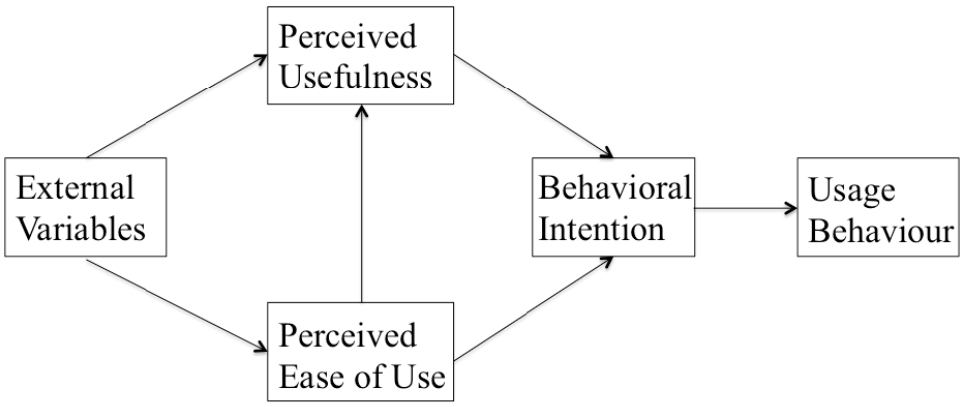
Figure 29: Technology Acceptance Model (TAM)



Using TRA as theoretical backdrop, TAM uses *perceived usefulness* (U) and *perceived ease of use* (E) as the main constructs that influence the *attitude toward using* a computing tool (A). TAM suggests that users' *behavioral intention* to use a system (BI) is the single best predictor of actual system usage and it is determined by A and U. In contrast to TRA, *perceived usefulness* (U) and *perceived ease of use* (E) in TAM do not depend on the specific context and are considered as two fundamental and distinct constructs.

Perceived usefulness (U) is defined by Davis as "the degree to which a person believes that using a particular system would enhance his or her job performance". U is understood as effectiveness, productivity and time savings. Its direct effect on BI refers to the fact that people may use a technology even if they do not have a positive attitude towards using it but because it can enhance their performance leading to some reward. The original theoretical conceptualization of TAM included the attitude construct (A). However, based on the empirical evidence, the final TAM model (Davis et al., 1989) excluded it because A did not fully mediate the effect of U on intention.

Figure 30: Final version of Technology Acceptance Model (Venkatesh and Davis 1996)



Perceived ease of use (E), in contrast, refers to "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989; Davis et al., 1989). E includes self-efficacy (Bandura, 1982) or, in other words, the ability to carry out the

sequences of behavior needed to operate the system, and instrumentality, which is related to the contribution of E to increase overall user's performance by relocating effort saved to enable a person to accomplish other activities or more work for the same effort (Radner & Rothschild, 1975). For that matter, E has a direct effect on U. Both components are related to physical effort, mental effort and ease of learning. Although E is important, U is even more important and should not be overlooked (Davis, Bagozzi, & Warshaw, 1989).

Subjective norm (SN), unlike TRA, is not included in TAM. External variables influence behavior indirectly via A, through U and EOU.

In 1991, Moore and Benbasat (1991) developed a 38-item instrument to study the voluntary adoption of an information technology innovation comprising previous researches. A short, 25-item version of the instrument is also suggested. They relied primarily on the extensive work of Rogers (1983) together with Tornatzky and Klein's (1982) analysis and TAM's main constructs, E and U.

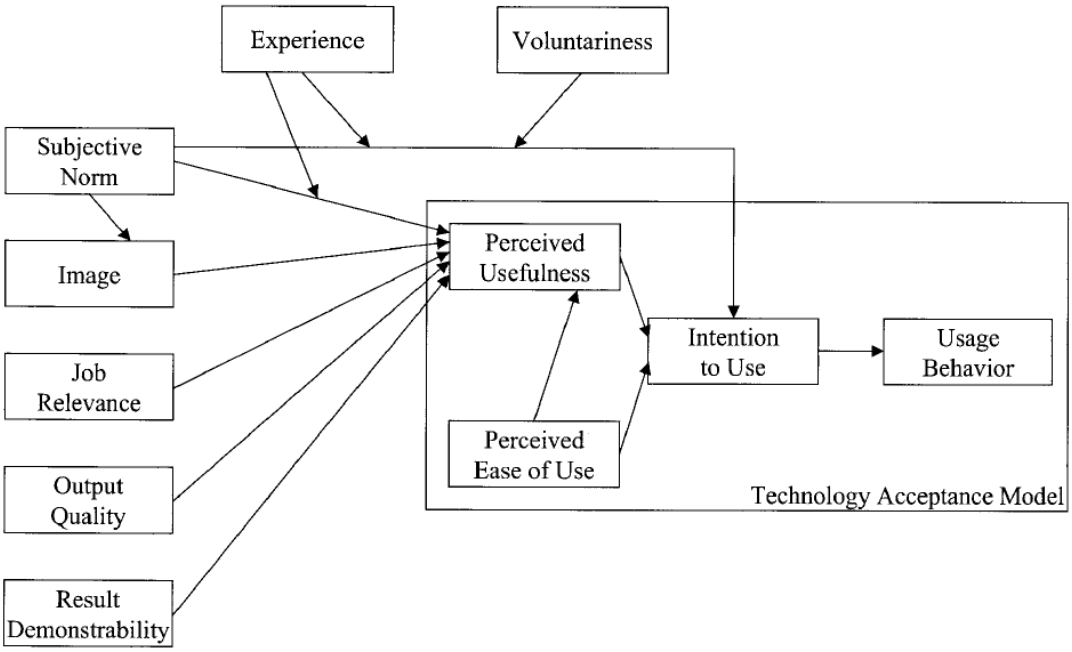
Expansion efforts began to introduce new variables hypothesizing different relationships between key TAM constructs, U and E, and their possible antecedents to better explain user acceptance and use and to design correction actions (Bagozzi 2007; Lee et al. 2003; Youszafai et al. 2007; Benbasat and Barki 2007).

In 1996, Venkatesh and Davis studied the antecedents of Perceived Ease of Use (E). They discovered that before hands-on experience with systems, system characteristics do not play a significant role in the perceptions of users in the early stage of adoption until they have direct experience. Potential users without direct experience with a system or with a similar tool base their perceptions on abstract beliefs related to general technology self-efficacy, irrespective of the extent of information given to users. Self-efficacy, thus, must be considered as a key construct of user acceptance before and after hands-on use.

Venkatesh and Davis (2000) introduced TAM2, a theoretical extension of the TAM that includes previous studies and examine the antecedents of U, such as social influence (subjective norms, voluntariness and image) and cognitive instruments (job relevance, output quality, result demonstrability and E).

Unlike TAM, TAM2 presents a direct effect of subjective norm on intention to use the system over and above perceived usefulness. Subjective norm may take the form of internalization, which refers to the incorporation of an important referent's belief into one's own belief structure, or identification, which is related to enhancing one's image or status within a social system by performing a behavior that is suggested by important members of the social group. Identification, like internalization, occurs in both mandatory and voluntary settings.

Figure 31: TAM2 (Source: Venkatesh and Davis 2000)



According to previous research, social influence has a major influence on users' attitude towards a system when it has not been developed yet or when users have not had hands-on experience before. In this situation, user's knowledge about the system is vague and, thus, they rely on others' opinion. After direct experience, the influence of subjective norm weakens over time. Result demonstrability - which is the ability to attribute benefits gained to the use of the system - plays a significant role on user acceptance and system adoption.

Venkatesh (2000) following up the research of 1996, provides a further understanding of the determinants of E by focusing on how perceptions form and change over time with increasing experience with the system. Variables include anchors (computer self-efficacy or internal control, perceptions of external control, computer anxiety and computer playfulness) and adjustments (perceived enjoyment and objective usability).

Later, Venkatesh et al. (2003) formulated the Unified Theory of Acceptance and Use of Technology (UTAUT), a unified model that integrates elements across eight user acceptance models. By reframing the concepts used in previous studies and including facilitating conditions as an additional predictor of intention, they identified three direct determinants of behavioural intention (performance expectancy/perceived usefulness, effort expectancy/perceived ease of use and social influence/subjective norms) and two direct determinants of usage behavior (behavioural intention and facilitating conditions). Four key moderating variables (experience, voluntariness, gender and age) were incorporated to the model. Age and gender were demonstrated to be fundamental moderators in technology acceptance models.

Figure 32: Theoretical Framework for the Determinants of Perceived Ease of Use (Source: Venkatesh 2000)

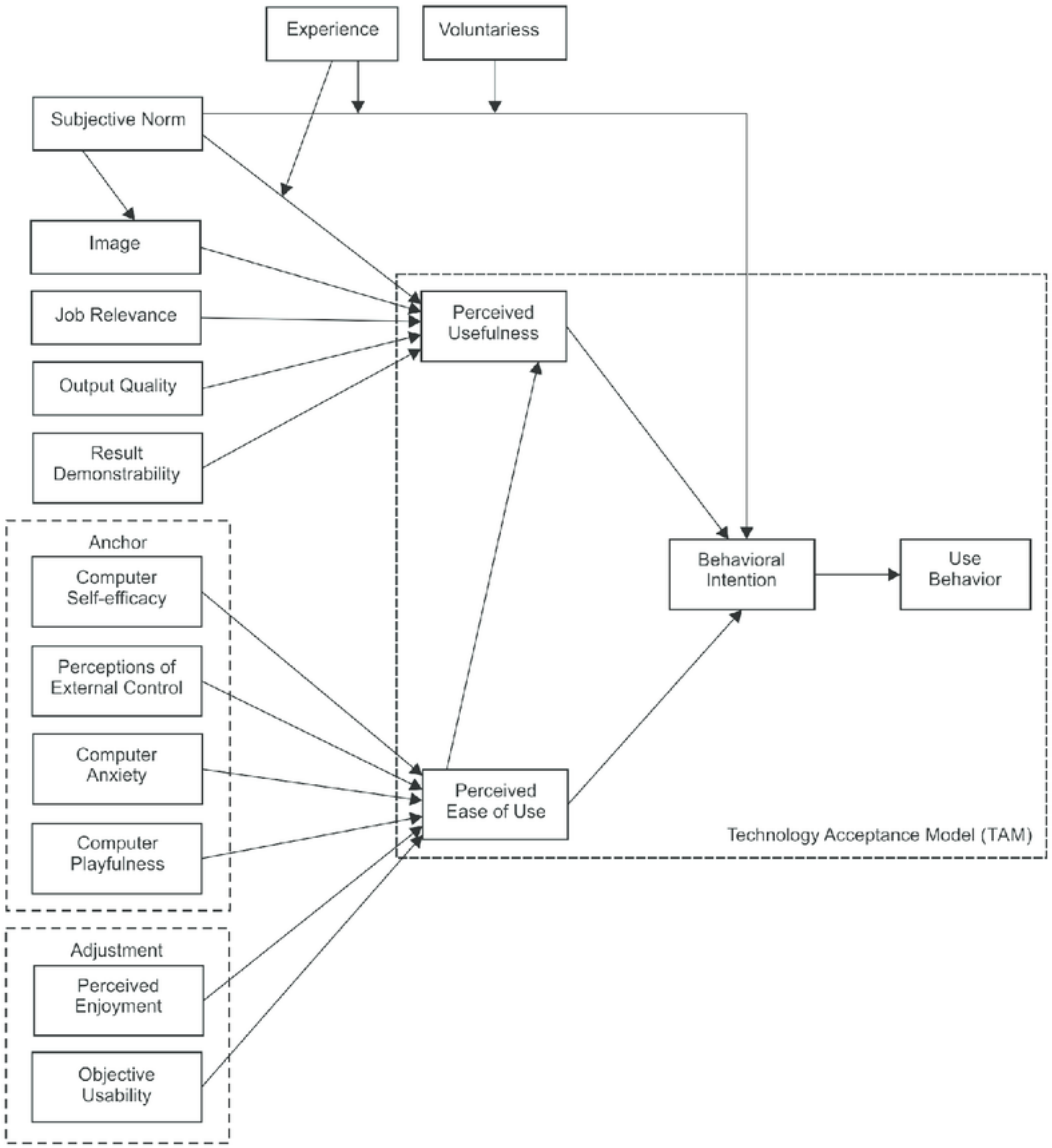
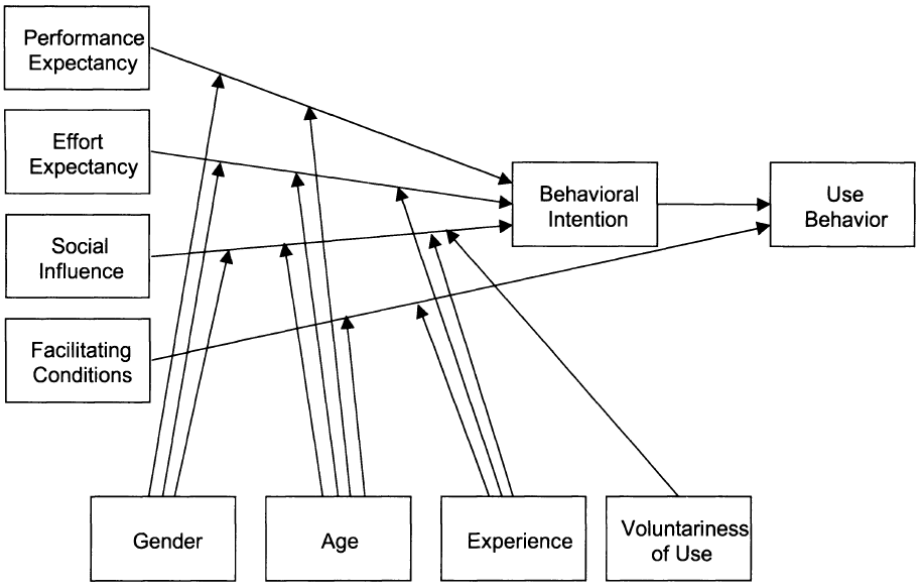
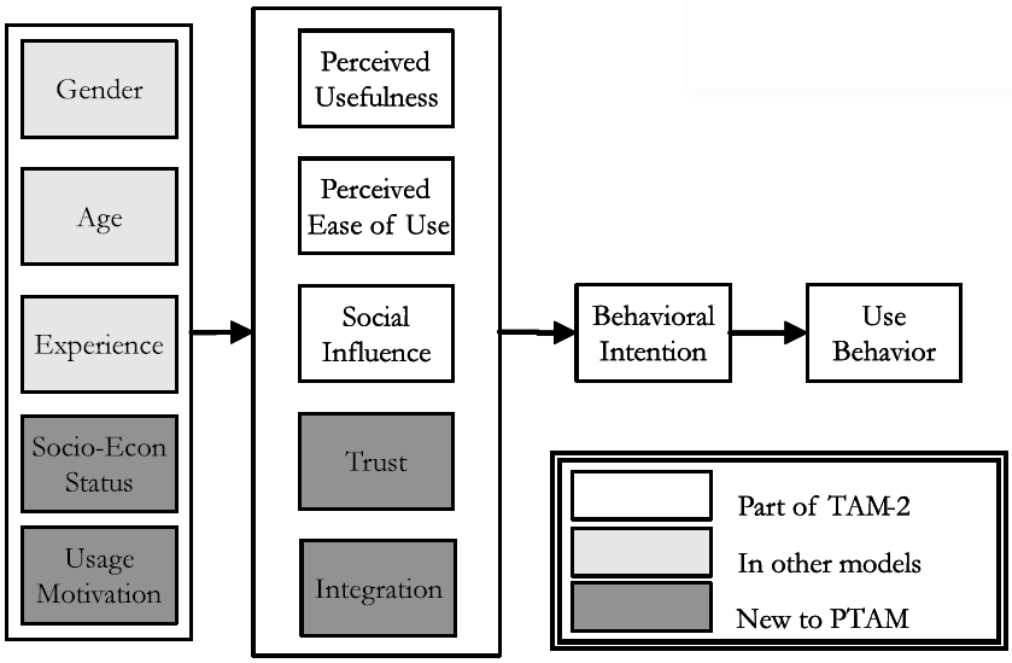


Figure 33: The Unified Theory of Acceptance and Use of Technology, UTAUT (Source: Venkatesh et al., 2003)



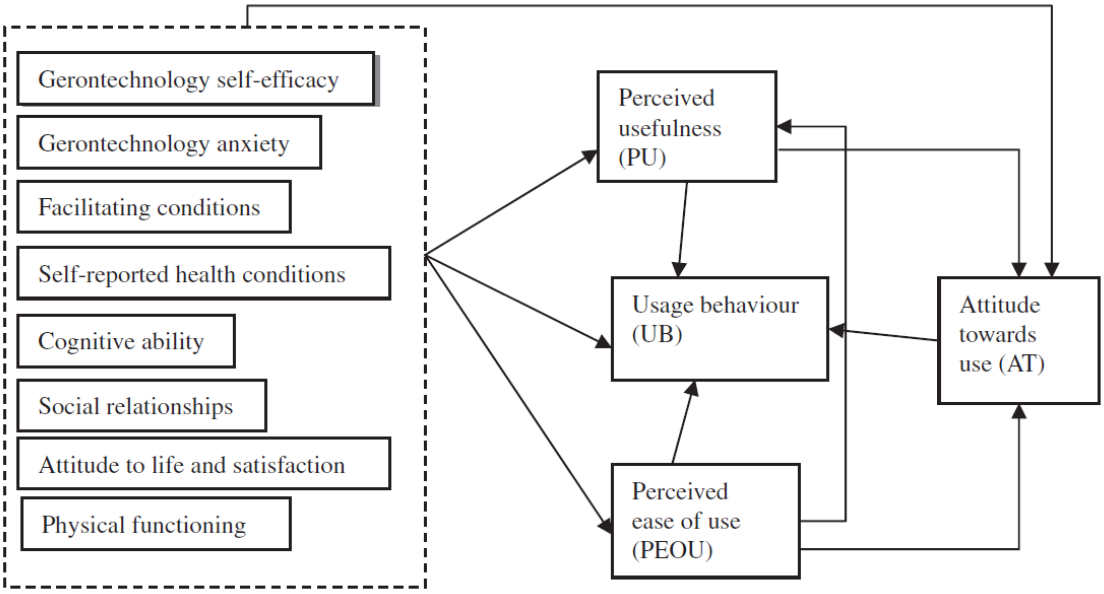
In accordance with the progress of technological innovations, Kay Connelly presented The Persuasive Technology Acceptance Model (PTAM), in 2007 (Connelly, 2007). PTAM is an extension to TAM which is directly related to the topic at hand, virtual coaching tools. It was the first time that computing tools acceptance was analyzed for other purposes than improving job performance, such as improving one's health. Thus, user acceptance should account for the user's motivations beyond job-related reasons and for pervasive computing technologies' specific characteristics. In this regard, PTAM adds Trust and Integration constructs that are related to distinctive features such as personal data gathering, pervasive technology's autonomy to behave and the integration of the technology in daily life. As a result, the proposed model was based on five constructs: perceived usefulness, perceived ease of use, social influence, trust and integration.

Figure 34: The Persuasive Technology Acceptance Model, PTAM (Connelly 2007)



Finally, in 2014 Chen and Chan proposed a Senior Technology Acceptance Model (STAM) in the world of gerontechnology, which aims to give older people the chance to be healthier, more independent and more socially engaged. For the first time, unique characteristics, capabilities, limitations and life course events (e.g. retirement, loss of spouse) of the elderly were considered. Individual attributes such as self-efficacy and anxiety resulted to be the best predictors of usage behavior. The model extends the UTAUT model by adding age-related health and ability constructs: self-reported health conditions, cognitive abilities, attitudes towards ageing and life satisfaction, social relationships and physical functioning. It incorporates four control variables: age, gender, education level and economic status.

Figure 35: Senior Technology Acceptance Model, STAM (Chen and Chan, 2014)



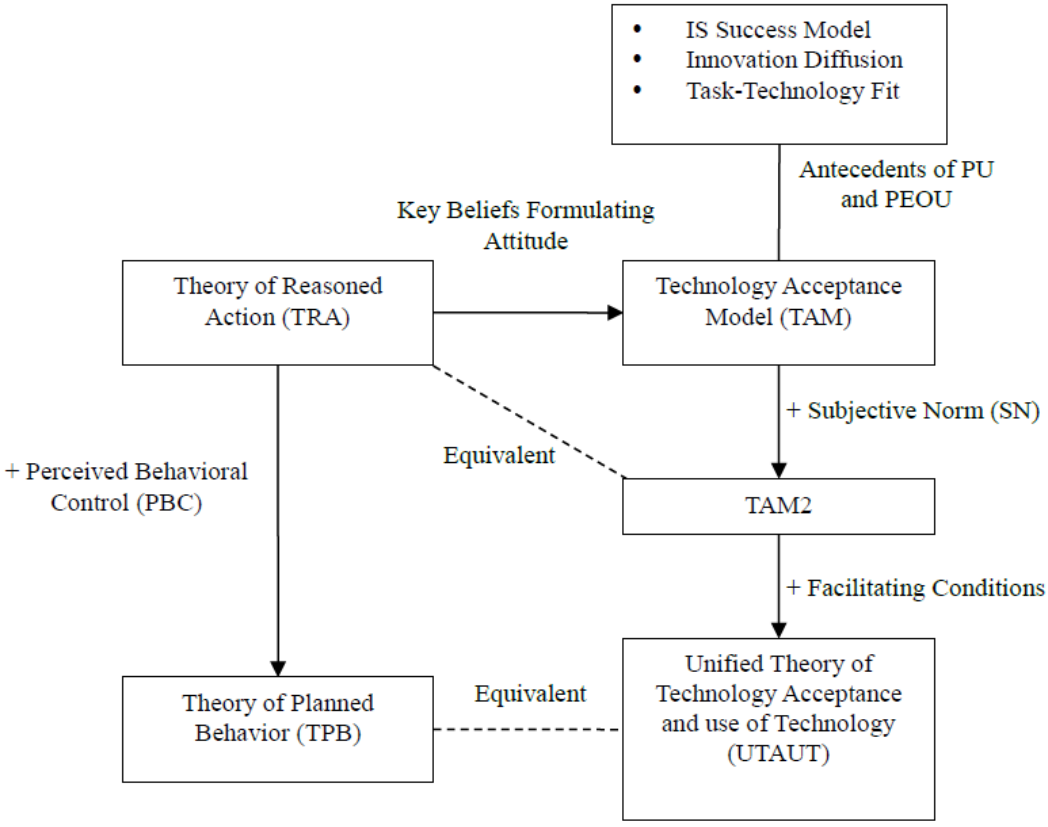
To have a general vision of external variables that have been taken into consideration in extensions of the TAM, Winarto (2011) did a review in which he identified more than 70 external variables used in different studies. According to Yousafzai and colleagues (2007) these variables can be classified into four categories: organizational characteristics, system characteristics, user`s personal characteristics, and other variables.

The original TAM accounts for around 40% of the variance in usage intentions and behaviour. TAM2 has been shown to explain up to 52% of behavioral intent. UTAUT has outperformed previous models by explaining up to 70% of the behavioral intent variance. To sum up, figure 36 represents an overview of the literature review explained.

Many empirical studies on consumers' health technology adoption behaviour have been based on technology acceptance theories (Hu et al. 1999; Rawstorne et al. 2000, Weng 2016; Beldad and Hegner 2017). However, only few studies exploring TAM concerned virtual coaching systems, in particular those for adopting healthy behaviours by older adults. Among these, social influence component appears to be a recurrent external variable in the adoption of new technologies because, generally, when a technology rises, potential user's knowledge about the system is vague and, thus, they rely on others' opinion. This situation is especially true for 60 and older adults, where younger family members (Teo and Pok 2003) but also doctors (Wu et al. 2007) are considered as a reference for the acceptance of a new technology (Chang and colleagues, 2016; Wolf and colleagues, 2018). Trust, which is related to the quality and reliability of using the system, is also relevant especially for the elderly population (Schnall and colleagues, 2017; Deng and colleagues, 2017). Finally, data privacy, which includes personal data security, is generally considered important by the individual when approaching a new IT system (Lai 2015). This is particularly true in the healthcare field, where seniors are

afraid to share their health data on digital devices (Deng and colleagues, 2017; Schomakers and colleagues, 2018).

Figure 36: An Overview of Technology Acceptance Theories (Source: Sun et al., 2013)



3. Hypotheses development and theoretical framework

This study develops and empirically tests a theoretical extension of the Technology Acceptance Model (TAM) as a model of user acceptance of a virtual coaching system, particularly for the NESTORE system. The TAM model and its consecutive extensions presented in previous sections, in particular the TAM2, as well as the HBM will be used as the anchor of the proposed model.

The aim is to identify and better understand the behavioral determinants that lead older adults to accept and use a virtual coaching system to help them to engage a healthier lifestyle, and therefore experience a healthy ageing process. As Chen and Chan (2014) pointed out, distinctive abilities and limitations of the target population will be taken into account due to their significant influence in accepting a new technological system. Thus, they will be crucial to determine the predictors of intention to use a coaching system.

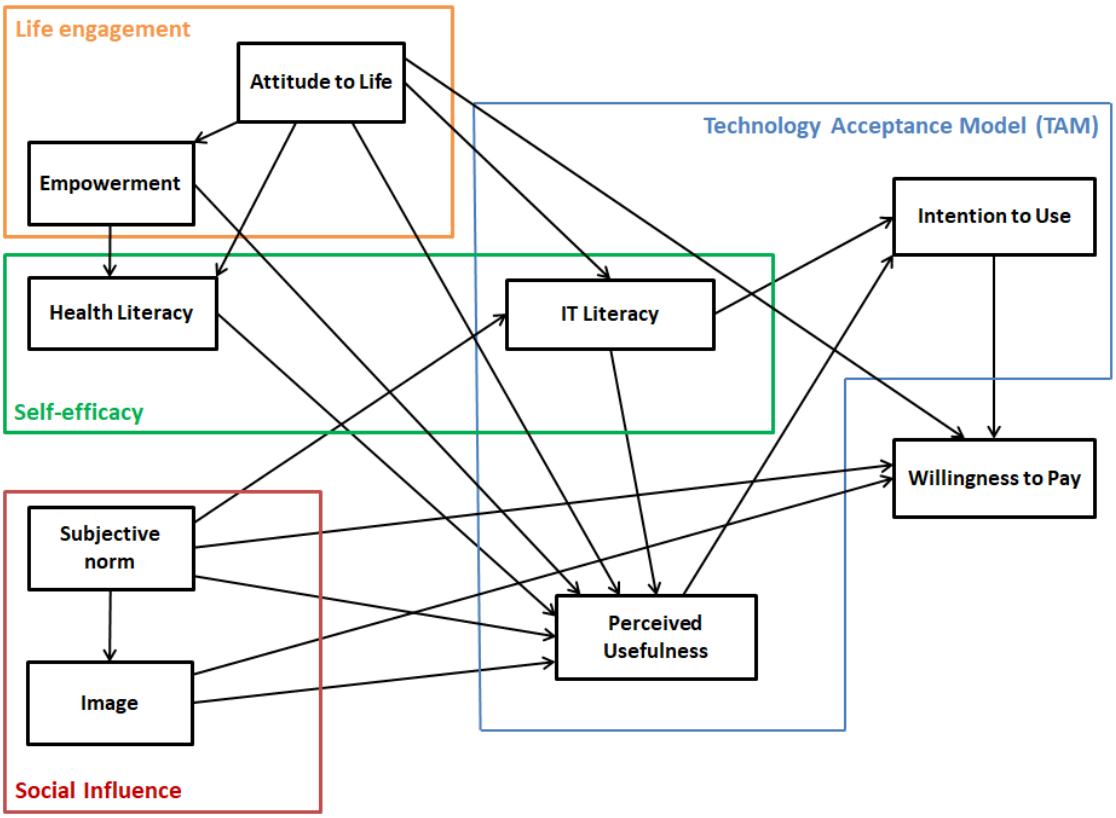
For that matter, only taking into account key TAM constructs seemed to be inadequate to have an integrated perspective to determine the factors that significantly influence on users' acceptance of a technology in the healthcare domain. With this respect, Zhaoa et al. (2018) affirmed that mobile health adoption behaviour is also considered as health behaviour. In order to improve the model we incorporated some constructs presented in the Health Belief Model (HBM) to address factors that make users adopt long-term health-promoting behaviours. Self-efficacy was designed to address both healthcare and technological domains. External cues to action were addressed as social influence; we used TAM2 to incorporate the constructs that represent such effect. Lastly, as the target population is the elderly, users' self-worth and engagement with life are key aspects that should be considered because they play a key role in people's behavior and activity during the late adulthood. Therefore, the proposed model combines users' cognition, social environment and attitude to life.

3.1. An extended TAM: theory and hypotheses

Figure 37 shows the proposed model. Taking the TAM as theoretical anchor, six additional theoretical constructs that assess social influence (Subjective norm and Image), users' self-efficacy (IT Literacy and Health Literacy) and engagement to life (Empowerment and Attitude to Life) have been incorporated in order to better explain user intention to use a coaching system in older adulthood. In addition, we have analyzed their impact on users' willingness to pay, adding such construct as a consequential behavior of the TAM model.

Before the establishment of a theoretical model for the proposed research, a detailed literature survey was undertaken to analyze the state of the art of acceptance models of healthcare technological solutions.

Figure 37: Proposed model and hypotheses



Perceived Ease of Use construct has been replaced by *IT Literacy* as users' *Perceived Ease of Use* of the system relies mainly on their own technology self-efficacy because the system is in its early stage of development; this will be explained further on. In addition, there is lack of knowledge of the existence of this technology and users lack of experience using this type of system. Therefore, users could not answer related questions to the specific system usability as it was hard to convey to them in a realistic way what the proposed system consists of. Additionally, NESTORE is the bundle of different technologies (sensors, chatbot, wearable devices, software and application…). For this reason, the most suitable way to assess the system's Perceived Ease of Use was assumed to be the individual IT Literacy as it encompasses every part of the coaching system.

With respect to constructs included in TAM2 that refer to social influence, *Voluntariness* was dropped because the use of NESTORE system is not mandated and there is no expectation that it will be mandated in the foreseeable future.

Below we define each of the constructs that make up the model and develop the theoretical foundation for the causal relationships between them.

Table 1: Main constructs of the proposed model

Construct	Definition	Source
Perceived Usefulness (PU)	The degree to which a person believes that using a particular system would enhance his or her job.	Davis, 1989
IT Literacy (ITL)	The ability to identify, locate, retrieve, store, organise and analyse digital information, judging its relevance and purpose.	Ferrari, 2013
Health Literacy (HL)	The ability to make sound decisions concerning health in everyday life.	Kickbusch & Maag, 2008
Empowerment (E)	The active involvement of a person in recognizing, promoting, and enhancing each one's abilities in order to meet own needs, attain health goals, promote and care for individual well-being by enhancing self-care behaviours and increasing control over the factors, decisions and actions that affect their health.	Jones & Meleis, 1993
Attitude to Life (ATL)	A user's engagement in life and overall life satisfaction.	Neugarten, Havighurst, & Tobin, 1961; Osborne, Elsworth, & Whitfield, 2007
Image (I)	The degree to which use of an innovation is perceived to enhance one's status within a social group.	Moore & Benbasat, 1991
Subjective norm (SN)	A person's perception that most people who are important to him think he should or should not perform the behaviour.	Fishbein & Ajzen, 1975

3.1.1. The role of performance expectancy: Perceived Usefulness

Previous studies of TAM and its extended versions have gathered empirical evidence that demonstrates the direct effect of *Perceived Usefulness* on *Intention to Use*. *Perceived Usefulness* is thought to be the most important predictor of technology acceptance. Within the healthcare domain, the effect of *Perceived Usefulness* of an IT system resulted to be significant for user acceptance in all healthcare-related TAM studies revised by Holden & Karsh (2010).

With regard to older people, as many of them are already retired, it is not suitable to consider *Perceived Usefulness* as "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989). However, older people would accept and use a new technology if they believe that it represents a clear benefit to them, such as having a role in society, having social relationships, being independent, being able to make own decisions or satisfying their needs (Kruse et al., 2016).

HYPOTHESIS 1. *Perceived usefulness of a coaching system has a positive effect on the Intention to Use them.*

3.1.2. The role of technological abilities: IT Literacy

Perceived Ease of Use is a fundamental construct of the TAM model that has been tested in numerous studies. It has been proved that it has significant influence over users' *Intention to Use* a technology (Venkatesh & Davis, 2000; El-Wajeeh, Galal-Edeen, & Mokhtar, 2014; Bidmon, Terlutter, & Röttl, 2014; Chang, Lee, & Ji, 2016; Cajita, Hodgson, Budhathoki, & Han, 2017; Beldad & Hegner, 2017; Deng, Hong, Ren, Zhang, & Xiang, 2018) and a positive effect on *Perceived Usefulness* (Venkatesh & Davis, 2000; Dünnebeil, et al., 2012; El-Wajeeh, Galal-Edeen, & Mokhtar, 2014; Dou, et al., 2017).

Though, given that the study is done in the early stage of development, it was difficult to convey to users in a realistic way what the proposed system consists of (El-Wajeeh, Galal-Edeen, & Mokhtar, 2014). *Perceived Ease of Use* construct resulted to be difficult to measure as respondents did not know how to answer the questions proposed by Venkatesh & Davis (1994). Therefore, the lack of knowledge of the existence of this technology and the lack of experience using this type of system made impossible the inclusion of *Perceived Ease of Use* construct as it is presented in TAM model.

We have found similar constructs in previous studies. Among them, we underscore *computer self-efficacy* which is defined as "one's belief about her/his ability to perform a specific task using a computer" (Compeau & Higgins, 1995). Self-efficacy does not mean actual skills; instead it refers to a personal judgment in one's own capability. The more a person believes in his ability, the less effort he would expect to perform a specific task. There is plenty of empirical evidence that demonstrates the impact of *computer self-efficacy* on the *perceived ease of use* of a system (Venkatesh & Davis, 1994; 1996). Actually, computer self-efficacy beliefs, both positive and negative, act as a determinant of *perceived ease of use*, both before and after hands-on use, about any computer system. Potential users without hands-on experience with the system or with a similar tool base their ease of use perceptions on the confidence in one's digital self-efficacy beliefs, based on general technology and the systems they use daily such as smartphones and tablets and their related abilities and knowledge, irrespective of the extent of technical information given to users. An easy-to-use system is normally understood as a system that has certain features and standards similar to those of familiar systems. Henceforth, not including such features in a new IT system could have a significant negative impact on its acceptance. Objective usability is not significant before direct experience as hands-on use is needed to form system-specific ease of use perceptions.

NESTORE system is composed of many different devices. Thus, asking for each element that constitutes the system would lead us to evaluate IT Literacy as a whole. Additionally, the system usage requires a broader range of abilities than the skills needed to use a computer. For this reason, instead of including *computer self-efficacy* in the model, *IT Literacy* or *Digital Literacy* was incorporated in order to cover not only computer related abilities but also other technological devices such as smartphones,

tablets and wearable devices. As a compromise and in response to the foregoing, we decided to directly replace *Perceived Ease of Use* construct with *IT Literacy* construct due to its total reliance on the latter.

According to Hobbs (2010), *Digital Literacy* refers to "the ability to effectively and critically use a range of digital technologies". High levels of digital literacy enable individuals to make responsible choices and to access information and ideas in the digital world and share them with others; which is an important prerequisite in today's digital world. However, in particular for health related issues, low levels of digital literacy can pose barriers to the access and use of health information and eHealth tools, especially if paired with low health literacy (Chang, et al., 2004).

Moreover, as explained in detail by Anusca Ferrari (2013), *Digital Literacy* consists of five core areas or functions: information processing, communication, content-creation, problem-solving, and safety. This definition not only includes Hobbs' approach but also takes into account the skills to create or edit new content, participate in communities and networks, guarantee one's data protection and update one's own competences (Ferrari, 2013).

Users' prior technology usage experience can shape their belief in the new technology (Taylor & Todd, 1995). Positive experience helps users to feel more confident and perceive that they have the capabilities and resources to use technological systems (Lim, et al., 2011). Taken together with the digital divide which runs between those aged 55 or older and the younger generations, the inclusion of *Digital Literacy* construct within the current study was considered essential.

According to each one's IT Literacy level, users will put different levels of effort to learn how to use a new system. A user with high IT literacy is expected to be willing to learn and use a new system; however, a user with low IT literacy would perceive it as hard to use and would reject it. Therefore, we expect that a higher level of digital literacy likely leads to a higher acceptance of new digital offers (Bidmon et al., 2014). In addition, it has been demonstrated by (Beckers & Schmidt, 2001) that people with higher digital literacy show less computer anxiety, which also likely leads to greater openness toward new offers.

Moreover, according to the TAM model (Davis, 1989) and its related studies, self-efficacy contributes to increase overall user's performance (Bandura, 1982) and enables the user to better accomplish activities for the same effort, be it physical, mental or ease of learning (Radner & Rothschild, 1975). Studies reviewed by Holden and Karsh confirm that this is also true with regard to health-related digital devices as intuitive systems allow users to perceive them as more effective (Barker et al. 2003; Schaik et al. 2002; Liu et al., 2013; Weng, 2016).

Therefore, the following hypotheses can be assumed:

HYPOTHESIS 2a. *IT Literacy has a positive effect on the Intention to Use a coaching system for healthy ageing*.

HYPOTHESIS 2b. *IT Literacy has a positive effect on Perceived Usefulness of a coaching system for healthy ageing.*

3.1.3. The role of health interest: Health Literacy

Health Literacy is referred as "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions", according to U.S Department of Health and Human Services (2010) definition. However, *Health Literacy* is a relatively new concept and there is no consensus of its definition.

We have considered as a reference the European Health Literacy Survey (HLS-EU-Q47) conducted across eight European countries for the measurement of *Health Literacy* as the conceptual model has been validated. In this context, Health Literacy can be defined as "the ability to make sound decisions concerning health in everyday life" (Kickbusch & Maag, 2008), which is closely linked to *Empowerment* as it encourages people to increase control over their health, increase their ability to seek out information and increase their ability to take responsibility. This approach covers four cognitive domains (proficiency to access, understand, appraise and apply health information) within three health domains (health care, disease prevention and health promotion). The combination of the cognitive and health domains yields a matrix with 12 dimensions of health literacy as illustrated in table 2.

Table 2: Health Literacy Matrix (Source: European Commission 2011)

	Access/obtain information relevant to health	**Understand information relevant to health**	**Process/appraise information relevant to health**	**Apply/use information relevant to health**
Health care	Ability to access information on medical or clinical issues	Ability to understand medical information and derive meaning	Ability to interpret and evaluate medical information	Ability to make informed decisions on medical issues
Disease prevention	Ability to access information on risk factors for health	Ability to understand information on risk factors and derive meaning	Ability to interpret and evaluate information on risk factors for health	Ability to make informed decisions on risk factors for health
Health promotion	Ability to update oneself on determinants of health in the social and physical environment	Ability to understand information on determinants of health in the social and physical environment and derive meaning	Ability to interpret and evaluate information on health determinants in the social and physical environment	Ability to make informed decisions on health determinants in the social and physical environment

According to Kickbusch et al. (2013) and the European Health Literacy Survey (HLS-EU-Q47), there is a clear relationship between Health Literacy and the adoption of healthy behaviours. Low Health Literacy is associated with poorer health conditions (Sørensen, et al., 2015), higher mortality (Sørensen, et al., 2015) (Berkman, Sheridan, Donahue, Halpern, & Crotty, 2011) and unhealthy behaviours, such as smoking (Kickbusch, I.; Pelikan, JM.; Apfe,l F.; Tsouros, AD., 2013) (von Wagner, Knight, Steptoe, & Wardle, 2007), low physical activity (Fernandez, Larson, & Zikmund-Fisher, 2016) and less use of preventive services (Kickbusch & Maag, 2008) (Berkman, Sheridan, Donahue, Halpern, & Crotty, 2011).

There are some studies based on extensions of the TAM model that have included some domains of *Health Literacy* and demonstrate that they act as determinants of *Intention to Use* technology for health-related purposes. Among them, Cho et al. (2014) included the *Health Information Orientation* construct which is defined as "the extent to which a person actively seeks health information". They found that it positively influences on the *Perceived Usefulness* of health apps. Moreover, Ahadzadeh et al. (2015) defined *Health Information Seeking* as the "purposive seeking for information as a consequence of a need to satisfy some health goal". They demonstrated that it positively influences the *Intention to Use* the Internet for health-related purposes.

With a similar approach to the one taken in the present study, Mackert et al. (2016) defined *Health Literacy* as "how people obtain, understand, use, and communicate about health information to make informed decisions". In their study they founded that high levels of *Health Literacy* are significantly associated with greater *Perceived Usefulness* and *Perceived Ease of Use* of health information technologies.

In accordance with the above, we can conclude that people with high levels of Health Literacy are more likely to adopt health promotion behaviours and will develop an empowerment strategy to manage their health. Moreover, individuals with high levels of Health Literacy will have a higher perception of the benefits of new health-related technology, such as a virtual coaching system, perceiving it as a useful source of motivation and information. This leads us to the following hypothesis:

HYPOTHESIS 3. *Health Literacy has a positive effect on the Perceived Usefulness of using a coaching system for healthy ageing.*

3.1.4. The role of active participation in health control: Empowerment

Health empowerment refers to "social process of recognizing, promoting, and enhancing people's abilities to meet their own needs, solve their own problems, and mobilize necessary resources to take control of their own lives" (Jones & Meleis, 1993). In other words, it is the process by which one person increases his/her autonomy, knowledge and self-confidence to increase control over the factors, decisions and actions that affect their health and care and the process of gaining power externally over them. Empowerment implies an active involvement in the attainment of health goals and the promotion and caring of individual well-being enhancing self-care behaviours.

Even though proactive approach to care for one's well-being seems to have a clear impact on the acceptance of technologies that support health management, after an extensive literature review of past studies, we have not found one that has yet considered *Empowerment* as a predictor of the intention to use technological systems for health-care purposes.

Being empowered in relation to health has been important to the older populations in many Asian countries such as Korea (Park & Park, 2013) and Malaysia (Ahadzadeh, Pahlevan Sharif, Ong, & Khong, 2015). In the paper written by Ahadzadehet al. (2015), *health consciousness* which is defined as "the degree to which health concerns are integrated into a person's daily activities" is included as a new construct of the TAM model. Health-conscious people are considered those that are concerned about their well-being and, therefore, they are motivated to adopt healthy behaviours and preventive actions in order to improve and/or maintain their health. In this study *health consciousness* is found to significantly influence the intention to use the Internet for health management in a positive way; the effect is mediated by the *Perceived Usefulness* of using it.

Taking as a reference point what has been found about *health consciousness* in the previous study, we assume that *Empowerment* could be a predictor of the use of technological systems for health management. Given that *Empowerment* encourages people to be proactive in managing their health, it is expected that people that have high levels of health empowerment will easily perceive the benefits coming from an e-coaching system for healthy ageing than those that are not used to controlling the factors that affect their health. Also, empowered people will be more interested in using the coaching system to enhance self-care behaviours than people that have not taken the responsibility for their own health yet. According to the definition of health empowerment, we assume that empowered people will have higher health literacy levels as they will be constantly increasing their knowledge to manage their health effectively.

This leads us to the following hypothesis:

HYPOTHESIS 4a. *Empowerment has a positive effect on the Perceived Usefulness of using a coaching system for healthy ageing.*

HYPOTHESIS 4b. *Empowerment has a positive effect on Health Literacy.*

3.1.5. The role of a positive and active engagement in life: Attitude to life

Attitude to Life is considered as "a user's engagement in life and overall life satisfaction". A positive attitude towards ageing acts as a motivation to be active and directly influences on the likelihood that the individual will be willing to learn about new things and accept new advances in technology (Werner et al., 2011). Moreover, Johnson et al. (2010) found that positive attitude acts a motivational source, allowing people to cope with challenging situations and enhance capability levels. In this way, older people that have a positive attitude towards life are expected to have a higher IT

Literacy as there is higher likelihood that those people will be more skillful in using technology and they will be willing to put more effort to learn how to use new technologies.

As a positive attitude to life leads to more active lifestyles, we assume that users that are engaged with life will tend to be more empowered people. Additionally, an active lifestyle is positively related to perceived self-efficacy and, thus, it can positively affect behavioral intention to use technology (Chen & Chan, 2014). Related to this, the study by Teh and Yong (2011) suggests that older people sense of self-worth develops positive attitudes towards using technology and, in return, the use of technology increases older users' perception of self-efficacy. Therefore, users that have a higher attitude to life will tend to attribute gains to the use of the system and will perceive the system as more useful than those with a more negative sense of life.

It is therefore hypothesized that:

HYPOTHESIS 5a. *Attitude to life has a positive effect on IT Literacy.*

HYPOTHESIS 5b. *Attitude to life has a positive effect on Empowerment.*

HYPOTHESIS 5c. *Attitude to life has a positive effect on the Perceived Usefulness of using a coaching system for healthy ageing.*

3.1.6. The role of status within a social group: Image

Image is defined as "the degree to which use of an innovation is perceived to enhance one's status within a social group" by Moore & Benbasat (1991). Rogers (1995) stated in his work that "undoubtedly one of the most important motivations for almost any individual to adopt an innovation is the desire to gain social status".

As Pfeffer (1982) exposes, increased status within a group of reference is considered as a basis of referent power and influence. By performing behaviours that are consistent with group norms, an individual "achieves membership and the social support that such membership affords as well as possible goal attainment which can occur only through group action or group membership". The increased power and influence resulting from elevated status provides a general basis for greater productivity. In this way, *Image* can be seen as an aspect of relative advantage or *Perceived Usefulness* (Venkatesh & Davis, 2000).

Additional research has considered the importance of fashion or trends on users' acceptance and intention to use (Chang et al., 2016). Seymour (2008) defines fashionable technology as "designed garments, accessories, or jewellery that combines aesthetics and style with functional technology". As Pascoe & Thomson (2007) stated, smartwatches are an example of functional devices that are also socially and fashionably acceptable computing devices. Many other wearable devices can be considered as fashion items (Silina & Haddadi, 2015).

Therefore, the following hypotheses can be assumed:

HYPOTHESIS 6. *Image has a positive effect on Perceived Usefulness of a coaching system for healthy ageing*.

3.1.7. The role of social influence: Subjective norm

Subjective norm is defined as "the person's expectation that significant others expect them to perform some behavior" (Fishbein & Ajzen, 1975) or "a person's perception of the need to behave in a certain way due to social pressure" (Ajzen, 1991). According to the Theory of Reasoned Action's (TRA), social influence impacts on the behavioral intention to use a specific system or technology. People may choose to perform a behavior, even if they are not themselves favorable toward the behavior or its consequences, if they believe one or more important referents think they should, and they are sufficiently motivated to comply with the referents. For this reason, Venkatesh and Davis (2000) extended the TAM model and presented TAM2 including *Subjective norm* as a predictor of people's behavioral intention. *Subjective norm* was presented as *Social Influence* in the Unified Theory of Acceptance and Use of Technology (UTAUT) proposed by Venkatesh et al. (2003). Similarly to previous definitions, it was described as "the degree to which an individual perceives that important others believe he or she should use a system".

It should be taken into account that in voluntary contexts, *Social Influence* does not act as a direct determinant of behavioral intention to use a technology. Instead, *Social Influence* operates by influencing perceptions about the perceived usefulness of the technology (Venkatesh et al., 2003). This is because when as there is more people around the user that judge positively the use of a technology, the more the individual is induced to perceive its usefulness (Cho et al. 2014; Kim and Park 2012). According to the literature, the effect of *Subjective norm* on behavioral intention can be mediated by *Perceived Usefulness* in two different ways: internalization and identification (Venkatesh & Davis, 2000).

Internalization is defined as "influence to accept information from another as evidence about reality". Users perceive the referent person as an expert on the field and to incorporate the referent's belief about using a system, as if it was his/hers.

On another note, identification is related to the positive effect of social influence or Subjective norm on *Image*. This source of influence comes from the belief that by performing a behavior that important members of a social group encourage users to do, the individual increases his/her social status within the group (Pfeffer, 1982). Thus, complying with social norms allows individuals to establish or maintain a favourable image or status within their social group (Venkatesh & Davis, 2000).

In the healthcare field, important referents are considered family members, friends or doctors; whose perceptions, opinion and evaluation of a new technology affect users' decision about adopting or not a new technology. Even though previous studies (Chau

et al., 2001) about technology acceptance have found that social influence does not play an important role for health-related devices, they were all designed for professionals as end-users. When it comes to general consumers' adoption, empirical studies about mobile health applications have demonstrated that others' opinion can positively affect users' actual intention to use it (Jang Yul, 2014; Cho et al. 2014). Focusing on older adults as end-users, previous studies, such as the one developed by Conci et al. (2009), have shown that the elderly are influenced by social norms in order to accept a new technology. Moreover, the UTAUT (Venkatesh et al., 2003) establishes social influence effect is stronger for older users.

In addition, given that NESTORE system has not been already developed, Hartwick and Barki (1994) affirm that "when users' knowledge and beliefs about a system are vague and ill-formed, they must rely more on the opinions of others as a basis for their intentions". Henceforth, the lack of knowledge of the existence of this technology and the lack of experience using this type of system lead potential users to rely on important others' opinion. In the same vein, El-Wajeeh et al. (2014) found that consumers that are not familiar with a new technology, in particular in the healthcare domain, tend to rely on the opinion of people who are important to them. In this way, they can influence and push the user to use a new technology such as mobile solutions for adopting a healthier lifestyle. In other words, people readiness to receive mobile health services are affected by the perspective of other people.

Unfortunately, there is little research about the effect of Subjective norm on IT Literacy. However, it could be argued that some of the people that are important to the elder population aged 60+ such as relatives, friends and health care professionals who are already familiar with everyday technology, can induce the individual to improve his or her IT Literacy (Li and Luximon, 2018).

Based on these propositions, we establish the following hypotheses:

HYPOTHESIS 7a. *Subjective norm has a positive effect on the Perceived Usefulness of a coaching system for healthy ageing.*

HYPOTHESIS 7b. *Subjective norm has a positive effect on Image.*

HYPOTHESIS 7c. *Subjective norm has a positive effect on IT Literacy.*

3.1.8. The role of purchase decision: Willingness to pay

Willingness to Pay refers to "the maximum amount of money that a consumer is willing to pay for a certain quantity of a product or service" (Acquisti & Spiekermann, 2011). Consumers make purchase decisions based on a trade-off between their perception of the product's benefits relative to the costs (Luce, Bettman, & Payne, 2001). In other words, buyers' perceived value of a product is the result of the comparison between what they get against what they give. This is what is is usually called "value for

money". Sheth et al. (1991) developed a theory that suggests five consumption values: social, emotional, functional, epistemic, and conditional.

Traditionally, functional value is considered to be the main driver of consumer purchasing decisions. However, this is a rational approach about consumers' behaviour and does not cover certain important purchasing motivating forces.

Social value or *Image* is defined as "the utility derived from a product's ability to enhance social status within a social group" (Sheth, Newman, & Gross, 1991). It is the perceived utility that results from the positive effect that the acquisition of the product has on the consumer's perception or image within his/her reference group. Similar to what was explained in the previous section related to *Image* and *Subjective norm*, individuals maintain or enhance social status or gain social prestige within their reference group by performing behaviours that are consistent with group norms (Venkatesh & Davis, 2000).

Moreover, epistemic value refers to the feeling of novelty or curiosity that users could experience towards using the system. In this sense, it could be assumed that attitude to life, which is related to users' willingness to be active and learn about new things to be updated, would have a positive effect on their willingness to pay for an innovative product like NESTORE. Usually, consumers of this kind would purchase a product merely because it is novel or popular. However, the relationship between Attitude to Life and Willingness to pay for the system was not considered due to the need to focus and priorize possible relationships between behavioural determinants that could be more significant than this in order to infer conclusions.

The other two remaining consumption values (emotional and conditional) have not been considered in the present study. The former has not been included as it is unknown which feelings will the user receive from using the system. The latter, instead, refers to the temporary value of a product due to specific circunstances. As it completely depends on a specific context and the goal of the present study is to develop a model for overall conditions and for not a minority of cases, it was decided to not consider it.

So far TAM has been used only to determine factors that influence on consumer's online purchase intention. However, there are very few studies that allow the assessment of the factors that predict the *Willingness to Pay* for a technology (Bidmon, Terlutter, & Röttl, 2014).

On the basis of the abovementioned, we establish the following hypotheses:

HYPOTHESIS 8a. *Intention to Use has a positive effect on Willingness to Pay for a coaching system for healthy ageing*.

HYPOTHESIS 8b. *Image has a positive effect on Willingness to Pay for a coaching system for healthy ageing*.

HYPOTHESIS 8c. *Subjective norm has a positive effect on Willingness to Pay for a coaching system for healthy ageing*.

3.1.9. The role of demographic factors: Control variables

Adding control variables will increase the explanatory power. The control variables include gender, age, education, residence, form of cohabitation and having any kind of chronic disease that affects everyday life.

The most studied demographic variables on technology acceptance models include age, gender, marital status and education (Venkatesh & Davis, 2000; Venkatesh et al., 2003).

Increased age has been shown to be associated with difficulty in learning and using software systems due to age-related limitations and decline in functionalities. Therefore, the intention to use the system is expected to be greater among the youngest segments of the target population.

Moreover, men seem to be more interested in new technologies and to make use of their full potential. However, given that the aim of the intervention is to maintain and improve wellbeing which is a shared concern, the perceived usefulness of the system should be equal for both sexes and hence their intention to use a virtual coaching system for healthy ageing which is derived from it. Because of this, it is of interest to assess if men will have a higher intention to use the system due to the effect of having a higher IT Literacy and their greater interest in technology.

Marital status has been replaced by form of cohabitation. This is because of changing society habits in which unmarried cohabitation is considered an alternative to marriage and sometimes a variety of marriage. Currently, many people choose cohabitation instead of getting married due to fear of collapse and its related economic and emotional consequences.

It is generally believed that highly educated people concentrate in large cities due to higher wages and better amenities, which are the result of higher productivity. Moreover, a significant share of innovation occurs in big cities where knowledge spillovers come into play increasing productivity and workers' competence (Brinkman, 2015). However, there are downsides, urban populations struggle with huge environmental and health challenges. Air pollution caused by industries is becoming a common cause of death. In addition, city lifestyle induces to health diseases such as obesity, higher stress levels and diabetes. In line with these facts, we consider that the place of residence could be related to the intention to use a virtual coach for healthy ageing. In order to assess these effects we considered interesting to include the place of residence as a control variable of the model.

Patients with chronic diseases, who suffer throughout their lifetime, are more aware of their health condition and need constant health care. Thus, we propose that chronic diseases may push patients to use a virtual coach for healthy ageing because of the

associated convenience. Long-term monitoring of chronic diseases is very important for the treatment and transformation of diseases. We argue that whether users suffer from chronic diseases may affect the adoption intention toward coaching systems for healthy ageing to some extent.

HYPOTHESIS C1. *Younger elderly will have greater intention to use a virtual coaching system for healthy ageing.*

HYPOTHESIS C2. *Gender is significantly associated with intention to use; such that men will have higher intention to use a virtual coaching system to maintain their functional abilities.*

HYPOTHESIS C3. *A higher level of education has a positive effect on intention to use a virtual coaching system for healthy ageing.*

HYPOTHESIS C4. *Living environment or residence is significantly associated with intention to use a virtual coaching system for healthy ageing; such that living in a big city has a positive effect with respect to smaller settlements.*

HYPOTHESIS C5. *Form of cohabitation is significantly associated with the intention to use a virtual coaching system for healthy ageing; such that people living without any kind of support will be more likely to be interested in using a virtual coaching system to maintain their functional abilities.*

HYPOTHESIS C6. *Chronic diseases are significantly associated with intention to use a virtual coaching system for healthy ageing; such that chronic diseases may push patients to use the system because of the associated convenience.*

4. Methodology

In order to test the proposed theoretical model, a survey was developed in order to collect first-hand opinions from the potential users of the service. This chapter explains how the survey was designed, its main parts including the measurement of constructs and its subsequent administration for the data collection.

4.1. Research design

In order to collect the Data, a self-administered, non-experimental, cross-sectional and explanatory online survey was created. The survey was anonymous, in this way respondents could feel free to express themselves and reduce the risk of biased answers (Bush & Hair, 1985).

Self-administered surveys are expected to be more efficient because there is no need to have an interviewer for each interview and subjects are free to answer anytime and anywhere. Thanks to this, less biased responses and a more geographically diverse sample is obtained. In addition, online questionnaires allow customizing the survey questions dynamically.

Given that the researcher was not able to control, manipulate or alter neither the independent variable nor the participants of the survey, the research is considered as a non-experimental study. Analyses are based on the information gathered through the mere observation and interpretation of what is observed, which may be generalized to a larger population.

As the system is in its early stage of development and the study is constrained to be conducted within a limited time span, data collected depicts respondents' opinions and beliefs at a single moment in time. This is called a cross-sectional survey research, which allows conducting aggregated and comparative analyses.

Lastly, the theoretical model served to test relationships between two or more variables in order to determine cause-effect relationships. Thus, we considered the present research study as an explanatory survey.

4.2. Survey questionnaire

The survey questionnaire consisted of four main parts. The first part, which is the landing page, provided respondents an introduction of the project and its context.

The second part captured general information about the target sample: sources of information, actual usage and awareness of technology, healthy habits, self-reported health conditions and demographic characteristics. Questions regarding sources of information were presented in a combination of multiple choice, matrix and Likert scale format. For what concerns actual usage and awareness of technology, questions were obtained from Chen & Chan (2014) study; however, some questions were slightly modified to fit in the research's context. These items were measured in a three-choice selection between "Never heard of", "Heard of, but never used" and "Used or using"

linked to a scale score coded 1 to 3, respectively. By summing all items, a higher score indicated the respondent is more likely to use technology. Healthy habits, on the other hand, were measured using a combination of single choice, multiple choice and Likert scale format. Regarding self-reported health conditions, respondents indicated their perceptions on a scale from 1 to 10, where 1 is "Very bad" and 10 is "Very good". Lastly, demographic characteristics were presented in general as a single choice question or a free box to directly introduce the age, weight or height. In some multiple-choice questions, a free box to fill was added as an alternative in order to provide respondents the possibility to incorporate additional perspectives.

The third part involved questions regarding users' preferences with respect to the possible physical interface of the system. These items were introduced as a request of the designing team in order to create a tangible object that meets as much as possible potential users' requirements. A 7-point Likert scale ranging from 1 to 7, where 1 is "Dislike Very Much" and 7 is "Like Very Much" was used to evaluate 5 different physical interfaces. Additional questions regarding the tangible object and its features were introduced and measured with a 5-point Likert scale, where 1 meant "Strongly disagree" and 5 "Strongly agree".

The last part recorded the subject's perception of each construct in the model. The typical item tended to be a statement to which the respondent was asked to indicate his or her degree of agreement. A 5-point Likert scale, where 1 meant "Strongly disagree" and 5 "Strongly agree", was used to measure each item.

All items were translated and back-translated into Spanish by the researcher of the present thesis, then discussed and validated by other 2 researchers.

4.3. Constructs measurement

The nine constructs in the theoretical model were measured with a total of 39 items. Most of the measurement scales and items adopted have been widely used and validated previously. Therefore, prior to developing measurement instruments, an extensive literature review was conducted in order to find such scales in extant studies which were then evaluated in terms of their validity and reliability. However, some items were adjusted to take into account the context of this research and some new items were created when suitable instruments were not available. Items within each latent variable tend to have a lot of overlap in their meaning, which is consistent with the fact that they are intended as measures of the same underlying construct.

All measurement scales were evaluated to ensure contruct validity and reliability. Exploratory Factor Analysis, particularly Principal Component Analysis (PCA), and Cronbach's alpha were assesed in each of them, results that are shown in table 4.

The TAM construct of Perceived usefulness (U) was measured with 8 items, four of them adopted from the scale of Davis (1989). Given that Perceived Usefulness is not

considered in the present study as job performance and productivity but as benefits to the users, such as autonomy and better well-being, the content of the 8 items were substantially different from those of Davis'. Four additional items were added in order to assess the perceived usefulness of each of the four domains of NESTORE system (mental, physical, nutrition and social). These items were based on Davis et al. (1989) and Fishbein & Ajzen (1975) item of the construct Attitude Toward Behaviour ("Using the system is a bad/good idea.").

Meanwhile, Behavioural Intention to Use (BI) was measured with 5 items that were inspired by the scale of Davis et al. (1989). Similarly to Perceived Usefulness, items were adjusted to fit the context of the study and assess the intention to use NESTORE system for every domain that it covers. Moreover, three additional items were added which represented the compatibility of using the system with users' existing values and lifestyle (Chang, Lee, & Ji, 2016). We assumed that users' intention to use the system would be uncounsciously influenced by the consistency between the usage of the system and their daily routine. Items were adopted from Wua, Wanga, & Lind (2007) study.

IT Literacy (ITL) was measured with 5 items adopted from The Digital Competence Questionnaire developed by Al Khateeb (2017). In this case, some examples were provided to clarify the question asked in each measurement item.

Health Literacy (HLT) is measured with three items pertaining to healthy behaviours from the HLS-EU-Q47. At first, a set of 10 questions were selected from the HLS-EU-Q47. However, once the measurement items were assessed using Principal Component Analysis (PCA), two factors were determined and items were distributed in two possible scales: one referred to health problems and its related treatment and the second to prevention and healthy behaviours. Among these, the second scale was chosen due to its better adequacy to the context of the project. Finally, with the aim of meeting the necessary criteria for convergent validity (AVE and CR), these three measurement items that form the construct were considered to be the most appropriate.

Empowerment (E) is measured with four items: three of them were inspired by the K-HES scale of Park & Park (2013), which were modified to focus on health promotion and prevention; the fourth item was adopted from The Health Education Impact Questionnaire (heiQ).

Attitude to life (ATL) was also measured with two items obtained from the The Health Education Impact Questionnaire (heiQ) made by Osborne et al. (2007). In their study, among others, the dimension "Positive and Active Engagement in Life" is measured with 5 items and assesed using PCA to confirm internal consistency, validity and reliability. From the five items, two were selected.

Image (I) was considered and measured consistently with the items proposed by Moore & Benbasat's (1991) approach. The construct is made of four measurement items that are obtained from the extended TAM2 and modified taking into account the social value

construct proposed by Sweeney & Soutar (2001) to fit into the context of the study. This is largely due to the difference between the system under consideration in both studies: Moore & Benbasat were analyzing IT innovations within organizations to improve performance, whereas the present study analyzes a system made of wearable devices to improve and promote wellbeing. Also, regarding the fact that many wearable devices can be considered as fashion items (Silina & Haddadi, 2015), items related to status and conspicuousness proposed in Boguslaw's study were taken into account (Boguslaw, 2015).

Subjective norm (SN) measurement items were inspired by the scale of Venkatesh & Davis (2000). However, we directly alluded to the users' friends, family and general practitioner instead of the general approach of defining them as people who influence users' behaviour or people that are important to users.

Given that NESTORE is an especially unfamiliar good, the measurement of Willingness to pay (WTP) was the most difficult construct to determine a valid scale to avoid biased answers, which is particularly common when asking about the purchase intention. Three measurement items were selected from Dodds, Monroe & Grewal (1991) multi-item indicators and, similarly to other constructs, items were modified to fit the context of the present study.

Exploratory factor analysis (EFA) was conducted using Principal Component Analysis (PCA) applying Kaiser rule for factor retention (1960), thus, an extraction criterion of eigenvalue greater than one. In order to facilitate the interpretation of the factor loadings, an orthogonal rotation was done to find clusters of variables that are highly correlated with a particular factor and define it. In addition, factor loadings for the items were required to be greater than 0.7.

With regard to reliability and internal consistency, Cronbach's alpha for all constructs is above the 0.7 threshold for early stages of research (Nunnally & Bernstein; 1994). It ranges from 0.74 to 0.97. Moreover, item-rest correlations were considered to detect items that fitted poorly and distorted the scale as they may not be measuring the same construct as the other variables. Altogether, it is demonstrated that measurements have strong and adequate reliability and validity.

Table 3: Constructs, measurement items and resulting Cronbach's alpha.

Construct	Items	Measurement item
Behavioural Intention to Use (ITU)	ITU1	I would use NESTORE to manage my lifestyle.
	ITU2	I would use NESTORE to maintain my physical well-being.
	ITU3	I would use NESTORE to maintain my mental well-being.
	ITU4	I would use NESTORE to maintain my social well-being.
	ITU5	I would use NESTORE to control and manage my nutrition habits.
	ITU6	Using NESTORE would fit well with my lifestyle.
	ITU7	NESTORE would be a nice fit for my daily routine.
	ITU8	Using NESTORE for my routine activities is compatible with how I like to do things.

Construct	Items	Measurement item
Perceived Usefulness (PU)	PU1	Using NESTORE to help me maintain and improve my mental well-being is a good idea.
	PU2	Using NESTORE to help me maintain and improve my physical well-being is a good idea.
	PU3	Using NESTORE to help me manage and improve my nutrition well-being is a good idea.
	PU4	Using NESTORE to help me maintain and improve my social well-being is a good idea.
	PU5	Using NESTORE is beneficial to improve my overall well-being.
	PU6	NESTORE would make it easier to have a healthy lifestyle.
	PU7	I would find NESTORE useful in my life.
	PU8	I think it would be useful for my health to use NESTORE to monitor my lifestyle.
IT Literacy (ITL)	IT1	I am aware of chat messages (e.g. voice messaging, SMS, text exchange, Skype chat).
	IT2	I can use a wide range of communication tools (e-mail, chat, SMS, instant messaging, blogs, micro-blogs, social networks) for online communication.
	IT3	I can use online services (e.g., e-banking, public services, online shopping...etc.)
	IT4	I am aware of social networking sites (e.g. Facebook, Twitter, and Instagram) and online collaboration tools (e.g. Slack, Skype, Dropbox, and Google Drive).
	IT5	I can pass on or share knowledge with others online (e.g. via social networking tools or in online communities).
Health Literacy (HL)	HL1	How easy would you say it is to understand health warnings about unhealthy behaviours such as smoking and low physical activity?
	HL2	How easy would you say it is to find out about activities that are good for your mental well-being?
	HL3	How easy would you say it is to judge if your everyday behaviour (such as drinking and eating habits, physical activity, etc.) has a positive or negative impact on your health?
Empowerment (E)	EMP1	I can set up a plan to achieve health prevention goals (e.g. get adequate rest daily, get regular physical activity, etc.).
	EMP2	On most days of the week I set aside time for healthy activities (sport, cooking, etc.)
	EMP3	I can try out various ways to overcome hurdles to my health care goals (e.g. get adequate rest daily, get regular physical activity, eat more plant based foods, achieve/maintain a healthy weight, be free on dependence on tobacco, etc.).
Attitude to Life (ATL)	ATL1	I try to make the most of my life.
	ATL2	I am doing interesting things in my life.
Image (I)	IM1	The use of NESTORE will improve the image others have on me.
	IM2	Innovative technologies such as NESTORE are a symbol of wealth/social status.
	IM3	NESTORE can be used to impress other people.
	IM4	I would like to be seen wearing or using a NESTORE device.
Subjective Norm (SN)	SN1	My relatives think a virtual coach such as NESTORE would help me to manage my lifestyle.
	SN2	My General Practitioner thinks a virtual coach such as NESTORE would help me to manage my lifestyle.

Construct	Items	Measurement item
	SN3	My friends think a virtual coach such as NESTORE would help me to manage my lifestyle.
Willingness To Pay (WTP)	WTP1	Paying for NESTORE would be a good value for money as it is an intelligent system that would help me manage my overall well-being.
	WTP2	I would be willing to pay for NESTORE system as it will offer me a customized and proactive service to maintain a healthy lifestyle.
	WTP3	I feel that NESTORE is an unnecessary expenditure.

Table 4: Average variance extraction (AVE) and composite reliability (CR) for the research constructs.

Construct	Items	Factor loadings	Cronbach's Alpha
Behavioural Intention to Use (ITU)	ITU1	.904	.9563
	ITU2	.894	
	ITU3	.872	
	ITU4	.894	
	ITU5	.889	
	ITU6	.856	
	ITU7	.871	
	ITU8	.830	
Perceived Usefulness (PU)	PU1	.913	.9752
	PU2	.947	
	PU3	.947	
	PU4	.922	
	PU5	.937	
	PU6	.911	
	PU7	.886	
	PU8	.925	
IT Literacy (ITL)	IT1	.766	.8751
	IT2	.879	
	IT3	.789	
	IT4	.864	
	IT5	.795	
Health Literacy (HL)	HL1	.742	.7442
	HL2	.835	
	HL3	.864	
Empowerment (E)	EMP1	.803	.7865
	EMP2	.874	
	EMP3	.842	
Attitude to Life (ATL)	ATL1	.912	.7976
	ATL2	.912	
Image (I)	IM1	.806	.8585
	IM2	.847	
	IM3	.879	
	IM4	.847	
Subjective norm (SN)	SN1	.882	.9101
	SN2	.936	
	SN3	.943	
Willingness To Pay (WTP)	WTP1	.889	.8336
	WTP2	.911	
	WTP3	.803	

4.4. Survey administration and data collection

The survey was conducted between December 2018 and February 2019 through the online survey tool *Survey Monkey* after the Internal Review Board (IRB) of the project approved and verified the completeness, wording, and appropriateness of the instrument and its content. Several iterations were conducted and feedback served as a basis for correcting, refining and improving the questionnaire.

Online participants were reached with the help of *Sociedad Española de Cirugía Ortopédica y Traumatología* (SECOT), *Fundació Salut i Envelliment* and Universities of the Third Age such as Comillas Pontifical University (ICADE) and University of Navarra. All of them were given the inclusion criteria for the study as the sample was limited to Spanish older adults that are 60 years or older that are able to read and write in Spanish. Current use of health-related technological solutions or smartphone technology was not an inclusion criterion because the survey was also available in computer and tablet format to obtain as many responses as possible.

The typical time spent filling in the questionnaire by the respondents has been 30 minutes approximately, a little more than expected. The length of the questionnaire resulted to be a handicap to obtain answers and even more to obtain high quality answers which means that the survey has been completely filled in by the respondent.

5. Data Analysis and results

Through the questionnaire, it has been attempted to further explore the target population by collecting demographic and behavioural information about the users. In this way, identify both pains and gains to better understand users' needs and experiences that motivate them to use a virtual coaching system for healthy ageing such as NESTORE. The results obtained will complement the data collected through the desk analysis which has been done in previous studies in order to create a complete picture to design a sustainable business model. Microsoft Excel was used for conducting the descriptive analysis.

With respect to the identification of behavioural determinants of the intention to use a virtual coaching system for healthy ageing, the research model was transferred into a structural equation model (SEM) to analyse the causal relationships between the constructs. The SEM Builder of STATA 14 was used for this purpose. The level of significance was set at 0.05.

We obtained 251 responses with a 75% of completion rate. However, only 196 responses were used for the data analysis after conducting data screening and validity checks. Responses with a high number of missing values, which is considered having more than a 10% of blank items, were deleted. Common Method Variance (CMV), which is related to the variation in responses caused by the instrument rather than the actual inclinations of the respondents, was also controlled and tested by conducting ex-ante and ex-post remedies.

In order to avoid CMV, ex-ante research remedies were applied to the questionnaire design. In the introduction of the survey respondents were assured of the anonymity and confidentiality of the study and the inexistence of right or wrong answers. In the same vein, respondents were asked to answer as honestly as possible and to avoid giving answers that are socially desirable or acceptable.

In addition, ex-post remedies were also conducted by applying Harman test. Given that the total variance of the common factor of all items from each of the constructs was less than 50%, CMV was concluded to not be a pervasive issue and hence it did not affect the data and the results.

5.1. Descriptive analysis

The value proposition of a product or service is fundamental to create a sustainable business model. It represents the reason why potential users will use your product instead of relying on other methods or products that cover the same need.

With this purpose, the survey allowed to complement information about users with useful insights that can only be gathered by directly asking users, and not through desk analysis. Its aim was to provide a comprehensive vision of the user and help us build empathy with potential users. In this way, it has been possible to further understand users' needs, preferences, feelings, attitudes and preventive measures taken to maintain their wellbeing; which, in turn, might be useful to identify possible stimulus and

incentives to encourage the use and purchase of a virtual coach for healthy ageing. Evidence from the literature is presented along with the results.

5.1.1. Demographic characteristics of the participants

Demographic characteristics allow determining if the results obtained through the questionnaire can be generalized to the whole Spanish population that falls within the target segment of the project: older adults aged 60+ that have good health condition, which also includes people with mild chronic conditions.

In accordance with the requirements, the population sample is composed of Spanish citizens that are 60+. In order to restrict the answers to this range of age, we included in the introduction of the questionnaire a description of the project and the inclusion criteria for the study to fill it in (see Appendix 1). Also, a question about the respondent's age was added and it only allowed people to answer a digit greater than 60.

Table 5: Overview of demographic characteristics of the study sample

Variable and category	Study sample data (N=196)
Gender	
Men	64.2 %
Women	35.8 %
Age (years), mean (SD)	69
Age limits (years)	60 - 87
Age categories (years)	
60-70	36.9 %
71-80	48.2 %
>80	14.9 %
Education level	
No schooling	1 %
Less than high school	2.7 %
High school degree	20.9 %
Bachelor's degree or more	75.4 %
Occupation	
Unemployed	1.6 %
Retired	83.4 %
Employed full time	3.8 %
Employed part time	4.8 %
Other	6.4 %
Place of residence	
Big city (100.000+ inhabitants)	76.5 %
Small town (between 5.000 and 100.000)	18.7 %
Rural area (less than 5.000 inhabitants)	4.8 %
Form of cohabitation	
Alone	13.9 %
With my partner/family, supporting me	35.8 %
With my partner/family, but without the need of support	47.6 %
Alone but with need of continued assistance	0 %
I live in a retirement home	2.7 %
Suffering from chronic diseases	
Yes	36.4 %
No	63.6 %

With regard to the gender, females constituted the 36% of the sample while males outnumbered females accounting for the 64% of responses. Comparing the survey data with the real data, the distribution of the sample in terms of gender is not very similar to the Spanish adulthood. This is due to the fact that the prevailing gender of older adults in Spain is female and not male, because of a higher mortality rate of men.

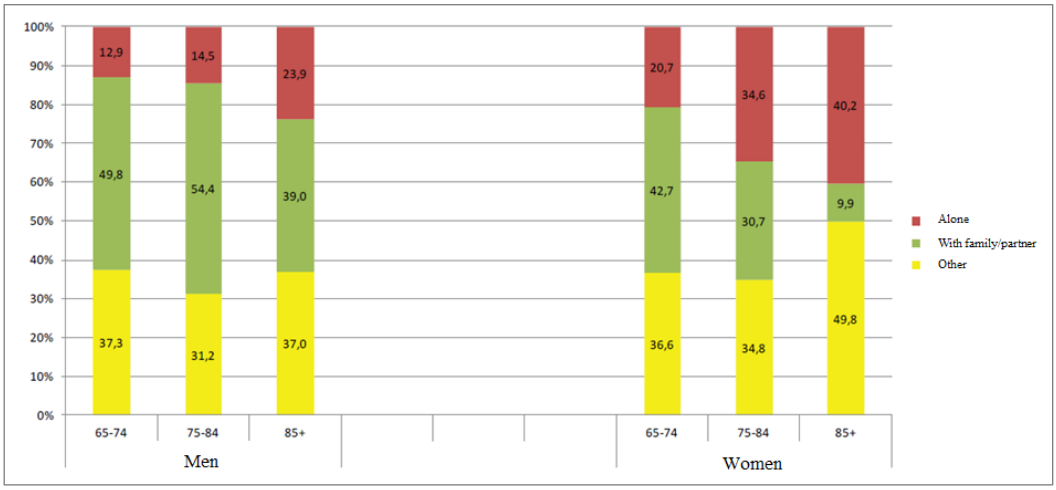
The average age of respondents is 69 and most of them affirm to be retired (83.42%). This is consistent with the age restriction to fill in the survey and the fact that Spanish citizens can only retire with 65 years and if they have already worked a minimum of 38 years and 6 months (Wit, 2016).

For what concerns education, it was surprising that the majority of respondents showed a high educational level, with an impressive proportion, 75.40%, of graduated people. These figures can partially be explained by the fact that some Third Age Universities such as ICADE, Universidad de Navarra and Universidad de Barcelona helped us with the dissemination of the survey among their students, who are mostly highly educated and culturally active seniors. Besides, the questionnaire was required to be filled in online, which restricts respondents to older adults that already have a greater tendency to use technology than the average older adult.

Urban population living in metropolitan areas or big cities account for the majority of respondents (76.47%) while respondents that live in a small town or in a rural area account for 18.72% and 4.81% respectively. In addition and consistently with the results about education, it is generally believed that highly educated people concentrate in large cities (Brinkman, 2015).

Instead of asking for the marital status, we considered to be more interesting to understand if the potential consumers are living with any kind of support or help in their daily activities and routine. Additionally, nowadays unmarried cohabitation is considered an alternative to marriage and sometimes a variety of marriage.

Figure 38: Percent distribution of forms of cohabitation among Spanish population 65+ by gender and age, 2016 (Source: INE/INEBASE. Elaboration: CSIC)

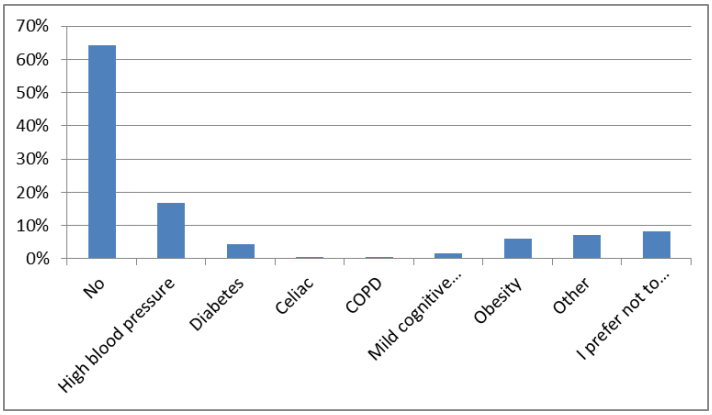


As reported below, the majority of respondents live with their partner/family. They are distributed between those that accept the support of their relatives and those who consider that they do not need support, accounting for 35.83% and 47.59% of all respondents respectively.

A little percentage (2.67%) represents people living in a retirement home. This form of living is becoming a new trend among the elderly, particularly in urban areas, since more women chose to work full-time and have less time to take care of their own elderly. In Spain, most of these facilities offer personal care, 24-hour emergency care, social and recreational activities to residents.

The majority of respondents (63.64%) consider not suffering any serious health condition that limits their everyday life. However, this is a far lower figure than 2014 data, in which people aged 65 and over reporting some limitation in their daily-life activities only reached 20.3% in Spain compared to 23.7% in EU27 countries. For severe limitations, figures were 5.4% in Spain, below the EU27 average of 8% (Bernal-Delgado, et al., 2018).

Figure 39: Health issues limiting everyday life



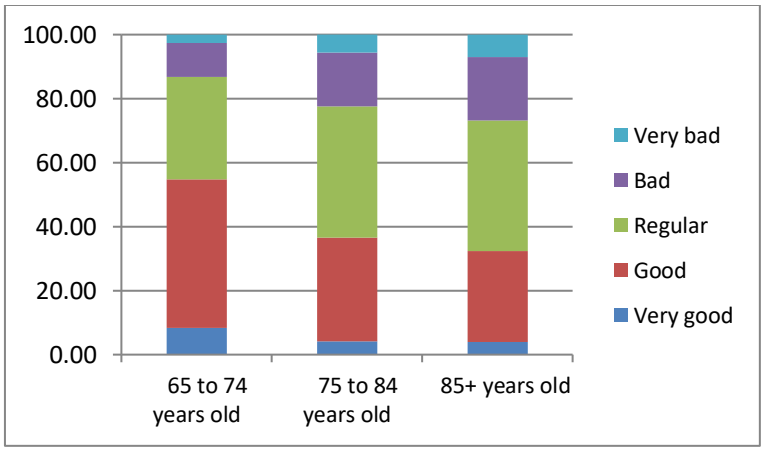
5.1.2. Self-reported health conditions

Individual perception about each one's health status can differ considerably from the real health status of the person. Users' thoughts and feelings about his or her health status may be an important motivator to maintain or improve well-being. Thus, self-reported measures about health conditions are thought to be useful to understand and predict the inclination of potential users towards a virtual coaching system dedicated to promote well-being in the older adulthood.

Self-reported health status

Respondents self-assessed their health condition on a scale from 1 to 10, where 1 was considered as "Very bad" and 10 "Very good". The weighted average of the values given by respondents is 7.37, which corresponds to people reporting good health and is consistent with the data obtained from MSCBS and INE in 2017 for the age group 65-74 years old that corresponds with the average age of respondents.

Figure 40: Self-reported health status (Source: MSCBS e INE)



Self-reported quality of life

Respondents declared to have a high quality of life. The weighted average of responses is 7.88 over 10 on a scale from 1 to 10, where 1 was considered as "Very bad" and 10 "Very good". This slight difference to self-reported health status is probably because the concept of quality of life is understood to be "overall general well-being that comprises subjective evaluations of physical, material, social, and emotional well-being together with the extent of personal development and purposeful activity, all weighted by a personal set of values" (Felce & Perry, 1995).

Perception of weight

A high proportion of respondents (65.35%) consider being over the right weight. Among those, a considerable proportion (10.96%) declares to be very overweight. Only a 30.70% of respondents consider being about the right weight. Analyzing results separately for both genders, we find significant differences in between them.

In general, women are under constant pressures to have the ideal body shape during their lifespan. However, elder women seem to be more satisfied with their body than younger women. Meanwhile, as men age they are more likely than women to experience a sense of decreased attractiveness, which leads to a change in men's perceptions and attitudes regarding their physical appearance. Thus, elderly men are more likely to express less positive attitudes about their body and appearance and at the same time this might lead them to stop taking care of their nutrition and weight (Baker & Gringart, 2009).

In accordance with the above, a high proportion of men affirm to be slightly or very overweight, 58% and 12% of men respectively. Even though a significant number of women self-report to be about the right weight (38%), there is a high percentage that state to be slightly overweight (45%) or overweight (10%). If we link the objectives of the target population related to weight objectives with self-perception of body image we can deduce some important characteristics of the sample studied.

Table 6: Self-perception of body image and weight objectives by gender

	MEN				WOMEN				
	Tot	**Lose weight**	**Stay the same**	**None**	**Tot**	**Lose weight**	**Stay the same**	**None**	**Gain weight**
About the right weight	**27%**	14%	83%	3%	**38%**	4%	86%	11%	0%
Slightly underweight	**2%**	0%	100%	0%	**7%**	0%	40%	20%	40%
Slightly overweight	**59%**	68%	29%	3%	**45%**	73%	21%	6%	0%
Very overweight	**12%**	80%	7%	13%	**10%**	100%	0%	0%	0%

From the previous table, we can see that a considerable proportion of elders who consider to be slightly underweight feel comfortable with their weight and try to keep it the same or do not worry about doing anything about it. In addition, some of those who declared to be about the right weight are willing to lose weight. This could be due to the effects of cultural influences on body image. In this respect, there is a cultural prejudice in favor of slenderness and against overweight in affluent Western societies. Slenderness is generally associated with happiness, success, youthfulness and social acceptability. Being overweight is linked to laziness, lack of will power and being out of control (Baker & Gringart, 2009). Only a few women that consider being slightly underweight intend to gain weight, while none of the men with the same perception of their weight do.

Additionally, BMI has been calculated based on each respondent's height and weight data. In this way, self-perception of weight and real BMI have been compared in order to better understand the target population general desire with respect to their body image. As shown by table 7 and following the foregoing, there is a considerable percentage (20%) that even though their BMI is within the healthy range, they consider to be slightly overweight.

Table 7: BMI and self-perception of body image

		Slightly underweight	**About the right weight**	**Slightly overweight**	**Very Overweight**
BMI	**Healthy range**	7%	72%	20%	0%
	Overweight	1%	9%	74%	15%

Altogether, we can argue that the former slice of the sample population is not completely satisfied with its own weight and would potentially be more inclined towards solutions to keep or lose weight.

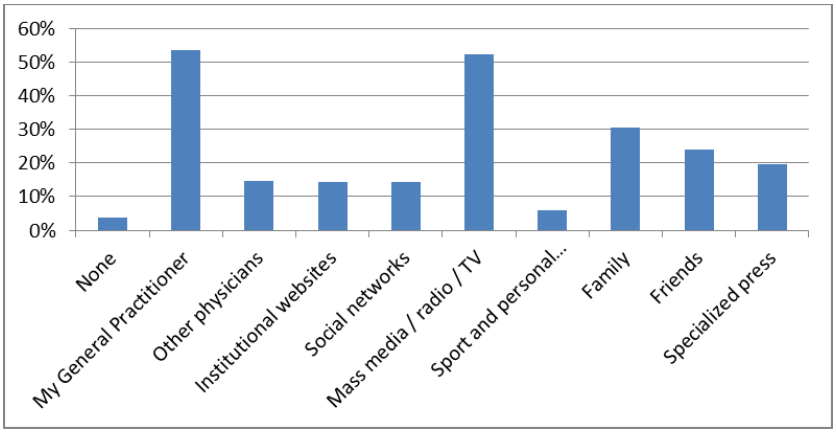
5.1.3. Sources of information

Users encounter in their daily experiences different people and activities. Among these interactions, it is paramount to know users' habits and preferences when obtaining health advice and especially identify their most reliable sources. In this sense,

understanding the role of family, friends and health care professionals as well as the different communication channels can be crucial to design an effective marketing strategy to raise awareness of the product and to promote its use.

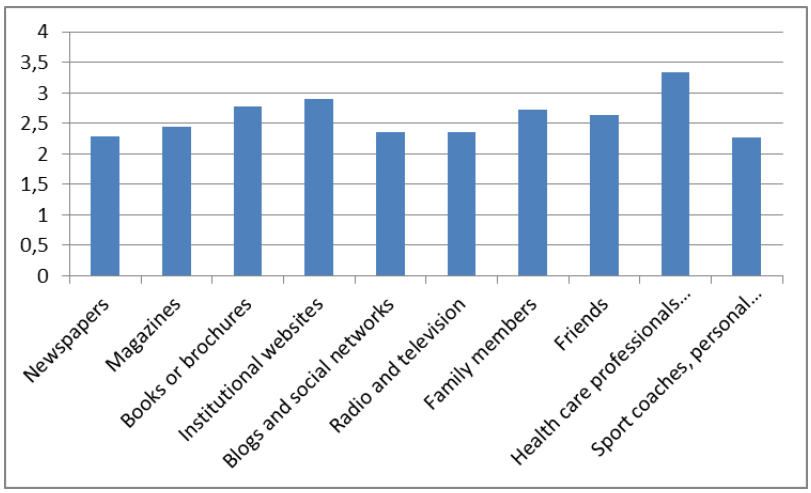
In order to obtain information about healthy lifestyles and disease prevention, senior adults rely especially on their general practitioner (53.78%) and mass media (52.19%). Family (30.68%) and friends (23.51%) result to be their alternative sources of information and, to a lesser extent, elders consult specialized press (20.32%), institutional websites (14.34%) or ask advice in social networks (15.14%).

Figure 41: Sources of information about healthy lifestyles



Keeping in mind the order of preferences to obtain information about healthy lifestyles, respondents' rating about the reliability of each source was not totally consistent with it. Health care professionals received the highest score over 4, where 1 was "None" and 4 was "Excellent", with a punctuation of 3.34. Institutional websites and books or brochures are the two next more reliable sources of information according to the survey data with a punctuation of 2.89 and 2.78, respectively. Family and friends are considered in a similar way. Surprisingly, even though people typically rely on mass media such as radio and television to find information, it did not receive such a good punctuation, 2.35 points out of 4.

Figure 42: Reliability of sources of information about healthy lifestyles



Note, however, that 56.57% of respondents did not punctuate reliability of personal trainers and sport coaches as they selected the option "Don't know". From this information, we can deduce that few people of the target population are familiar with the concept and benefits of coaching. Moreover, there is a considerable proportion that declared to not know about the reliability of information about healthy lifestyles published in institutional websites (24.70%) and blogs or social networks (26.69%). The former could be due to the lack of habits among the target population in using the Internet to search information; while the latter could be because not everybody uses social networks to gather information about healthy lifestyles or disease prevention but for social relationships and entertainment.

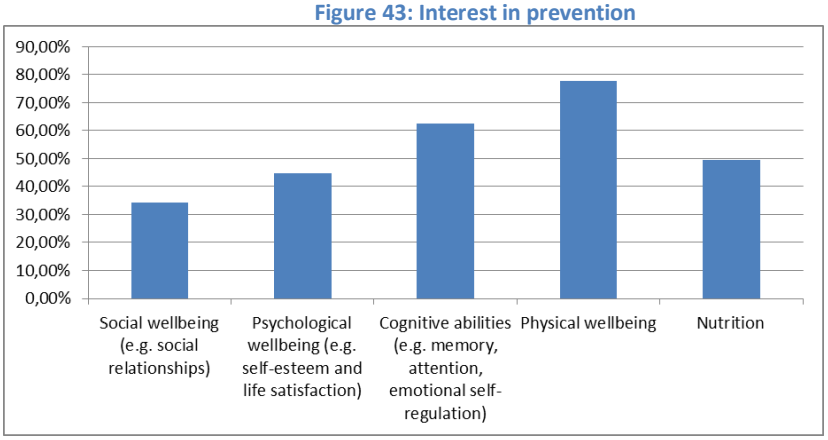
As word of mouth advertising comes into focus, almost half respondents (48.02%) declared to be undecided if they would recommend or not NESTORE. This appears due to the uncertainty about the benefits and usefulness of the system which is related to the lack of knowledge about the existence of this type of technology and the lack of direct experience using this type of system.

5.1.4. Healthy habits and lifestyle

Behaviours and actions taken by users in order to have a healthy lifestyle and maintain their wellbeing provide useful information about their main interests and preferred activities. As well, it allows determining points of improvement in their lifestyles and negative experiences and emotions that users experience in the process of adopting healthier habits.

Elders seem to care about their physical wellbeing first; 77.69% of respondents stated to be interested in this domain. Cognitive ability is the second concern in the ageing process with a 61.75% of interest among respondents. Nutrition is the third interest with 49% of frequency. Unexpectedly, even though Spain is part of the Mediterranean culture in which a balanced social life matters, social wellbeing was the least selected domain with just a 34.26% of frequency in responses. Another possible explanation is that Spanish elderly people already have plenty of social interactions everyday as a result of their personality and culture. Actually, almost half of respondents (46.61%) indicated to belong to a group, association or network where they share their experiences with other people.

Figure 43: Interest in prevention



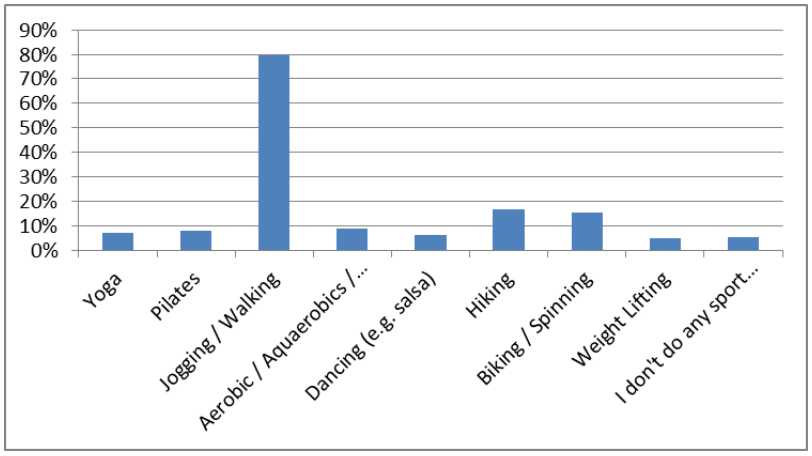
Fitness daily habits

Focusing on the physical activities that the target population does, respondents were asked about their fitness daily habits taking as reference the previous week of the moment in which they filled in the survey. Surprisingly 68.42% of respondents declare to be physically active at least 30 minutes 5 days a week, many of whom (37.28% of respondents) affirm to do physical activities daily (e.g. climb stairs, walk). The recommended level of activity for an adult is at least 30 minutes of moderate activity, five times a week. According to London's Department of Health (2004), this amount of 30 minutes can be accumulated throughout the day in shorter periods of 10 minutes or more.

Concerning gymnastics or aerobic exercises such as weight lifting, push-ups or sit-ups the frequency of performance drops sharply. The 42.11% of the sample declares to not have performed any kind of muscular tone exercise in the last week.

As can be clearly seen in figure 44, the target population prefers dynamic and outdoor activities such as walking, jogging, biking and hiking rather than static exercises such as weight lifting. There is an overwhelming majority, 79.39% that prefer to walk or do jogging compared to other sports. Respondents had the option to include sports that did not appear in the answer choices; many of them listed swimming, paddle tennis, gymnastics and golf. There is just a 5.26% of the sample that does not do any sport exercise.

Figure 44: Sport exercises usually done by respondents



However, the benefits of walking, which is the main mode of aerobic exercise among older adults, cannot be transferred to improving balance, have no effect on preventing falls and no clear benefit in relation to strength. Henceforth, strength and balance training should be promoted by the virtual coach to include them in elder's daily exercise routine.

Nutrition daily habits

The 48.68% of the target population declared to consume fruit two or more than two times per day; however, 61.40% declared not to consume vegetables in a daily basis but

once every two days. With regard to the consumption of carbonated drinks, many of them, 52.31%, do not drink them while 30.09% drink a can, bottle or glass of soda once a week. Also, 95.83% of the target population consumes breakfast every day. Given that the daily consumption of fruit, vegetables and breakfast is suggested in many diets and on the contrary, the consumption of sodas is discouraged by dietitians; we can deduce that the target population tends to follow a healthy diet.

Additionally, respondents were asked about specific diets (e.g. vegetarian) or eating styles. The 80.26% of them does not follow any specific diet. The remaining 18.5% was equally distributed in between semi-vegetarian, glucose free and the option added by respondents, the Mediterranean diet. Among those who follow a specific diet there is more people whose motivation to do it is an election (55%) rather than a necessity (45%). The voluntariness of following a specific diet also reflects the tendency of elderly to follow a healthy diet and to control their nutrition habits.

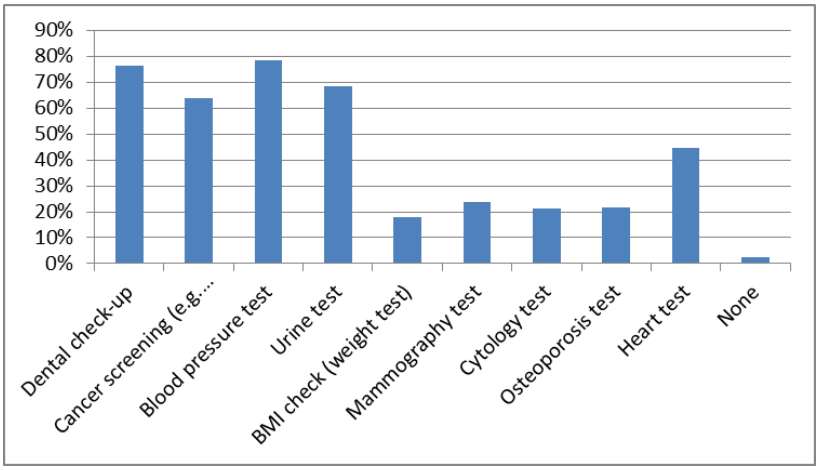
Smoking

Almost all respondents affirmed to be nonsmokers (93%) and those who did, declared to smoke less than 5. Since 2006, daily smokers have decreased thanks to the 2010 anti-tobacco law (Law 42/2010) which established a much stricter regulation than the one in 2005 (Bernal-Delgado, et al., 2018).

Diseases prevention and health exams

There is just a 2.19% of respondents that state not to undergo regularly any medical examination.

Figure 45: Regular health exams in order to prevent diseases or health problems.



Taking into account that only 36% of respondents are women and some of the health exams are only for women such as the mammography and the cytology test (where we assume that there have been some errors as few men listed them), we must not consider absolut results but relative ones with respect to the gender to which each exam applies fundamentaly. Respondents also pointed out other health exams such as osteoarthritis

exams, visit an oculist, a neurologist or an otologist, glycemia control and general blood test.

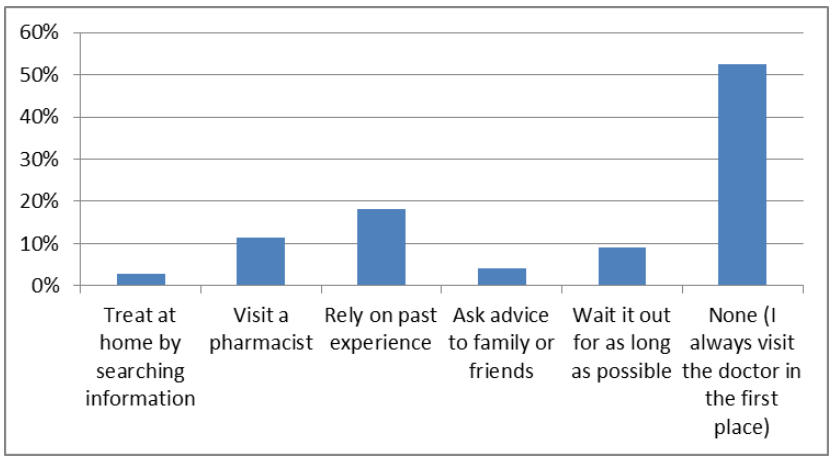
Table 8: Regular health exams by gender

	Dental check-up	Cancer screening	Blood pressure test	Urine test	BMI check
Men	74%	74%	85%	78%	19%
Women	84%	48%	63%	53%	15%

	Mammography test	Cytology test	Osteoporosis test	Heart test	None
Men	2%	5%	2%	51%	2%
Women	78%	62%	60%	33%	1%

There are some elders that before addressing themselves to the doctor tend to rely on past experience as their first option (18.45%), visit a pharmacist (10.73%) or wait it out for as long as possible (9.01%). To a lesser extent, some people ask advice to family or friends (3.86%) or treat at home by searching information (2.58%). Fortunatelly, the great majority visit the doctor in the first place (53.22%).

Figure 46: Solutions adopted before addressing a doctor



5.1.5. Current use of technologies

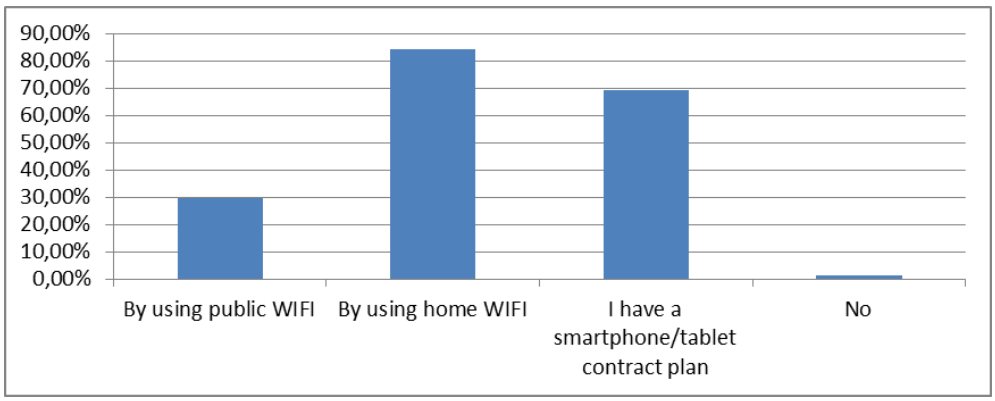
Given the fact that the intervention will be delivered through a bundle of technologies and there is still an existing digital divide, gaining further knowledge about users' awareness and familiarity with everyday technologies is crucial. In particular, learning about users' knowledge and previous experience using mobile health interventions plays a crucial role in understanding system-specific properties or attitudes that made users use and stay engaged as well as those that made users reject the use of the intervention or stop using it. In this way, by learning from past errors, it is intended to design a suitable and personalized experience that will be able to attract and retain users by engaging them and ideally turn them into referrals of the service.

Fortunately the digital divide has been decreasing over the years, and, as shown in the survey data, the target population is already familiar with technologies.

With regard to the awareness and familiarity with everyday technological items such as smartphones, computers, remote control devices, electric cooking products (e.g. Thermomix) and smartwatches; the average score of respondents was 58 over 69. The score is computed by summing the punctuation that is given for each object, which linked to a scale score, coded 1 to 3. Thus, the minimum that a respondent can obtain is 23, which correspond with the number of questions related to different technologies, and the maximum is 69. This figure reflects a good knowledge basis of everyday technologies. However, if we distinguish in between genders, we find that women have a lower level of technological knowledge with an average score of 56 while men have an average score of 59, which is consistent with the statements made in *Section 2.5*.

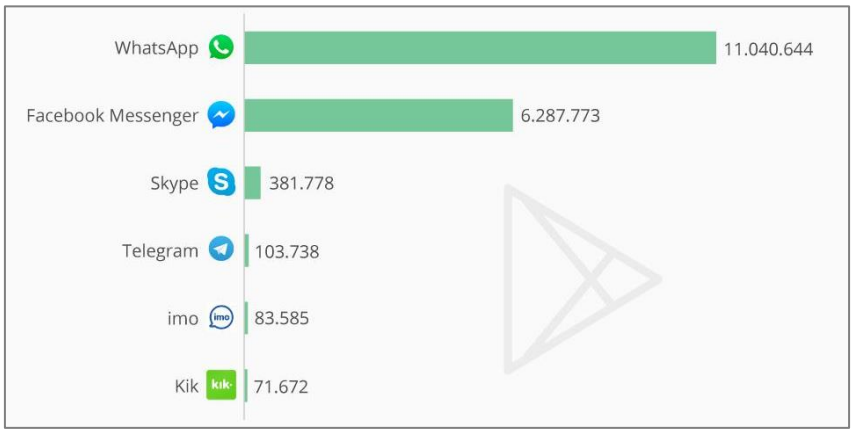
Moreover, 83.33% of respondents affirm to have regular access to an internet connection by using home WIFI and 67.48% have a smartphone or tablet contract plan.

Figure 47: Regular access to an internet connection



Messaging systems such as WhatsApp, Skype, Instagram, emailing, SMS/MMS, Facebook chat and even Telegram, which is not the typical messaging system used in Spain, are frequently used by the population. The only messaging system that our sample has declared to be completely unfamiliar to it is Snapchat.

Figure 48: Most popular messaging systems in Spain by number of active users, April 2018 (Source: Priori Data)



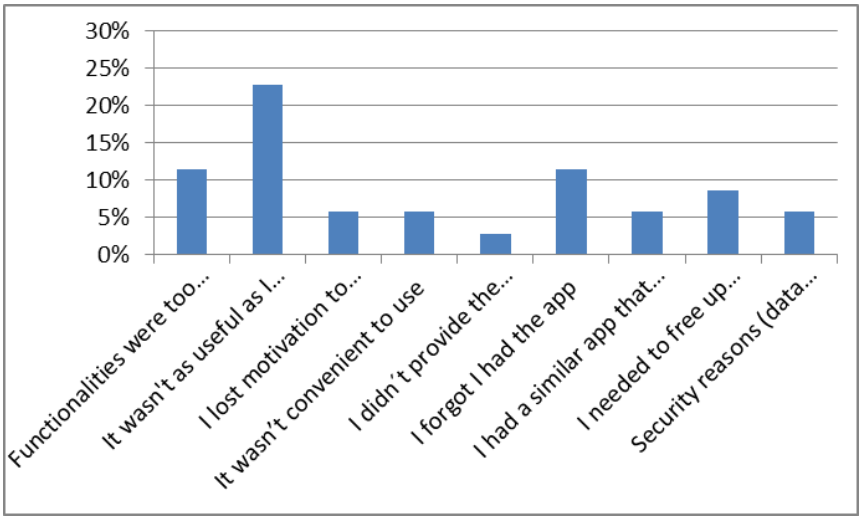
The field of voice-first technology is still fairly new, the usage of vocal interaction option to communicate with technological devices is beginning to flourish as Voice-User-Interfaces (VUIs) are possibly an easier way for people, particularly elders, to interact with intelligent technology than the typical visual interface that often over-burdens users with too many imagesa and multi-touch interactions. However, one of the biggest disadvantages of VUIs is the still significantly high rate of errors (Hunold, 2018). For the sample studied, approximately half of respondents (42.32%) declares to use it.

Health applications

The 34.44% of respondents declared to have used an application to control or support their lifestyle; among those 54.88% of them still use it.

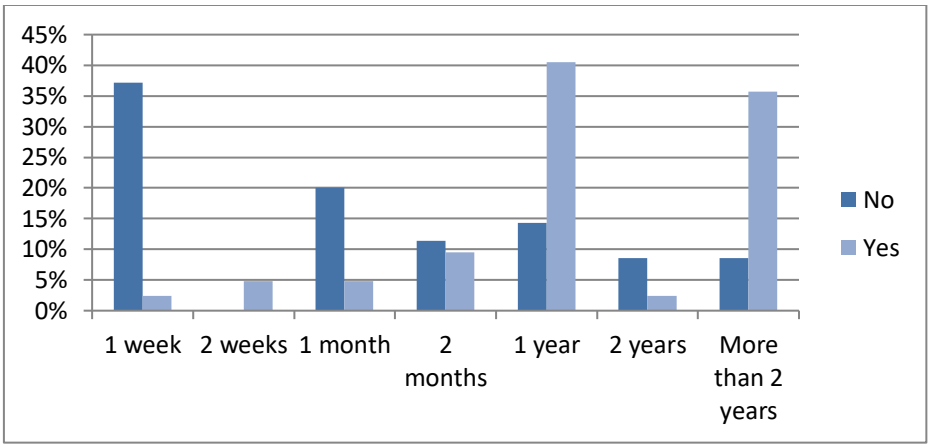
The most important reasons why the remaining 45.12% stopped using them were, in descending order of the number of responses, users did not perceive the app as useful as they thought, the app's functionalities resulted to be too trivial, they forgot they had the app or they needed to free up memory.

Figure 49: "Why did you stop using it?"



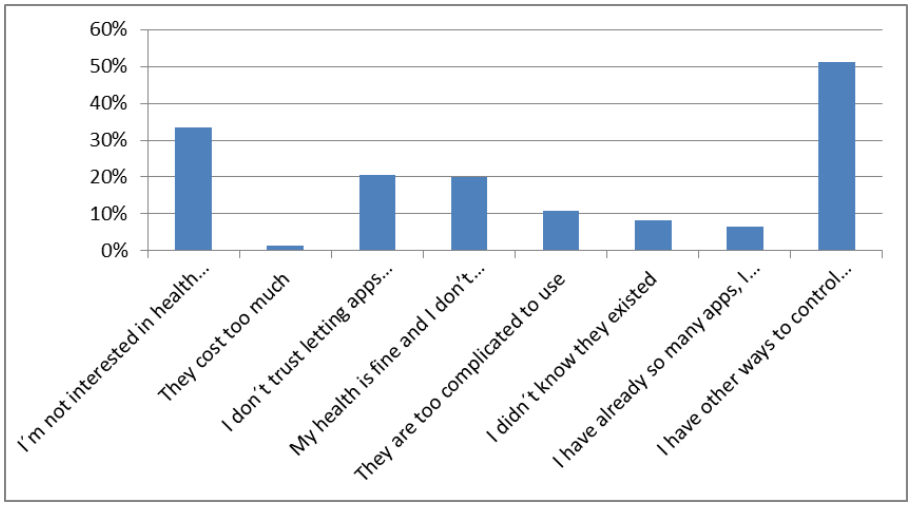
There is a clear difference between those who still use the mobile application and those who stopped using it by looking at figure 50 in which it is illustrated the longest period that users made use of the application. By gathering the graph, we can deduce that, in general, the decision to continue or not using an eHealth application is made in the first week of usage. Also, a high proportion (57%) of those who currently use applications to control or support their lifestyle are not beginners but experienced users that have been using the application for at least 1 year.

Figure 50: Longest period using an eHealth application by those who still use it or not



Moreover, more than half of respondents (51.83%) that have never used a health application before justified it by stating that they rely on other ways to control or support their lifestyle such as periodical medical revisions. A third of them (33.54%) admitted not being interested in health applications and, in equal proportion, 21.34% revealed mistrust on applications that handle personal data and other 19.51% declared to be healthy and have no need for this service.

Figure 51: "Which are the most important reasons you have not used a health application?"



Unexpectedly, given the fact that the most known mobile health applications are those for physical activity monitoring and nutrition habits monitoring, there is a significant proportion of respondents that stated to not monitor their physical activity and nutrition, 56.02% and 82.16% respectively, but to play memory games. Tablets and laptops seem to be the preferred devices for memory games, probably due to their bigger screen than that of the smartphones'. Anyway, smartphones are also becoming a commonly used device thanks to the development of applications for such purpose. Social relationships seem to be the most common healthy activity and it is mainly done using the smartphone, probably due to their easiness to be carried at all times.

Table 9: Preferred technological devices to do healthy activities

	Smartphone	Tablet	Laptop	Smart Devices	Not applicable/ I don't do this
Memory games	17.43%	21.99%	20.75%	1.66%	38.17%
Physical activity monitoring	26.56%	1.66%	2.07%	13.69%	56.02%
Nutrition habits monitoring	5.81%	4.98%	4.98%	2.07%	82.16%
Social relationships	61.83%	4.56%	13.69%	6.22%	13.69%

5.1.6. Product design

The user will be able to interact with the system through a tangible embodiment or physical interface of the virtual coach, which will be situated in the user's home, and tangible displays, which provide unobtrusive monitoring. In this way, interactions will be provided by the recognition of physical gestures apart from the classic inputs through touch screens.

In order to develop an appropriate product that offers a personalized coaching service to older adults, both tangible interfaces and features must satisfy users' needs, tackle their concerns and match limitations that come with aging.

Tangible object: Features

With respect to the system's features, privacy seems to be the main concern of users, particularly when it comes to health information. Potential users would like to understand which data will be collected and how it will be treated in order to be in control of such parameters and be able to change privacy settings.

Users would like to have control over the system in order to be able to disconnect it, receive notifications or establish communication whenever they want rather than letting NESTORE interact with them independently. The interaction with NESTORE would be preferably by voice rather than typing.

Also, the coach's behaviour (attitude and personality) should be manually customized by each user and it should adapt itself to the user's mood.

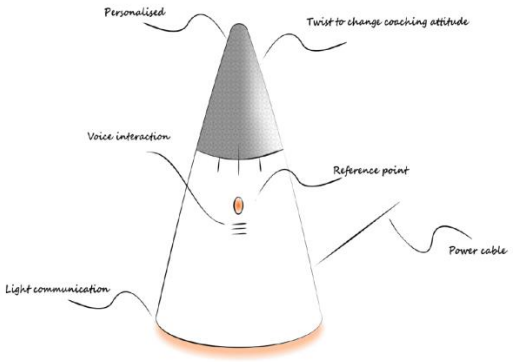
Tangible object: Physical interface

If we compare the proposed physical interfaces of NESTORE with that of Google Home or Alexa, the preferred alternative is the Compact Coach or option #3 whose design is considered as attractive as Alexa. The other NESTORE designs are shown in *Appendix 1: Tangible Object*.

Table 10: Punctuation over 7 of each physical interface

	Google Home	Alexa	Nestore#1	Nestore#2	Nestore#3
Punctuation over 7	3.97	3.83	3.72	3.53	3.87

Figure 1: Compact coach design



5.1.7. Product purchase

The system should be priced, positioned and distributed in a way that allows potential buyers can easily find the product and afford it. These specifics together with the variables that significantly affect the construct of Willingness to Pay directly impact on the decision about the business model to adopt in the exploitation strategy of the system.

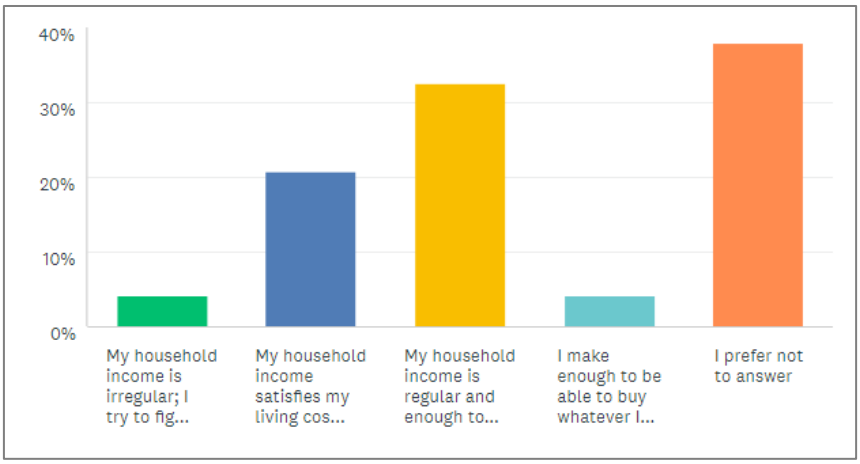
Willingness to pay

We have focused on perceptions, in particular we aimed to know if elders considered that their monthly household net income was enough or not in order to cover basic needs and if they could afford to spend some of it on extraordinary expenditures.

It is argued that it is perception of cost or relative cost which has the greatest effect on buying behaviour, instead of the actual cost price. This is because the adopter could consider price relative to disposable income, and thus, what might appear "costly" to one potential adopter, could be "inexpensive" to another, depending on their relative levels of income.

However, there is a considerable percentage of respondents (37.97%) that prefer not to state anything about it. Among those who answered, there are more elders that consider their monthly income enough to satisfy their living costs and afford extraordinary costs (32.62%) than those who consider that they can just cover basic needs with it (20.86%). Also, there is a considerable percentage of elders (4.28%) that consider their household net income to be abundant as to be able to afford whatever they want without any hesitation.

Figure 52: Perception of monthly income with respect to living costs



Respondents do not have a clear idea of the system's value for money. Results clearly show that there is a high percentage that is undecided (41.58%). The rest of respondents tend to distrust probably due to lack of results demonstrability: there is only modest evidence for the advantages of existing apps even though the evidence is increasing rapidly (Bruijink, Viser, & Marshall, 2012).

Table 11: "Paying for NESTORE would be a good value for money as it is an intelligent system that would help me manage my overall well-being"

STRONGLY DISAGREE	DISAGREE	UNDECIDED	AGREE	STRONGLY AGREE	NO ANSWER / DON'T KNOW	WEIGHTED AVERAGE
17.33%	20.79%	41.58%	9.41%	0.00%	10.89%	2.48

Once we ask respondents to evaluate the acquisition of the system in a subjective way implying a personal economic outlay, the results change. Many of those who were undecided or did not know how to evaluate the value for money of the coach, they adopt a negative position with respect to paying for the service. Similarly to the previous results, this could be due to the ignorance and/or uncertainty of the reliability and benefits of the system that could affect them personally.

Table 12: "I would be willing to pay for NESTORE system as it will offer me a customized and proactive service to maintain a healthy lifestyle"

STRONGLY DISAGREE	DISAGREE	UNDECIDED	AGREE	STRONGLY AGREE	NO ANSWER / DON'T KNOW	WEIGHTED AVERAGE
21.78%	30.69%	31.19%	9.41%	0.00%	6.93%	2.30

Out-of-pocket payments play a significant role in Spain. They represented 23.9% of total health expenditure and a 3.62% of total household expenditure in 2015 with a growing trend since 2006.

Figure 53: Trends in health expenditure in Spain, 1995–2015

EXPENDITURE	1995	2000	2005	2010	2014	2015[d]
THE per capita in Int USD (Purchasing Power Parity)[a]	1 193	1 536	2 267	3 025	2 966	3 183[b]
THE as % of GDP[a]	7.4	7.2	8.3	9.6	9.0	9.3[d]
General government expenditure on health as % of THE[b]	72.2	71.6	70.6	74.4	70.1	71.1[d]
Private expenditure on health as % of THE[b]	27.8	28.4	29.1	25.6	29.1	28.9[d]
General government expenditure on health as % of general government expenditure[b]	12.1	13.2	15.3	15.5	14.5	15[d]
Government health spending as % of GDP[a]	5.4	5.2	5.9	7.2	6.4	6.6[d]
OOP payments as % of total expenditure on health[a]	23.5	23.6	22.1	19.9	24	23.9[d]
OOP payments as % of private expenditure on health[a]	84.6	83.1	76	77.8	82.4	82.5[d]
Private insurance as % of private expenditure on health[b, c]	12.1	13.7	18.9	16.1	15	14.9[d]

Sources: WHO (2017a).

Figure 54: Household out-of-pocket expenditure related to health care (Source: INE)

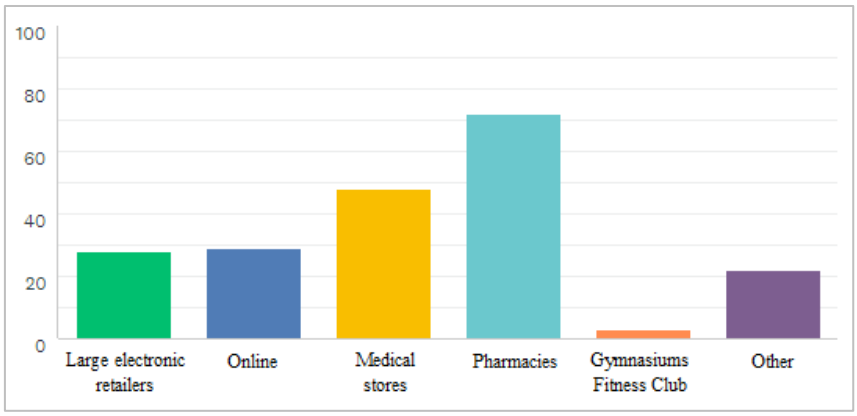
	2006	2008	2011	2014	2015[a]
Household expenditure on health items (million €)	14 179	17 229	16 013	17 475	18 204
Percentage of household total expenditure	2.90	3.18	3.07	3.53	3.62
Average expenditure by household (€)	876	1 010	895	955	991

One in five Spanish citizens owns a voluntary health insurance plan in addition to the universal obligatory public insurance. Voluntary health insurance in Spain is supplementary and independent of the Statutory National Health System (SNS) and may provide the same goods and services as those offered by the public sector. The purchase of voluntary health insurance plans is mainly driven by faster access to some services.

Product distribution

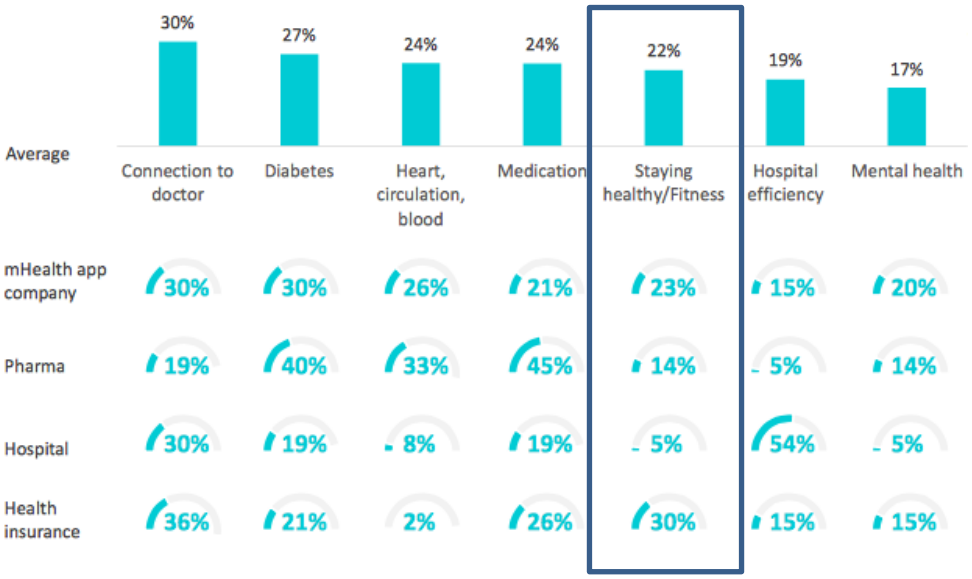
Half respondents (49.50%) consider that the best way to acquire the product would be through the SNS, while a considerable percentage (27.23%) considers that the health insurance should provide it. Other options such as a monthly subscription plan, one-time payment and Freemium were equally contemplate by the rest of respondents with 7.43%, 6.93% and 8.91% of answers respectively. According to respondents' answers, as the product is related to health care, it should be provided by health systems such as the SNS or health insurance and should be distributed through them in pharmacies, medical stores or directly sent by the Health System to citizens as some respondents stated in the open ended option "Other". In this vein, a national survey of US consumers conducted by PwC in 2014 found out that most consumers do not want to pay much for their wearable devices. Companies, especially insurers and health systems, exploring health and wellness programs involving wearables can expect buy-in if incentives are offered.

Figure 55: "Which would be the best purchasing channel?"



Consistently with the information gathered from the survey data, insurance companies and pharmacies, without attention to mHealth app companies, mainly provide all services to maintain or adopt a healthy lifestyle.

Figure 56: Healthcare sectors providing services for each category (Source: Research2Guidance-mHealth App Developer Economics study 2017)



5.2. Structural equation modeling: Hypotheses evaluation

The research model was transferred into a structural equation model (SEM) to analyse the causal relationships between the constructs. The SEM Builder of STATA 14 was used for this purpose.

SEM can examine different statistical methods simultaneously, such as multiple regression analysis and factor analysis. Thus, SEM allows to model and test both measurement properties and hypotheses about theoretical relationships among variables, which may be unobservable latent variables that cannot be measured directly. The latent variables are connected to observable variables by a measurement model.

In short and according to Hair et al.(2014), SEM models can be characterized by three characteristics:

1. Estimation of multiple and interrelated dependence relationships.
2. An ability to represent unobserved concepts in these relationships and account for measurement error in the estimation process.
3. Defining a model to explain the entire set of relationships.

The measurement model construct validity was verified through the Confirmatory Factor Analysis (CFA), the average variance extracted (AVE) and the composite reliability (CR) calculated with the output obtained from the SEM model analysis conducted in STATA 14. AVE and CR values were computed on the basis of the factor loadings reported in CFA results. They resulted to be higher than the prescribed acceptable levels, 0.5 and 0.7 respectively.

The convergent validity of the measurement model was assessed by calculating the average variance extracted (AVE) and the composite reliability (CR). AVE measures the level of variance captured by a construct in relation to the level that is attributed to the measurement error. All of the values were above 0.5, the acceptable range recommended by the literature, whereas some were above 0.7 which is considered very good (see table 13).

The composite reliability (CR) evaluates the internal consistency of the measurement model and is a less biased estimate of reliability than Cronbach's alpha when SEM is used (Hair et al., 2006). For every construct, CR exceeded the recommended level of 0.6, as it is shown in table 13.

Table 13: Average variance extraction and composite reliability for the research constructs based on CFA results

Construct	Items	Factor loadings	AVE	CR
Behavioural Intention to Use (ITU)	ITU1	.875	.568	.949
	ITU2	.889		
	ITU3	.884		
	ITU4	.909		
	ITU5	.883		
	ITU6	.776		
	ITU7	.791		
	ITU8	.753		
Perceived Usefulness (PU)	PU1	.909	.624	.967
	PU2	.950		
	PU3	.940		
	PU4	.910		
	PU5	.911		
	PU6	.849		
	PU7	.804		
	PU8	.864		
IT Literacy (ITL)	IT1	.796	.566	. 866
	IT2	.857		
	IT3	.707		
	IT4	.730		
	IT5	.654		
Health Literacy (HL)	HL1	.567	.534	.770
	HL2	.749		
	HL3	.849		

Construct	Items	Factor loadings	AVE	CR
Empowerment (E)	EMP1	.754	. 568	. 798
	EMP2	.769		
	EMP3	.737		
Attitude to Life (ATL)	ATL1	.891	.700	.823
	ATL2	.779		
Image (I)	IM1	.807	.564	.838
	IM2	.714		
	IM3	.724		
	IM4	.757		
Subjective norm (SN)	SN1	.797	.775	.912
	SN2	.899		
	SN3	.939		
Willingness To Pay (WTP)	WTP1	.852	. 643	.842
	WTP2	.870		
	WTP3	.669		

According to the literature, discriminant validity is assured when the value of the AVE is above the threshold value of 0.50 and when the square root of AVE is larger than correlations among the constructs (El-Wajeeh et al., 2014).

Table 14: Discriminant validity of constructs (Campbell & Fiske, 1959)

	ITU	PU	ITL	HL	E	ATL	I	SN	WTP
ITU	**0.77**								
PU	0.83	**0.80**							
ITL	0.26	0.21	**0.82**						
HL	-0.09	-0.10	0.03	**0.82**					
E	0.09	0.05	0.21	0.41	**0.84**				
ATL	0.01	-0.01	0.32	0.28	0.44	**0.91**			
I	0.48	0.58	0.12	-0.02	-0.05	-0.06	**0.84**		
SN	0.51	0.60	0.18	-0.01	0.03	0.03	0.73	**0.92**	
WTP	0.55	0.57	0.12	-0.09	-0.11	-0.11	0.72	0.67	**0.87**

In order to assess the goodness-of-fit (GOF) of the structural model, four indices were used: Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI), the Root Mean Square Error of Approximation (RMSEA) and the Standardized Root Mean Square Residual (SRMR). The results show that it has a good fit as indices largely comply with the prescribed acceptable ranges: the Comparative Fit Index (CFI) value of 0.904 is higher than the recommended value of 0.9. However, Tucker-Lewis Index (TLI) value of 0.895 is slightly less than the benchmark of 0.9. Additionally, the Root Mean Square Error of Approximation (RMSEA) value of 0.068 belongs to the adequate fit range of 0.05-0.08 (Hair et al.; 2014) and SRMR value of 0.064 is widely below the 0.08 threshold that determines its acceptance.

Table 15: Goodness-of-fit of the structural model

Index	Acceptable ranges	Value
Comparative Fit Index (CFI)	> 0.9	0.904
Tucker-Lewis Index (TLI)	> 0.9	0.895

Index	Acceptable ranges	Value
Root Mean Square Error of Approximation (RMSEA)	0.05 – 0.08	0.068
Standardized Root Mean Square Residual (SRMR)	< 0.08	0.064

The research model explains 66% (R^2 = 0.6649421) of variance of the intention to use NESTORE, a virtual coach for Healthy Ageing, and 62% for willingness to pay for NESTORE (R^2 = 0.6171848). The coefficient of determination is 0.99, which confirms that the model explains to a great extent the overall variance.

Table 16: Path analysis and hypotheses testing results

Hypothesis	Path	Standardized β	p-value	Hypothesis testing result
H1	PU → ITU (+)	0.7690225	0.000***	Supported
H2a	ITL → ITU (+)	0.1217398	0.022*	Supported
H2b	ITL → PU (+)	0.1589583	0.023*	Supported
H3	HL → PU (+)	- 0.1466082	0.054*	Supported
H4a	E → PU (+)	0.1238193	0.147	Not Supported
H4b	E → HL (+)	0.4422659	0.000***	Supported
H5a	ATL → ITL (+)	0.3216280	0.000***	Supported
H5b	ATL → E (+)	0.4239500	0.000***	Supported
H5c	ATL → PU (+)	- 0.0833788	0.290	Not Supported
H6	IM → PU (+)	0.3777843	0.002**	Supported
H7a	SN → PU (+)	0.2422383	0.039*	Supported
H7b	SN → IM (+)	0.7597424	0.000***	Supported
H7c	SN → ITL (+)	0.1978895	0.009**	Supported
H8a	ITU → WTP (+)	0.2107056	0.001***	Supported
H8b	IM → WTP (+)	0.4672383	0.000***	Supported
H8c	SN → WTP (+)	0.2313661	0.028*	Supported
HC1	Age → ITU (+)	-0.0978494	0.035*	Supported
HC2	Gender → ITU (+)	0.0162711	0.745	Not Supported
HC3	Education → ITU (+)	-0.0059519	0.897	Not Supported
HC4	Residence → ITU (+)	0. 0264214	0.580	Not Supported
HC5	FOC → ITU (+)	0.0752034	0.096	Not Supported
HC6	Disease → ITU (+)	0.0272793	0.571	Not Supported

In short, a general outline of the structural model findings is reported in table 16. Results from the path analysis present direct and indirect effects supporting most of the hypotheses that were raised in section *3.2.An extended TAM: theory and hypotheses.* All hypotheses were supported except H4a and H5c. Control variables were coded as dummy variables (0 and 1) or indicator variables (categorical); the variables education and occupation were excluded from the model because of large number of missing values. None of the demographic variables had any significant influence on intention to use except age, which was represented as an indicator variable with three age groups: 60-70; 70-80 and >80 years old (standardized β =-.098, $p < .05$) (Hc1). As expected, younger elders will have higher intention to use NESTORE.

Consistent with theory, the basic TAM relationships between key constructs were well supported. As predicted by the TAM model (Davis, 1989) and its related studies, higher perceived usefulness (standardized β =.769, $p < .000$) (H1) showed strong positive

effects on intention to use NESTORE. Moreover, Perceived Ease of Use, which has been replaced by IT Literacy in the present study, has a direct positive effect (standardized β =.122, $p < .05$) (H2a) on Intention to use. However, this effect is not as significant as PU.

In addition, higher IT Literacy (standardized β =.158, $p < .05$) (H2b) leads to higher perceived usefulness, which is consistent with Bandura's statement (1982): "self-efficacy contributes to increase overall user's performance". The R^2 values for PU and ITL are not as good as they could be, explaining the 41.7% and 14.3% of the variables respectively.

To our surprise, a higher health literacy (standardized β = -.147, $p = .05$) (H3) did not have a positive effect on the perceived usefulness of the system. Instead, it can subtly influence the user's perceived usefulness by decreasing it. Health Empowerment results to be a strong determinant of Health Literacy (standardized β = .442, $p < .000$) (H4b). Yet, it does not have any direct effect on Perceived Usefulness but a significant indirect effect (standardized β = -.124, $p < .000$) (H4a) through Health Literacy.

A positive attitude to life (ATL) has been verified to be a strong motivator of elderly people to adopt healthy behaviours (standardized β = .424, $p < .001$) (H5b) with the aim of remaining active and independent as well as to adopt and learn about new technologies (standardized β = .322, $p < .001$) (H5a), and thus improve their IT Literacy. However, ATL does not influence on the Perceived Usefulness of the system, neither directly or indirectly (H5c).

Furthermore, Image significantly impacts on the Perceived Usefulness (standardized β = .378, $p < .01$) (H6) as well as on Willingness to Pay (standardized β = .467, $p < .000$) (H8b). In the same vein, Subjective norm (SN) impacts on both constructs but with a less intense effect (standardized β = .242, $p < .05$) (H7a) and (standardized β = .231, $p < .05$) (H8c) respectively. Moreover, SN has a positive and significant indirect effect on PU through IT Literacy (standardized β = .415, $p < .01$).

Subjective norm shows to significantly and positively impact on Image through the enhancement of the social status by complying with group norms (standardized β = .760, $p < .001$) (H7b). Moreover, SN has been verified to be also a predictor of ITL due to the influence of referent people on the adoption of new technologies (standardized β = .198, $p < .01$) (H7c).

Finally, higher ITU is found to increase users' willingness to pay for using the system (standardized β = .211, $p < .001$) (H8a).

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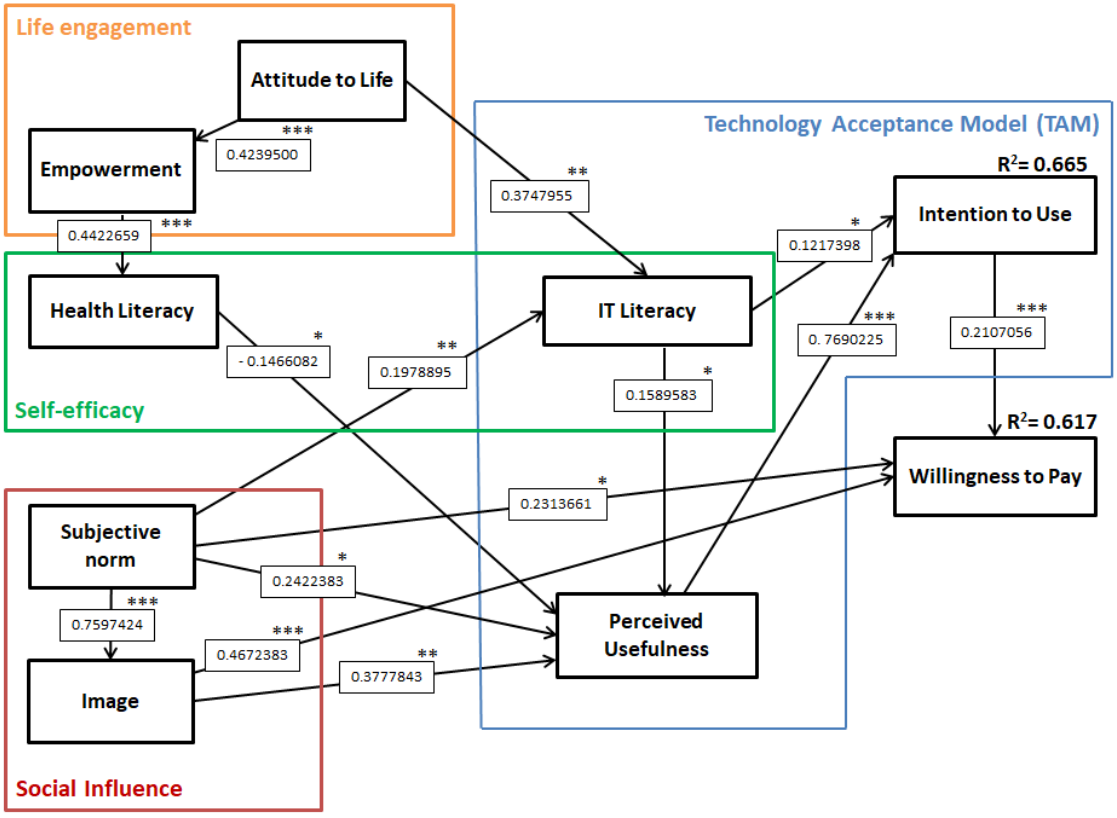
Figure 57: Results of path analysis with standardized β and significance levels



6. Discussion and implications

This study contributes to existing literature and has many practical implications.

First of all, it contributes to the current understanding of virtual coaching, where a lot of research remains to be done. The study confirms the results of existing studies about health-driven technology acceptance, especially in its early stages of development. Moreover, it combines well-known theoretical models (TAM, TAM2 and HBM) in order to propose a more suitable theoretical model for an intervention to engage users in long-term health-promoting behaviours. Among the constructs proposed, the most noteworthy outcomes were the significant effect of IT Literacy in replacement of Perceived Ease of Use, which was found to positively influence the intention to use a virtual coaching system for healthy ageing, and the negative effect of Health Literacy in contradiction with what was thought.

In addition to the theoretical contribution, based on the results of the questionnaire and this study, certain managerial and policy implications are deducted. The lack of knowledge and familiarity with this type of interventions makes it necessary to design marketing strategies in order to raise awareness and highlight the benefits that come from its use. Developers should take into account the major role of medical practitioners in informing and counselling potential users about healthy lifestyles in order to design an effective business strategy. Moreover, marketing strategies should target the younger segment of older adults with low levels of health literacy.

6.1. Contribution to theory

Results of the current study confirm that the two key constructs of the TAM model (Perceived Usefulness and Perceived Ease of Use) predict the intention to use a virtual coaching system, particularly NESTORE. In fact, it is consistent with findings reported in the literature about different forms of technology for wellbeing, such as health applications (Cajita et al., 2017; Beldad & Hegner, 2017; Chang et al., 2016). Therefore, this work can be considered as additional evidence of proving the usefulness of the extended TAM in the healthcare field.

The effect of Perceived Usefulness is stronger than that of Perceived Ease of Use, which is currently represented by users' perception of self-efficacy with technology. Due to limitations that come with aging, learning and using new technology is in general more challenging for older adults. Thus, older adults probably prefer to adopt easy-to-use technologies, which are considered as technologies that have similar features to those of familiar systems. As stated by Dou et al. (2017), previous experience with similar technologies provides older adults with the confidence to be able to use the new technologies. In this way, they develop a sense of self-efficacy which may lead them to evaluate new technologies to be easy-to-use and to increase their intention to use them. In this vein, Bidmon et al. (2014) verified the positive influence of digital literacy on the intention to use m-health apps as well as on their perceived usefulness.

The nature of the technology investigated in this research could provide additional contribution in the field of virtual coaching for healthy ageing, where a lot of research

remains to be done. Not only this type of technology is only weakly known but also there are not many studies examining the factors that determine technology adoption among the elderly population. In fact, the results of this study demonstrate that younger elderly adults are more likely to adopt a virtual coach and to pay for it.

Healthcare is a complex matter that requires the consideration of many factors aside from the technology's high-tech features. Given that health-driven technologies impact in everyday life and particularly on our overall health, their understanding cannot have the same approach to the general aim of the TAM model. For this reason, the present study combines TAM2 and HBM as the backdrop of the theoretical model. Like in Dou et al.'s (2017) work, it has been verified that HBM can be applicable in explaining users' engagement in long-term health-promoting behaviours, such as adopting a virtual coach for healthy ageing.

Moreover, multiple-behavior interventions in health promotion research are found to have superior potential impact on health compared to single-behavior interventions. This is due to greater results coming from the interaction between the interventions' effect and from the sum of the interventions' independent impact on specific domains. However, there is not much investigated in this area. In general, proposed solutions encompass physical activity and nutrition but do not address the two remaining healthy ageing domains: cognitive and social. Only recently a few studies have addressed all domains (*PreventIT*, 2016; Baskar et al., 2017; Op den Akker, et al., 2018). In this way, the current study constitutes a significant step forward in the development of effective health promotion interventions.

With regard to the significant influence of Image on both Perceived Usefulness and Willingness to pay, it follows that respondents' decision to use a virtual coach may not be fully grounded on the system's primary function of promoting health but rather on its ability to enhance users' social status within their social group (Beldad, 2017). In this vein, many previous studies have proved that wearable devices, such as wrist watches, are considered fashion items that users feel that they should wear them just like people around them (Chang, Lee, & Ji, 2016).

It is also noteworthy to mention outcomes that did not accord with originally posited hypotheses. Contrary to what it was thought, Health Literacy negatively affects the Perceived Usefulness of the virtual coach. A potential explanation, in line with Cho et al. (2014) findings, may be that people with higher health literacy have developed their own strategies and facilities for managing their health. Consistent with this, more than half of respondents (51.83%) that have never used a health application before justified it by stating that they rely on other ways to control or support their lifestyle such as periodical medical revisions. These users may try to avoid the additional investment of changing their daily routine and could devalue the usefulness of an e-coaching system by considering its functionalities to be trivial or not sufficiently effective to contribute to their health goals. Moreover, Health Literacy encompasses the capacity to evaluate and understand various types of health information and not all information might be

available using the virtual coach, nor the way to expose it. Consequently, while each person prefers to analyze and understand information in a different way, it is reasonable to argue that people with higher Health literacy levels would perceive virtual coach to be less useful, due to its limited sources of health information and ways to convey such information.

Furthermore, another surprising finding has been the absence of influence of suffering chronic diseases over the intention to use a virtual coach. Contrary to expectations, it was assumed that patients that suffer chronic conditions typically keep a constant eye on their health and they would be more likely to have greater intention to use a system that facilitates such task (Deng et al., 2018). However, due to the lack of awareness of this type of technology and its effectiveness, a possible explanation for the lack of association could be the mistrust and disregard towards the potential of the system that might lead users to hold a similar view of the system and intention to use it, no matter if they suffer or not chronic diseases.

6.2. Managerial contribution and policy implications

Given the results obtained, some advices with regard to the product design and business strategy can be derived.

Developers of virtual coaching systems for healthy ageing purposes should provide clear evidence of the salutary effects of coaching and to inform about the outcome-of-usage benefits from using a virtual coach. To that end, awareness-raising, targeted practical interventions and educational courses should be given to increase awareness of the existence and benefits of this type of intervention and ensure that users use the full potential of this new technology. In this way, not only user acceptance to use an e-coaching system would be leveraged but also, it would boost the engagement of older adults with high levels of Health Literacy that tend to undervalue its usefulness. Along the same lines, respondents stated that they stopped using a health application mainly because they did not perceive the app as useful as they thought or because the app's functionalities were too trivial.

There is a considerable proportion of respondents (21.34%) that revealed mistrust on applications that handle personal data. Privacy is an important concern of users, particularly when it comes to health information. Potential users would like to understand which data will be collected and how it will be treated in order to be in control of such parameters and be able to change privacy settings.

Given that senior adults mainly obtain information about healthy lifestyles and disease prevention from their general practitioner (53.78%) and mass media (52.19%), doctors should be involved in the product promotion. Thus, developers should contact medical practitioners and design the business strategy taking into account practitioners' major role. Moreover, marketing strategies should target the younger segment of older adults with low levels of health literacy. Communication campaigns should be developed in order to raise the prestige associated with system use leveraging the positive effect of

Image on intention to use and willingness to pay. According to the survey results, mass media would be the appropriate channel to deliver them.

Some respondents stated to stop using a health intervention because they forgot they had it. With this respect, Battaglio and Bickmore (2015) stated that the most important prerequisite for the success of an interaction that makes use of conversational agent is that users need to remain engaged (Op den Akker, et al., 2018). Taking the Council of Coaches as a reference, the existence of a conversation between the coaches that form the council allows keeping the dialogue forward when the user's initiative of interacting with the system is low. Thus, developers should seek a way of reengaging users even without any active participation on their part.

Walking seems to be the main mode of aerobic exercise among older adults. Even though target users prefer outdoor and dynamic activities, designers should design strategies to encourage older adults to do exercises that improve strength and balance through the virtual coach.

In order to develop solutions that take all the previous advices into consideration, a participatory and user-centered approach should be used to design the system. In this way, developers ensure that the health intervention addresses user's needs and the effort needed to use the virtual coach matches limitations that come with aging and target users' ability to learn new technologies (Cajita et al., 2017).

Consideration should also be given to policy implications, in particular ethical issues. The system should avoid discrimination in favour of older adults with higher technological education and income than the average Spanish older adult. In this sense, the system should be universal, that is, inclusive and with an egalitarian approach. In this way, it would avoid increasing the digital and economic divide between older adults.

7. Conclusions

This study aimed at developing and empirically testing a theoretical model to understand the acceptance of an e-coaching system for healthy ageing called NESTORE during the early stages. The theoretical model is an extension of the TAM model by combining TAM2 and HBM. In this way, it has been verified TAM's applicability in explaining users' acceptance of health-driven technological interventions that lead to long-term health-promoting behaviours, such as NESTORE system for healthy ageing.

The proposed model combines users' cognition (IT Literacy and Health Literacy), social environment (Subjective norm and Image) and engagement to life (Empowerment and Attitude to Life). These factors were incorporated to the basic TAM constructs (Perceived Usefulness and Perceived Ease of Use) which were adapted in order to fit the context of the study.

An online survey was conducted to collect user's perceptions and opinions. Data collected was used to test the proposed model and to gather insights about users' preferences and actual habits that could influence their intention to adopt a healthier lifestyle. In this way, it was possible to better understand users' motivations to adopt a system that promotes healthy ageing behaviours as well as their pains and gains.

It has been shown that the intention to use a virtual coaching system for healthy ageing is determined by TAM's key constructs: its Perceived Usefulness (PU) and the user's IT Literacy (ITL), which serves as a proxy of the system's Perceived Ease of Use in its early stages of development. PU is affected by the user's self-efficacy in technology and in healthcare, and by the social influence coming from its environment in the form of Image and Subjective norm. However, engagement to life did not have any direct effect on PU. Meanwhile, ITL is affected by Attitude to Life, as older people sense of self-worth develops positive attitudes towards using technology; and by Subjective norm, as consumers that are not familiar with a new technology, and in particular in the healthcare domain, tend to rely on the opinion of people who are important to them when deciding to use it or not.

On the other hand, Willingness to pay is mainly determined by two consumption values: functional and social. The functional value is related to a rational approach about consumers' behaviour. Consumers buy the product due to the objective benefits that come from using the product, which is represented by the effect of Intentio to Use on Willingness to Pay. The social value, however, refers to the perceived utility that comes from the acquisition of the product which may lead to the enhancement of the user's social status within his or her reference group.

From the qualitative analysis of the survey it can be argued that the sample population is more inclined towards solutions related to physical activity and nutrition domains. However, a significant proportion of respondents stated to not monitor their physical activity or their nutrition, but to play memory games. Therefore, there is need to promote an active approach to manage health among seniors; which denotes an

opportunity for the diffusion and success of a virtual coaching system for Healthy Ageing.

Senior adults rely especially on their general practitioner and mass media in order to obtain information about healthy lifestyles and disease prevention. Family and friends result to be their alternative sources of information. Among them, health care professionals are considered the most reliable source mass media is not considered reliable at all.

The adoption of health-related technologies is still very low among seniors. Few of the respondents are familiar with the concept and benefits of coaching and just over a third of them declared to have used an application to control or to support their lifestyle. Among those, only about half of them still use it. The first week of usage of an intervention results to be the most important period to engage the user.

NESTORE should be provided by the Statutory National Health System (SNS) and by health insurances, which are voluntary and supplementary to the SNS and distributed in pharmacies, medical stores or directly sent by the Health System to citizens. Additionally, given that users are not willing to pay for the wearable devices that made up the system but they seem to be interested in its usefulness, NESTORE should be commercialized as a service and not like a product.

The outcomes from this study reveal that there is still much to be done, especially to increase people's awareness of the concept of coaching, the existence of technologies that deliver such service and the benefits of adopting a coaching system for healthy ageing. Given that this technology is in its early stage of development, further research should be done in order to better understand the drivers that make users adopt an e-coaching system for wellbeing among older adults. In this sense, this research provides additional contribution in this field, which is not yet well understood. Moreover, results obtained in this research serve as guidelines to develop virtual coaching systems for Healthy Ageing and their corresponding sustainable business model that will be able to meet users' expectations and needs.

7.1. Limitations and future research

A possible limitation of the present study might be the impossibility to generalize the results to the whole Spanish population due to the demographic characteristics of participants. Even though the survey administration succeeded in reaching older adults within a great age span (60-87 years old), participants were younger than 80 years old to a great extent and men vastly outnumbered women. For this reason, results of the present study might not be generalized to the oldest range of age analyzed. Also, the sample represents largely older adults with higher education and income than the average Spanish older adult as a result of great participation by Spanish Third Age Universities in the survey dissemination. Besides, the questionnaire was required to be filled in online, which restricts respondents to older adults that already have a greater tendency to use technology than the average older adult.

In this respect, future research should encompass a larger randomized sample by collecting responses using paper format questionnaires and/or interviews apart from the online survey to obtain information from people with low levels of IT Literacy or with functional limitations that make them unable to complete a survey in digital format.

It should be taken into account that the research has been conducted in the Spanish context which is characterized by a public sanitary system and to a Mediterranean culture. Thus, results should not be generalized to other countries with different features.

Another limitation of the current research has been the limited knowledge about the technology studied. With this respect, a vast majority of respondents were not familiar with the concept and benefits of coaching and, even less, about the existence of health interventions for healthy ageing based on a virtual coach. In order to conduct the questionnaire, given that asking for existing virtual coaches was not an option due to the scarce use and knowledge of them, a definition of the system was provided by comparing it to a set of technological devices that target users might be familiar with and could imagine all together. However, answers about the system perceived usefulness and intention to use could not fully reflect their perception of the real system.

To deal with this issue during the development phase of the technology, a prototype or videotape mockup should be used to create a more realistic idea of what the system consists of. In this way, target users could better understand how it works by a brief exposure to a prototype system or by watching the training video to acquire well-formed beliefs.

Apart from that, once more health interventions based on a virtual coach are known, available and used by target users; a longitudinal research should be conducted to analyze the effect of "experience" on the model. According to Venkatesh and Davis (1996), after hands-on experience with these systems and particularly with NESTORE, users will form their own system-specific ease of use perceptions and the effect of constructs such as Perceived Ease of Use and Subjective norm on Perceived Usefulness and Intention to Use will change (Dou, et al., 2017).

Some of the constructs of the present study could be further developed. Attitude to Life, Health Literacy and Empowerment are measured with only two or three items. These variables, however, could include multiple aspects in addition to what has been assessed.

Furthermore, this study might have overlooked some constructs that influence over the intention to use a coaching system for healthy ageing. Previous studies show that Trust and Result Demonstrability have a significant effect in the adoption of health-driven technologies (Deng et al., 2018). As said, the privacy concern is an important factor influencing users' acceptance of technology, particularly if it involves health information (Avancha, Baxi, & Kotz, 2012). The construct of Trust should encompass

both trust towards the system developer and towards using the system itself (El-Wajeeh et al., 2014; Beldad & Hegner, 2017).

Given that NESTORE system is considered as a persuasive technology that promotes long-term behavior changes, it impacts in users' everyday life. Therefore, another future research direction would be the inclusion of Resistance to Change in the theoretical model. Findings obtained in El-Wajeeh et al.'s study (2014) show that resistance to change has a strong negative impact on intention to use a system that intends to change users' routine and lifestyle, no matter the expected benefits coming from system usage.

8. Appendix

8.1. Appendix 1: English version of the survey

This survey has been developed within the **European H2020 project NESTORE**, with the aim to better understand citizens' needs and preferences on the use of digital technologies for ageing well.

The European population is ageing, and wishes to remain independent and autonomous as long as possible. However, ageing is often accompanied by an increased risk of diseases and decline in function (mental and physical changes). To meet these challenges, mobile health solutions can support older adults to stay healthy and active in order to prevent or delay functional decline.

NESTORE is an innovative personalised coaching system to support healthy ageing. It generates motivation to take care of your health and **suggests nutrition, physical activities and social interactions to preserve your wellbeing**. As a friendly coach, it proposes activities and services on the basis of your punctual needs, preferences and your moods, taking into account your personality, your environment and your health status.

Due to the relevance and impact of the project, we would be grateful if you could take your time to fill-in the survey. **The survey is targeting citizens who are aged 60+.** The time required to fill in the questionnaire is approximately 25 minutes.

Answers are anonymous. More information on the NESTORE's data policy can be found here. The results of this survey will be shared on NESTORE website in Spring 2019: https://nestore-coach.eu/.

For any additional information, comments, questions or suggestions, please feel free to contact us:

Emanuele Lettieri
Phone number: +39 3458803376
E-mail: emanuele.lettieri@polimi.it

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 769643

8.1.1. Sources of information

- How do you keep yourself informed about health prevention and healthy lifestyles (nutrition, physical exercise, prevention…)? Select up to three:

- None
- My General Practitioner
- Other physicians
- Institutional websites
- Social networks
- Mass media/radio/TV
- Sport and personal trainers
- Family
- Friends
- Specialized press
- Other:_____

- How would you describe the quality of the information about healthy lifestyle (e.g. diet, exercise, disease prevention) in:

	None	Low	Average	High	Don't know
Newspapers					
Magazines					
Books or brochures					
Institutional websites					
Blogs and social networks					
Radio and television					
Family members					
Friends					
Health care professionals (e.g. doctors, nurses, therapists, or psychologists)					
Sport coaches, personal trainers					

- With respect to prevention, what interest you more? Select up to three:

- Social wellbeing (e.g. social relationships)
- Psychological wellbeing (e.g. self-esteem and life satisfaction)
- Cognitive abilities (e.g. memory, attention, emotional self-regulation)
- Physical wellbeing
- Nutrition

- Do you belong to any group, association or network where people share their experiences?

Yes	No

8.1.2. Health Literacy

On a scale from 1 to 5, where 1 is “Very easy” and 5 is “Very difficult”:

- How easy would you say it is to self-assess your health condition?

Very easy (1)	Easy (2)	Average (3)	Difficult (4)	Very difficult (5)

- How easy would you say it is to understand advantages and disadvantages of different treatment options?

Very easy (1)	Easy (2)	Average (3)	Difficult (4)	Very difficult (5)

- How easy would you say it is to understand health warnings about unhealthy behaviours such as smoking and low physical activity?

Very easy (1)	Easy (2)	Average (3)	Difficult (4)	Very difficult (5)

- How easy would you say it is to assess the reliability of warnings and risk of information on health in the media?

Very easy (1)	Easy (2)	Average (3)	Difficult (4)	Very difficult (5)

- How easy would you say it is to find information on how to manage mental health problems like stress or depression?

Very easy (1)	Easy (2)	Average (3)	Difficult (4)	Very difficult (5)

- How easy would you say it is to understand why you might need health screening (such as blood pressure, blood sugar test, breast exam)?

Very easy (1)	Easy (2)	Average (3)	Difficult (4)	Very difficult (5)

- How easy would you say it is to understand information in the media (such as Internet, newspaper, magazines) on how to maintain or improve your health?

Very easy (1)	Easy (2)	Average (3)	Difficult (4)	Very difficult (5)

- How easy would you say it is to find out about activities that are good for your mental well-being?

Very easy (1)	Easy (2)	Average (3)	Difficult (4)	Very difficult (5)

- How easy would you say it is to judge if your everyday behaviour (such as drinking and eating habits, physical activity, etc.) has a positive or negative impact on your health?

Very easy (1)	Easy (2)	Average (3)	Difficult (4)	Very difficult (5)

- How easy would you say it is to change and adapt your living environment and your behaviours to improve your health and wellbeing?

Very easy (1)	Easy (2)	Average (3)	Difficult (4)	Very difficult (5)

8.1.3. Digital Literacy

In general, I believe that…

	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree	No answer/ Don't Know
I am aware of chat messages (e.g. voice messaging, SMS, text exchange, Skype chat).						
I can use a wide range of communication tools (e-mail, chat, SMS, instant messaging, blogs, micro-blogs, social networks) for online communication.						
I can use online services (e.g., e-banking, public services, online shopping...etc.)						
I am aware of social networking sites (e.g. Facebook, Twitter, Instagram) and online collaboration tools (e.g. Slack, Skype, Dropbox, Google Drive)						
I can pass on or share knowledge with others online (e.g. via social networking tools or in online communities)						
I can modify default settings of software and applications						
I have installed security programmes on the device(s) that I use to access the Internet (e.g. antivirus, firewall).						
I can fix any technical problem that occurs						

- Do you have regular access to an internet connection? Multiple choice:

  - By using public WIFI
  - By using home WIFI
  - I have a smartphone/tablet contract plan
  - No

8.1.4. Current use of digital technologies

Which, if any, of these technologies do you know or have you used?

	Never heard of	Heard of, but never used	Used or using
Smartphone			
Tablet			
Computer/Laptop			
Remote control device			
Electric cooking products (e.g. Thermomix)			
Smart thermostat			
Automatic teller machine			
Credit card (usual)			
Transport smart card			
Wearable device (e.g. smartwatch)			
Intelligent home assistant (e.g. Google Home, Alexa)			
Connected car system			
Health monitoring device or sport equipment (e.g. blood pressure monitor, exercise tracker)			
Emergency alert system			
Electronic glucometer			
Telecare			
Smart balance (e.g. measures fat mass, bone mass, muscle mass, water…)			
Electronic dictionary			
Digital camera			
CD/MP3/MP4			
DVD/VCD player			
Smart TV			
Video game consoles			

- Which, if any, is currently your preferred device for each of the following activities?

	Phone	Tablet	Laptop/ Computer	Smart devices (e.g. smartwatch)	I don't do this
Memory games					
Physical activity monitoring					
Nutrition habits monitoring					
Social relationships					

- Have you ever used a mobile application to control or support your lifestyle?

Yes	No

***If NO,** why?

- I´m not interested in health apps
- They cost too much
- I don´t trust letting apps collect my data
- My health is fine and I don't need one
- They are too complicated to use
- I didn´t know they existed
- I have already so many apps, I don't want to add another one
- I have other ways to control or support my lifestyle.
- Other_____

***If YES,** could you specify the longest period that you have used it?

- 1 week
- 2 weeks
- 1 month
- 2 months
- 1 year
- 2 years
- More than 2 years

- Do you still use it?

Yes	No

***If NO**, why did you stop using it?

- Functionalities were too trivial
- It wasn´t as useful as I thought
- I lost motivation to change my lifestyle
- It wasn't convenient to use
- It wasn't easy to use
- It was very expensive or too expensive of its value
- It didn´t provide the results I was looking for
- I had a similar app that was more useful or easier to use
- I forgot I had the app
- I needed to free up memory
- Security reasons (data privacy)
- Other_____

- Do you use the vocal interaction option to communicate with your device (to make it complete some actions)?

Yes	No

- Which messaging systems do you use?

- WhatsApp
- Facebook messenger
- Telegram
- Snapchat
- Skype
- SMS/MMS
- Phone calls
- Emailing
- None
- Other_____

8.1.5. Empowerment

- Before addressing yourself to a doctor, do you…:

- Treat at home by searching information
- Visit a pharmacist
- Rely on past experience
- Ask advice to family or friends
- Wait it out for as long as possible
- None (I always visit the doctor in the first place)
- Other _____

- In general, I believe that…

	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree	No answer/ Don't Know
I understand my limitations and I am sufficiently self-aware to stop doing an activity before I become ill or injured.						
I can set up a plan to achieve health prevention goals (e.g. get adequate rest daily, get regular physical activity, etc.).						
On most days of the week I set aside time for healthy activities (sport, cooking, etc.)						
I know when my lifestyle is creating health problems for me						
I can try out various ways to overcome hurdles to my health care goals (e.g. get adequate rest daily, get regular physical activity, eat more plant based foods, achieve/maintain a healthy weight, be free on dependence on tobacco, etc.)						
I know a positive method to cope with stress.						

	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree	No answer/ Don't Know
I can ask for support for taking care of my health when I need it.						
When I have symptoms, I have the skills that help me identify what it is and cope.						
I know what helps me stay motivated to adopt/keep healthy habits.						
Even if I had some health problems, I can find ways to be positive.						
I often worry about my health						
I try to make the most of my life						
I am doing interesting things in my life						

8.1.6. Prevention and healthy behaviour

Health

- On scale from 1 to 10, where 1 is "Very bad" and 10 is "Very good", self-assess your health condition:

1	2	3	4	5	6	7	8	9	10

- On scale from 1 to 10, where 1 is "Very bad" and 10 is "Very good", self-assess your quality of life:

1	2	3	4	5	6	7	8	9	10

- How do you describe your weight?

Very Underweight	Slightly underweight	About the right weight	Slightly overweight	Very Overweight

- Which of the following are you trying to do about your weight?

Lose Weight	Gain Weight	Stay the same weight	I am not trying to do anything about my weight

- How much sleep do you usually get each night?

4 or less hours	5 hours	6 hours	7 hours	8+ hours

- How many cigarettes do you smoke every day?

None	Just a few (<5)	Half a package	A package	More than a package

- Do you undergo regularly any of these health exams in order to prevent diseases or health problems? (Multiple selection)

  - Dental check-up
  - Cancer screening (e.g. colon, prostate, …)
  - Blood pressure test
  - Urine test
  - BMI check (weight test)
  - Mammography test
  - Cytology test
  - Osteoporosis test
  - Heart test
  - None
  - Other _____

Food and nutrition

- Do you have specific diet (e.g. vegetarian) or eating style? Multiple choice:

- Vegetarian
- Semi-vegetarian (e.g. pollotarian, pescetarian,…)
- Vegan
- Gluten free
- Glucose free
- Clean
- Paleo
- None
- Other _____

*Is it related to a specific disease or to a lifestyle choice?

Specific disease	Lifestyle choice

- In a normal week, how many times did you eat fruit?

I did not	1 to 3	4 to 6	1 per day	2 per day	3 per day	4 or more per day

- In a normal week, how many times did you eat vegetables?

I did not	1 to 3	4 to 6	1 per day	2 per day	3 per day	4 or more per day

- In a normal week, how many times did you drink a can, bottle or glass of soda or pop?

I did not	1 to 3	4 to 6	1 per day	2 per day	3 per day	4 or more per day

- In a normal week, on how many days did you eat breakfast?

0	1	2	3	4	5	6	7

Physical activity

- In a normal week, on how many days were you physically active for a total of at least 30 minutes per day? (e.g. climb stairs, walk)

0	1	2	3	4	5	6	7

- In a normal week, on how many days do you perform any gymnastic or aerobic exercise (e.g. weight lifting, push-ups, sit-ups)?

0	1	2	3	4	5	6	7

- In a normal week, which type of sport exercises do you usually do? Multiple choice:

- Yoga
- Pilates
- Jogging / Walking
- Aerobic / Aquaerobics / Zumba
- Dancing (e.g. salsa)
- Hiking
- Biking / Spinning
- Weight Lifting
- I don't do any sport exercises
- Other_____

8.1.7. Intention

NESTORE is a virtual coach: an intelligent system that collects information in order to provide its users with customized advice to lead a healthy lifestyle. It generates motivation to take care of your health and suggests nutrition, physical activities, memory games and social interactions to preserve your wellbeing.

NESTORE is a virtual friend and coach able to understand your needs, your preferences and your moods. It will propose you activities and services corresponding to your personality, your environment and your health status. Think about an innovative personalized coaching system for the management of healthy lifestyle and the support of healthy ageing through the use of a user friendly digital technology.

On a scale from "strongly disagree" to "strongly agree", how would you rate the following sentences?

- I would use NESTORE to manage my lifestyle

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- I would use NESTORE to maintain my physical well being

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- I would use NESTORE to maintain my mental well being

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- I would use NESTORE to maintain my social well-being

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- I would use NESTORE to control and manage my nutrition habits

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- I would prefer using NESTORE individually than with other people (e.g. friends, relatives).

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- Using NESTORE would fit well with my lifestyle.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- NESTORE would be a nice fit for my daily routine.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- Using NESTORE for my routine activities is compatible with how I like to do things.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

8.1.8. Perceived Usefulness

On a scale from "strongly disagree" to "strongly agree", how would you rate the following sentences?

- Using NESTORE to help me maintain and improve my mental well-being is a good idea.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- Using NESTORE to help me maintain and improve my physical well-being is a good idea.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- Using NESTORE to help me manage and improve my Nutrition well-being is a good idea.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- Using NESTORE to help me maintain and improve my Social well-being is a good idea.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- Using NESTORE is beneficial to improve my overall well-being.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- NESTORE would make it easier to have a healthy lifestyle.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- I would find NESTORE useful in my life

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- I think it would be useful for my health to use NESTORE to monitor my lifestyle

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- Assuming that I have access to NESTORE, I intend to use it frequently

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

8.1.9. Tangible object

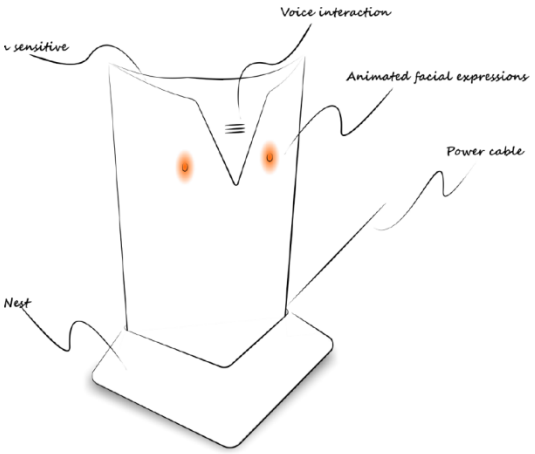
NESTORE will also be a tangible object with a physical interface like Google Home and Alexa. Thinking about NESTORE system and its functionalities, on a scale from 1 to 7, where 1 is "Dislike Very Much" and 7 is "Like Very Much", how would you rate the following product designs?

Alexa Physical Interface

1	2	3	4	5	6	7

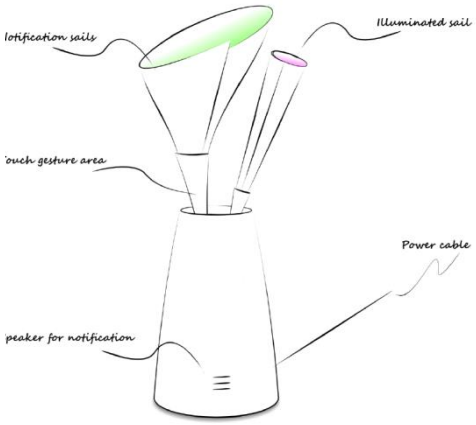
Google Home Physical Interface

1	2	3	4	5	6	7



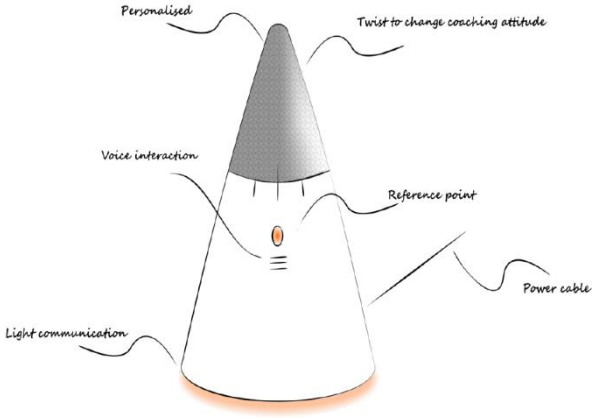
NESTORE Physical Interface #1

1	2	3	4	5	6	7



NESTORE Physical Interface #2

1	2	3	4	5	6	7



NESTORE Physical Interface #3

1	2	3	4	5	6	7

On a scale from "strongly disagree" to "strongly agree", how would you rate the following features?

CONTROLLABLE:

- I would like to understand which data will be collected and how it will be treated in order to be in control of such parameters and be able to change privacy settings.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- I should be able to disconnect the system whenever I want.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

ROBUSTNESS:

- The system should withstand everyday use.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

PERSONALIZATION:

- The coach's behaviour (attitude and personality) should be manually customized by each user.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- The coach's behaviour should adapt itself to the user's mood.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- The coach's behaviour should adapt itself to the coaching domains (e.g. nutrition, cognitive, physical activity).

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- The frequency of interaction and notification should be manually customized by each user.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

INTERACTION:

- I would prefer to interact with NESTORE using voice interaction rather than typing.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- In order to have an effective interaction with NESTORE, there should be a visual point of reference to identify the microphone.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- I would like to be the one who invokes vocal communication rather than letting NESTORE interact with me independently.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- I would prefer to receive notifications from NESTORE only when I ask for them.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- I would prefer to receive vocal notifications rather than text notifications.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- Before starting any notification, I would prefer that NESTORE would make me a signal like a soft sound or a light signal in order to attract my attention.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

8.1.10. Social influence and consumer behaviour

To what extent do you agree with these statements?

- The use of NESTORE will improve the image others have on myself.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- Innovative technologies such as NESTORE are a symbol of wealth/social status.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- NESTORE can be used to impress other people.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- I would like to be seen wearing or using a NESTORE device.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- My relatives think a virtual coach such as NESTORE would help me to manage my lifestyle.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- My General Practitioner think a virtual coach such as NESTORE would help me to manage my lifestyle.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- My friends think a virtual coach such as NESTORE would help me to manage my lifestyle.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

8.1.11. Willingness to pay

To what extent do you agree with these statements?

- Paying for NESTORE would be a good value for money as it is an intelligent system that would help me manage my overall well-being.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- I would be willing to pay for NESTORE system as it will offer me a customized and proactive service to maintain a healthy lifestyle.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- I feel that NESTORE is an unnecessary expenditure.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- I would recommend NESTORE to my friends and/or family.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Don't know

- How would you prefer to acquire the product?
  - Monthly subscription plan, related with the use
  - One-time payment, at the purchasing moment
  - Freemium (Basic version is free and a more sophisticated one costs extra)
  - Provided by health insurance (included in it)
  - Provided by social security

- Which would be the best purchasing channel?
  - Large electronic retailers
  - Online (e.g. Amazon, eBay)
  - Medical stores
  - Pharmacies
  - Gymnasiums / Fitness Clubs
  - Other_____

8.1.12. Socio-demographic variables

- Considering your monthly sources of income, what is your perception of your monthly household net income?
  - My household income is irregular; I try to figure out how to make more money to cover basic needs.
  - My household income satisfies my living costs but I cannot afford extraordinary expenditures.
  - My household income is regular and enough to satisfy my living costs unfailingly.
  - I make enough to be able to buy whatever I want without a second thought.
  - I prefer not to answer

- Any serious health condition limiting everyday life?
  - No
  - High blood pressure
  - Diabetes
  - Celiac
  - COPD
  - Mild cognitive impairment
  - Obesity
  - Other
  - I prefer not to answer

- Currently you are living

Alone	With my partner/family, supporting me	With my partner/family, but without the need of support	Alone but with need of continued assistance	I live in a retirement home

- Age:

  _____ years old.

- Weight:

  _____kg.

- Height:

  _____m.

- Sex:

Male	Female

- Education level

No schooling	Less than high school	High school degree	Bachelor's degree or more

- Occupation

Unemployed	Retired	Employed full time	Employed part time	Other

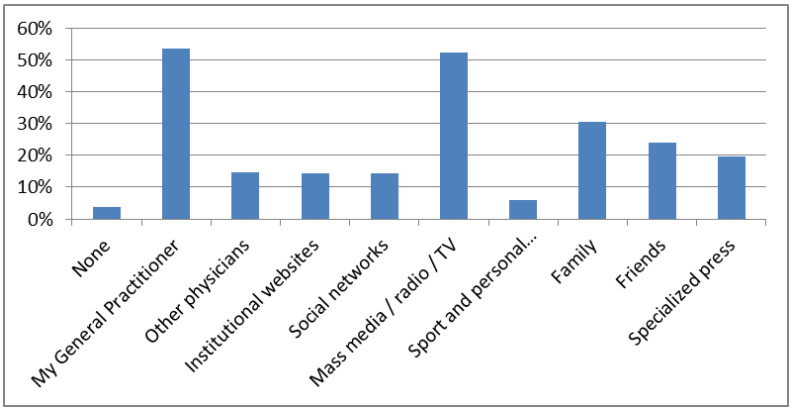
- Place (residence)

Big city (100.000+ inhabitants)	Small town (between 5.000 and 100.000)	Rural area (less than 5.000 inhabitants)

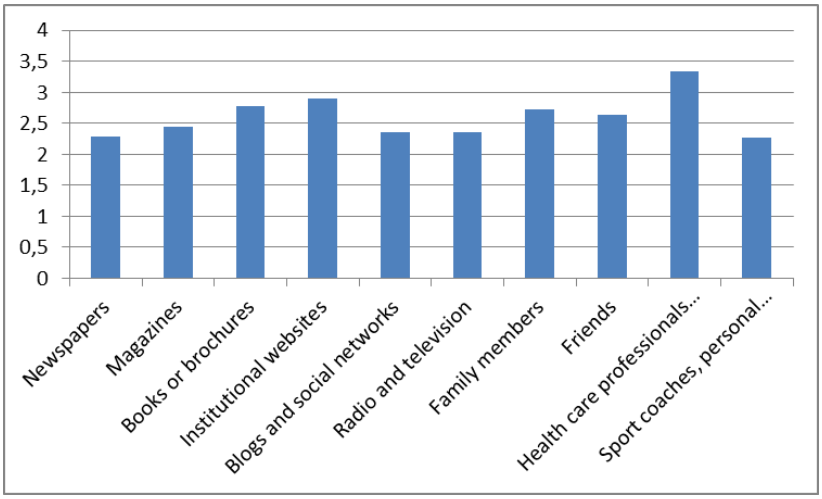
8.2. Appendix 2: Survey graphs

8.2.1. Sources of information

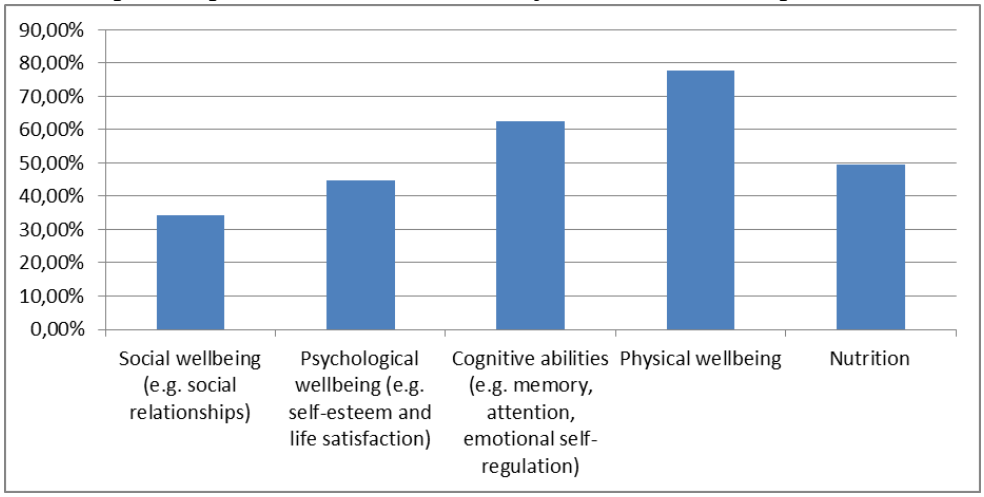
- How do you keep yourself informed about health prevention and healthy lifestyles (nutrition, physical exercise, prevention…)? Select up to three:



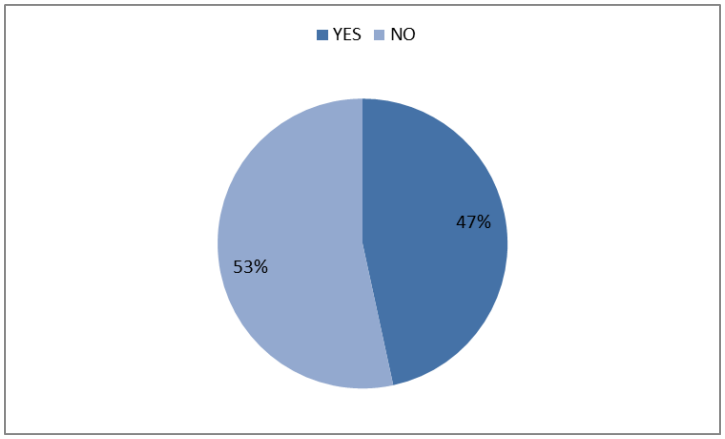
- How would you describe the quality of the information about healthy lifestyle (e.g. diet, exercise, disease prevention) in:



- With respect to prevention, what interest you more? Select up to three:

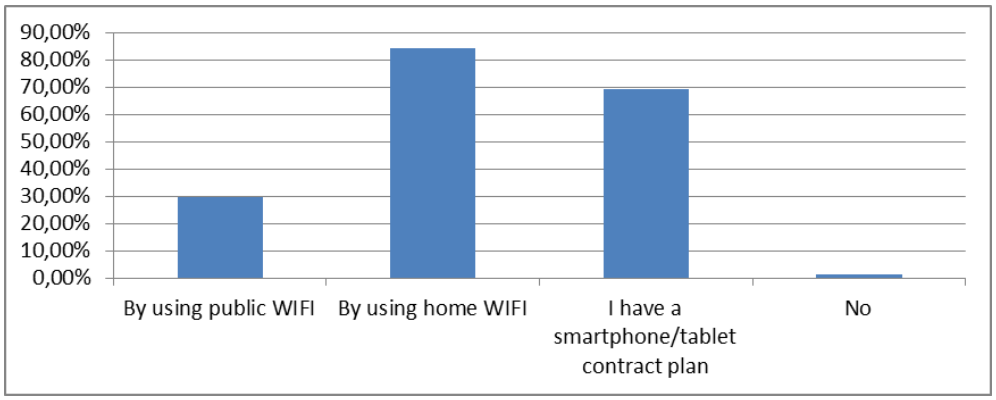


- Do you belong to any group, association or network where people share their experiences?



8.2.2. Digital Literacy

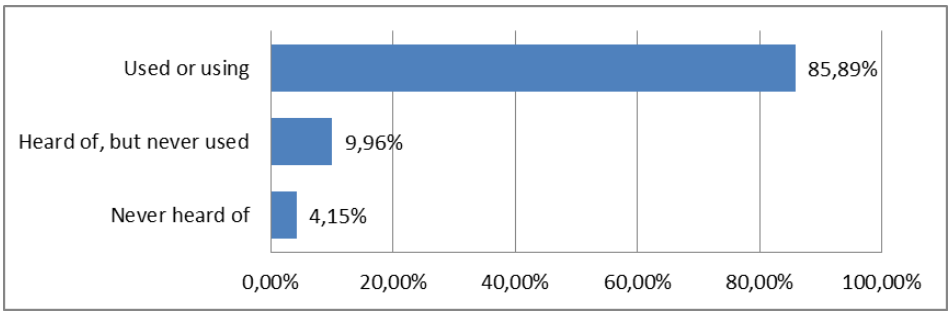
- Do you have regular access to an internet connection? Multiple choice:



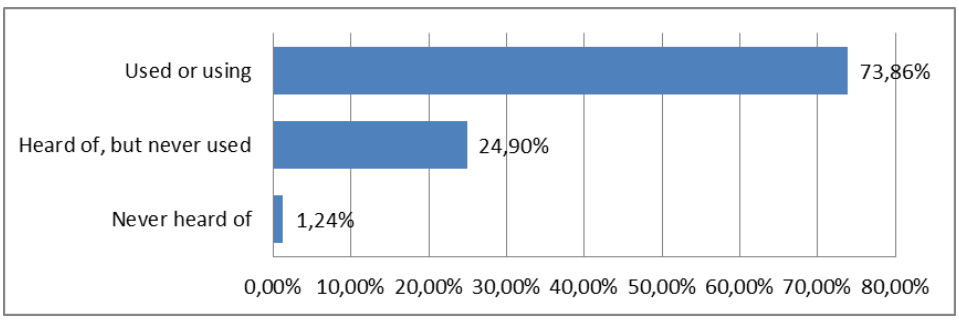
8.2.3. Current use of digital technologies

Which, if any, of these technologies do you know or have you used?

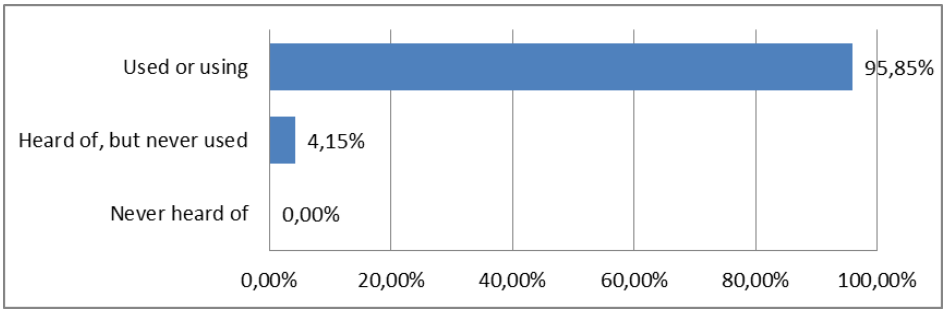
1. ***Smartphone***



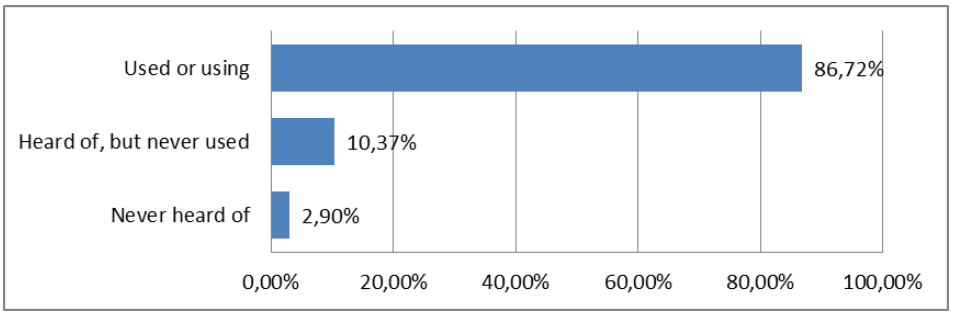
2. ***Tablet***



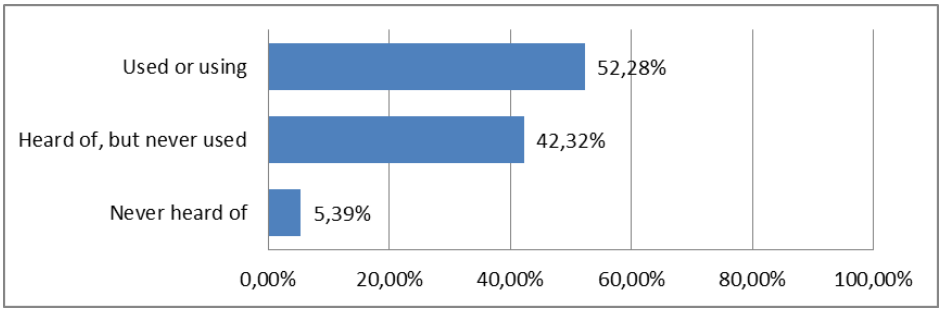
3. ***Computer/Laptop***



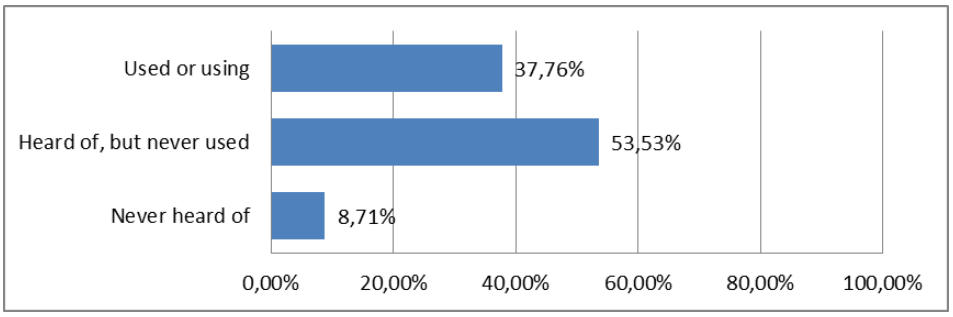
4. ***Remote control device***



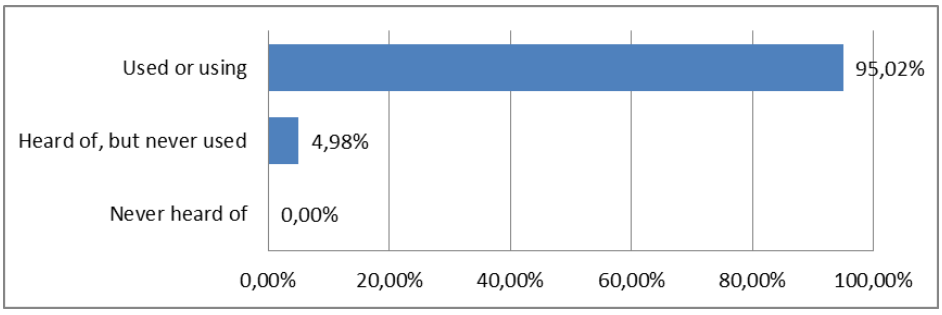
5. ***Electric cooking products (e.g. Thermomix)***



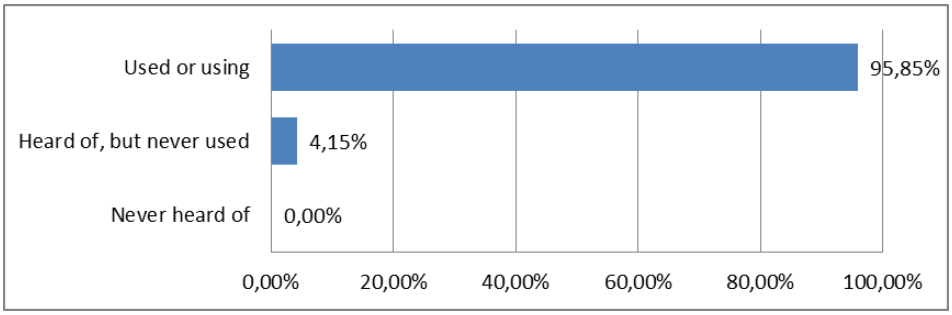
6. ***Smart thermostat***



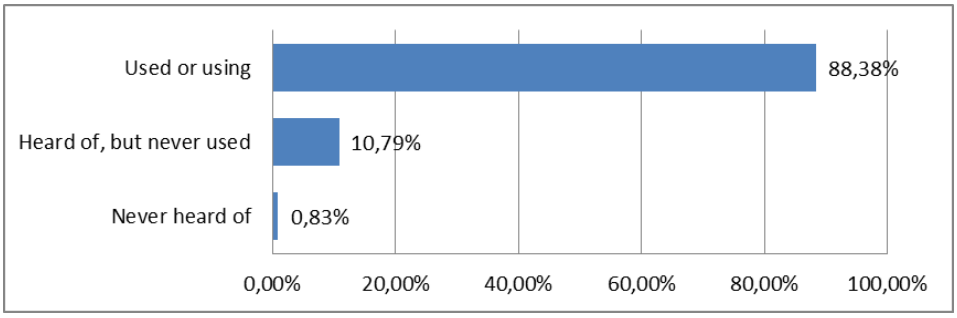
7. ***Automatic teller machine***



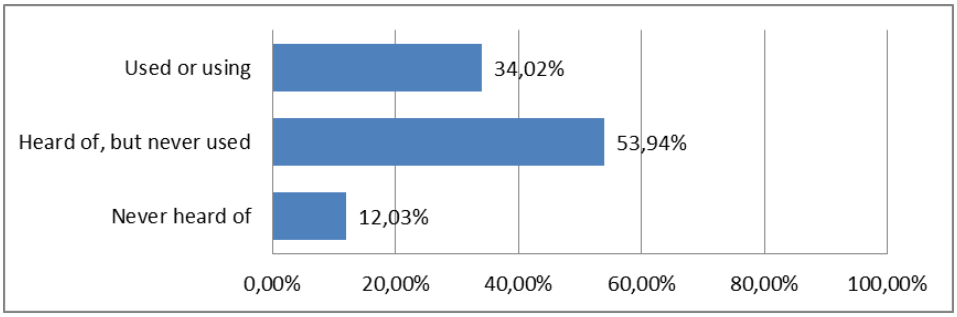
8. Credit card (usual)



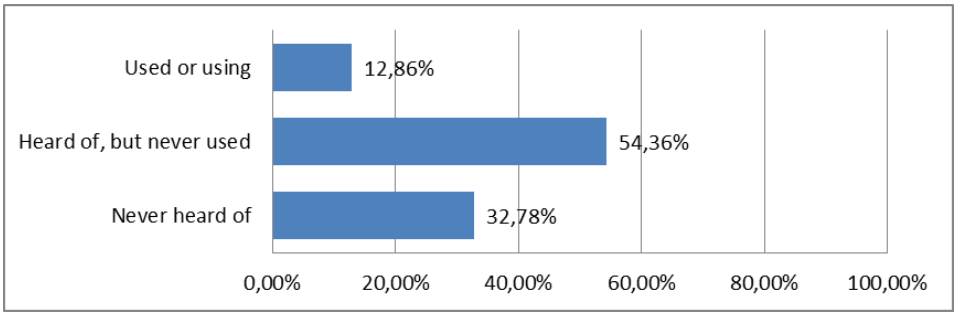
9. Transport smart card



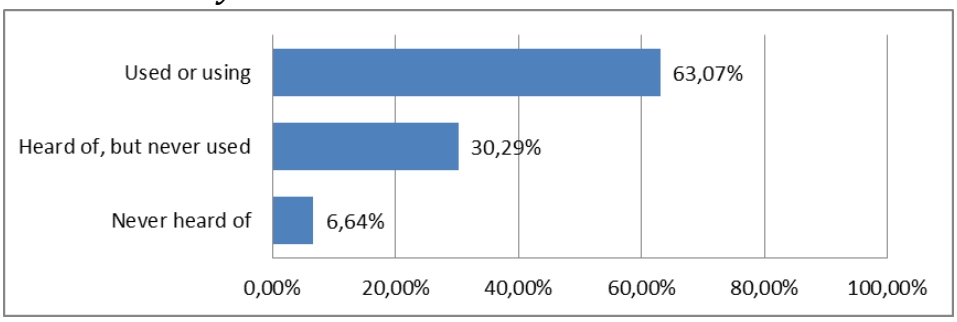
10. Wearable device (e.g. smartwatch)



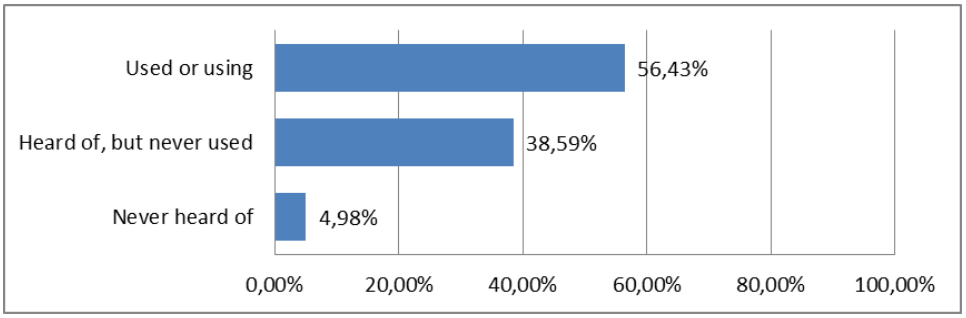
11. Intelligent home assistant (e.g. Google Home, Alexa)



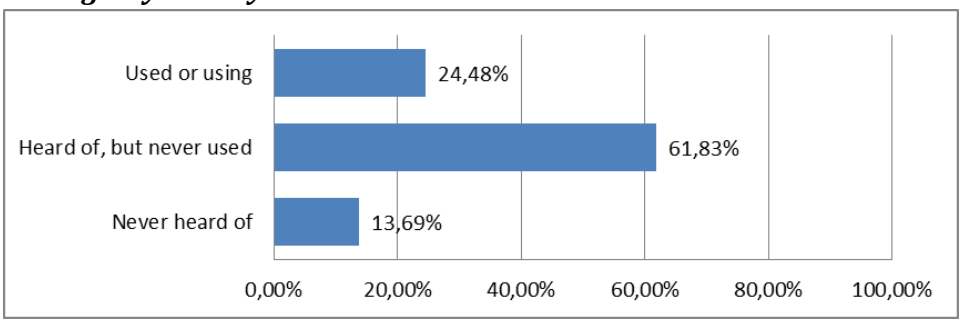
12. Connected car system



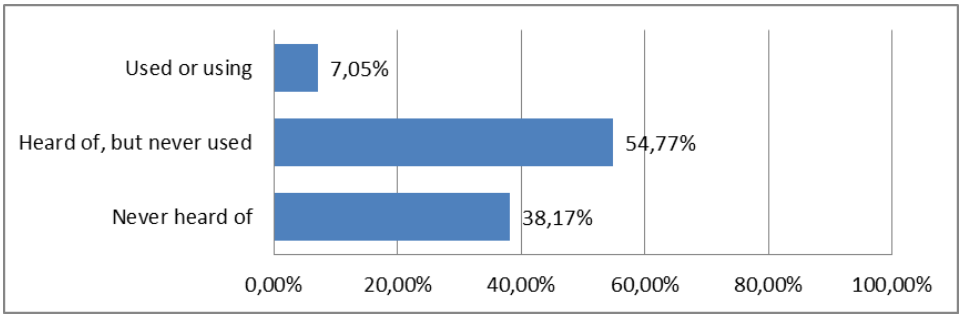
13. Health monitoring device or sport equipment (e.g. blood pressure monitor, exercise tracker)



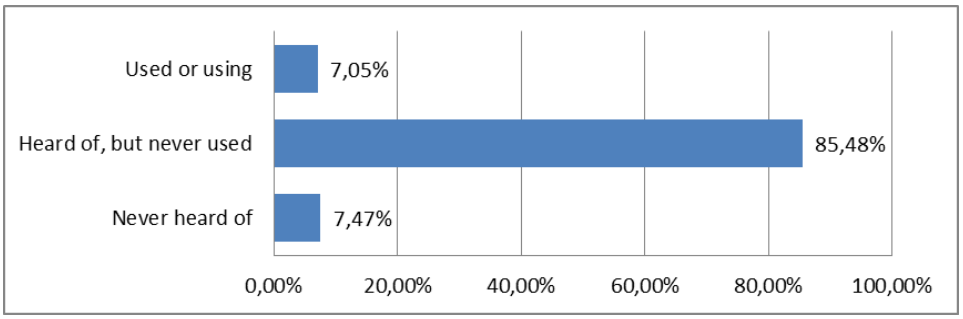
14. Emergency alert system



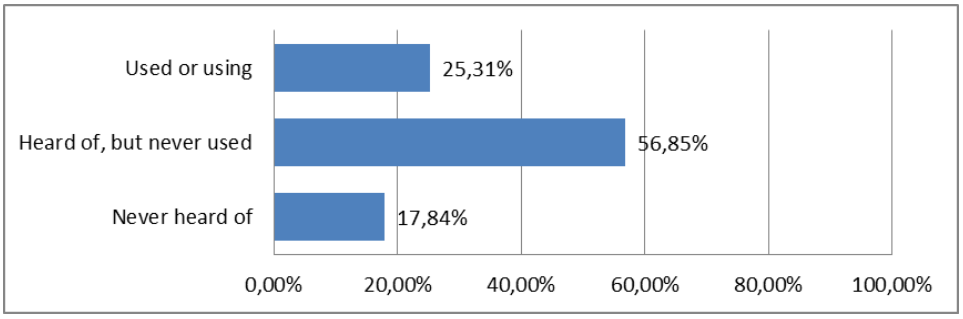
15. Electronic glucometer



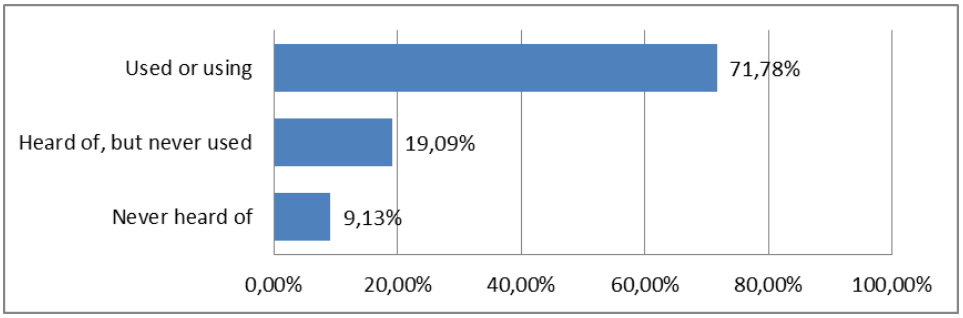
16. Telecare



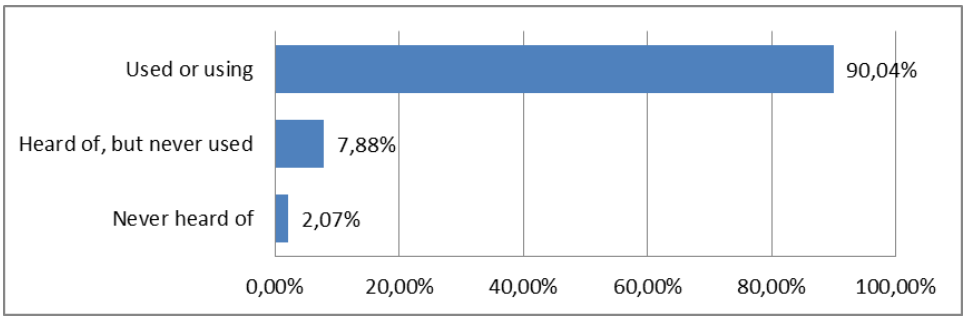
17. Smart balance (e.g. measures fat mass, bone mass, muscle mass, water…)



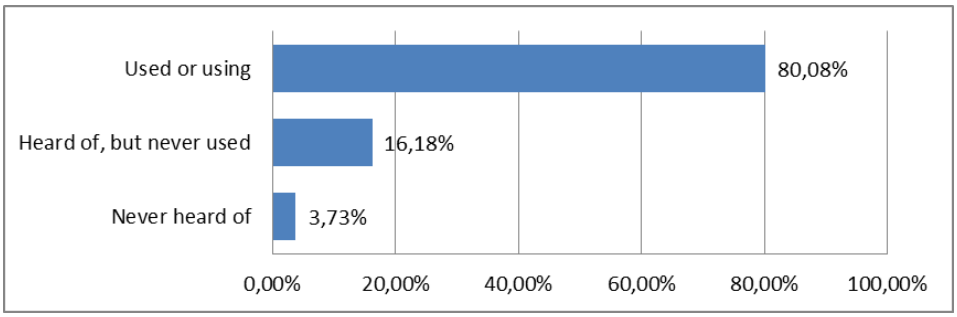
18. Electronic dictionary



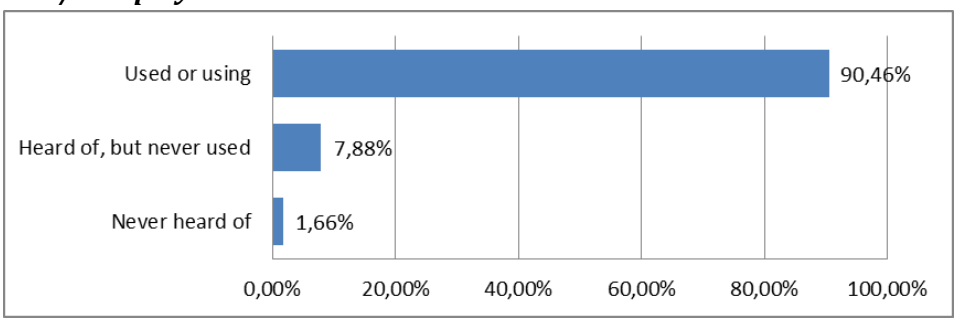
19. Digital camera



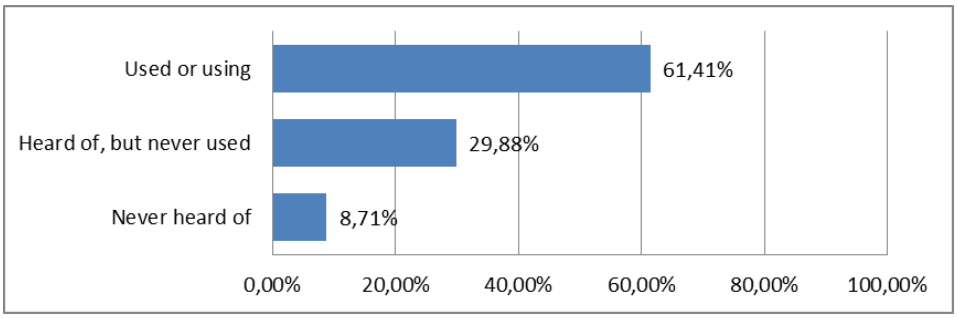
20. CD/MP3/MP4



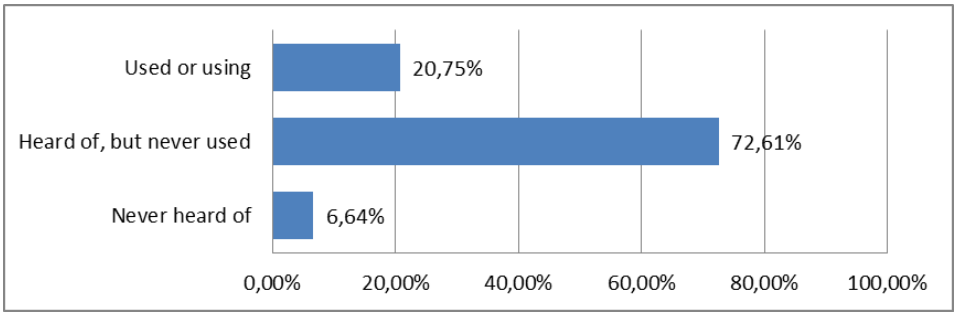
21. DVD/VCD player



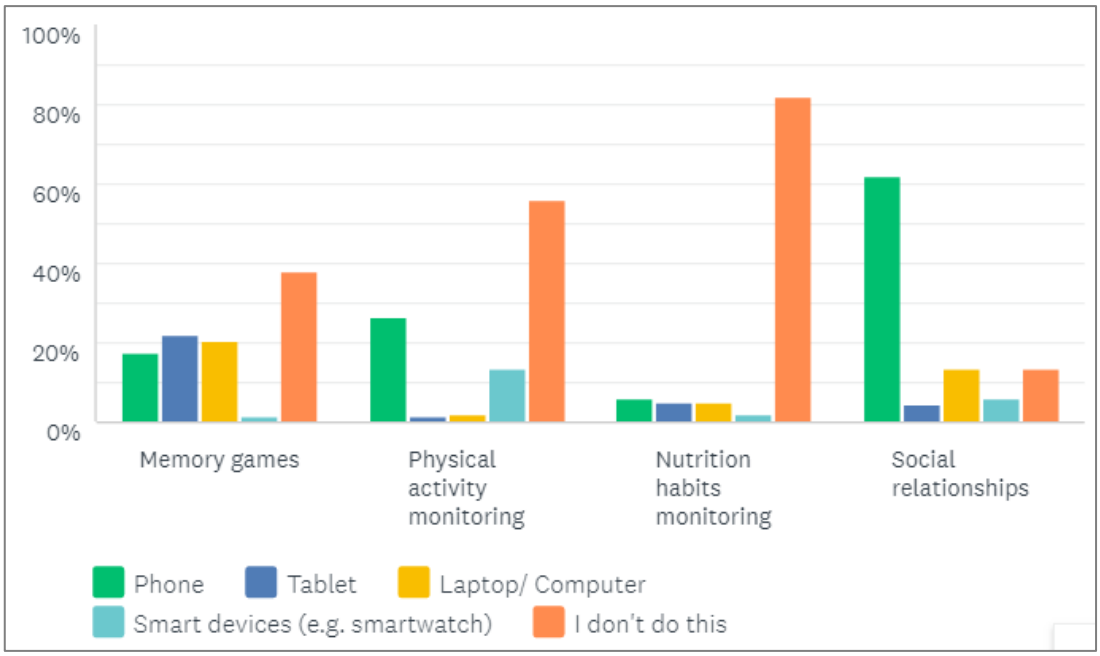
22. Smart TV



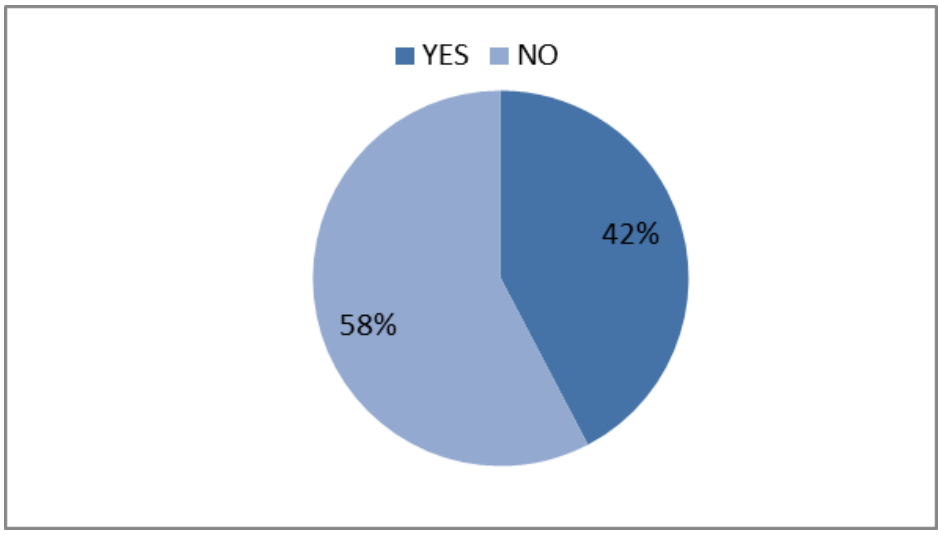
23. Video game consoles



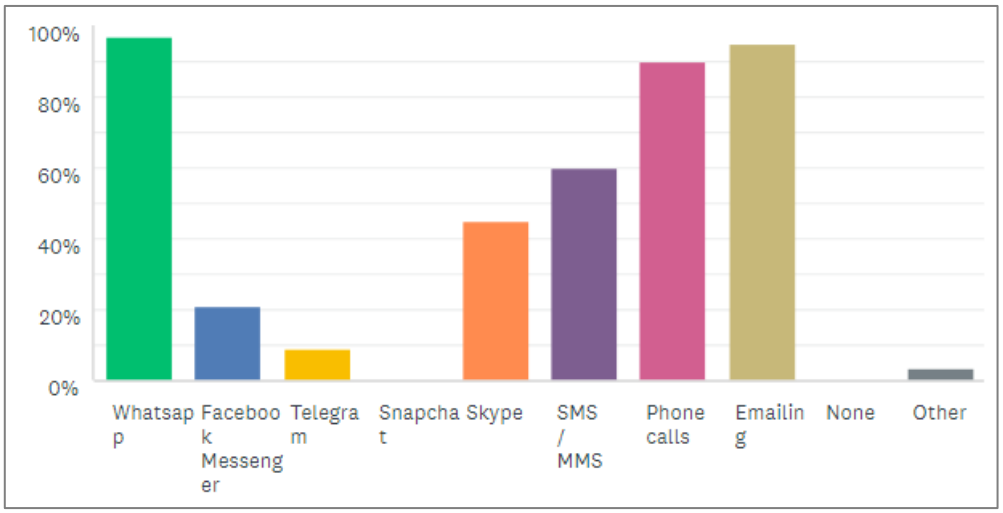
- Which, if any, is currently your preferred device for each of the following activities?



- Do you use the vocal interaction option to communicate with your device (to make it complete some actions)?

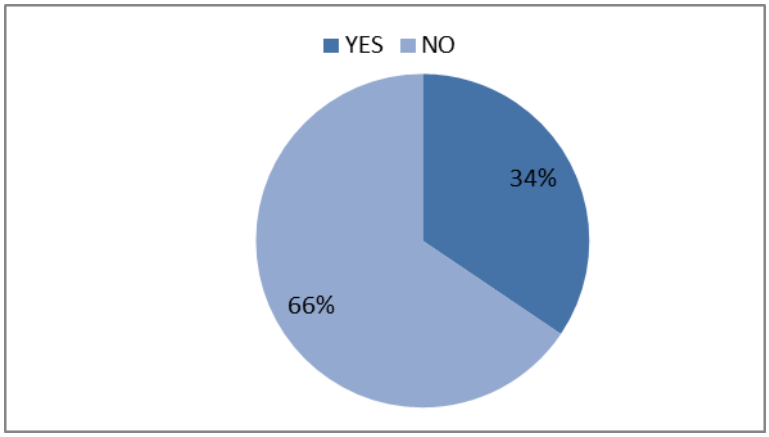


- Which messaging systems do you use?

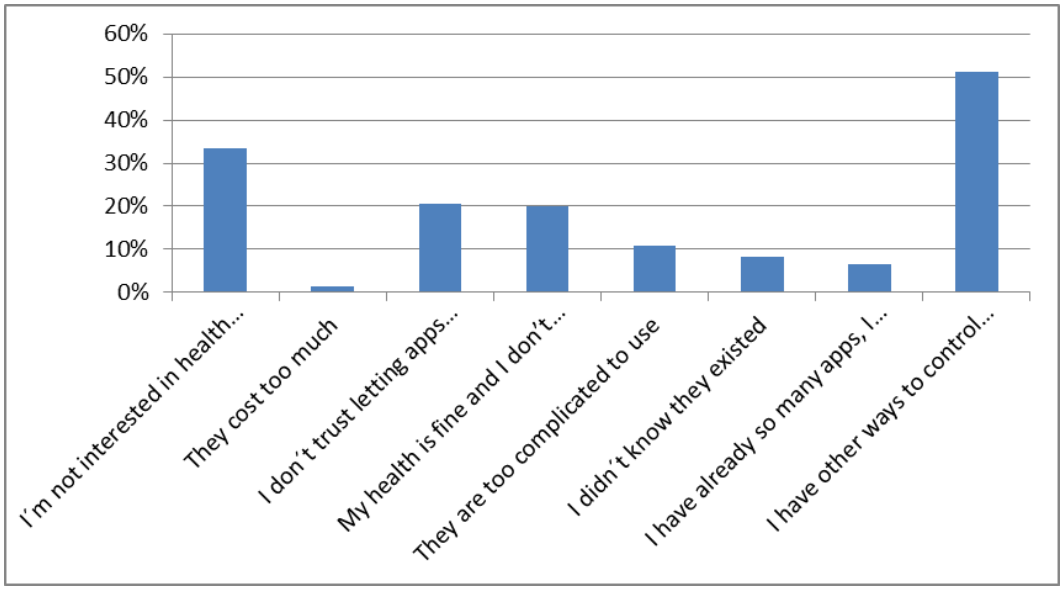


8.3. Health applications

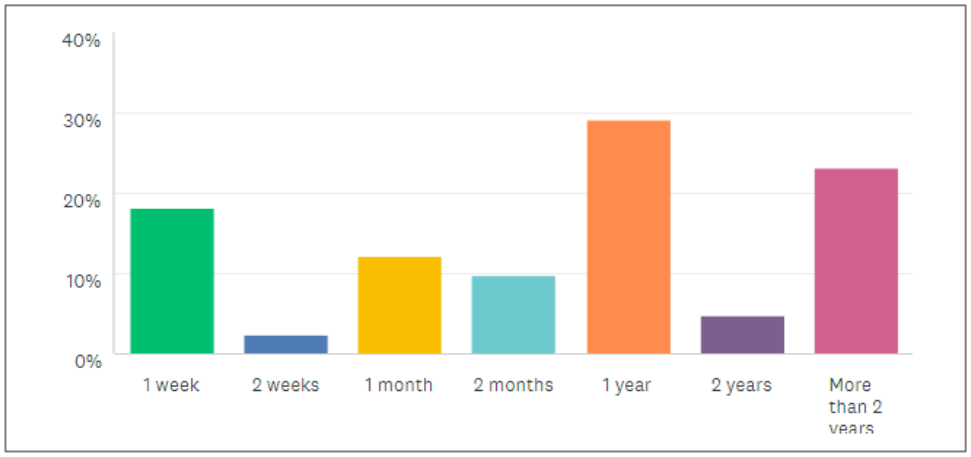
- Have you ever used a mobile application to control or support your lifestyle?



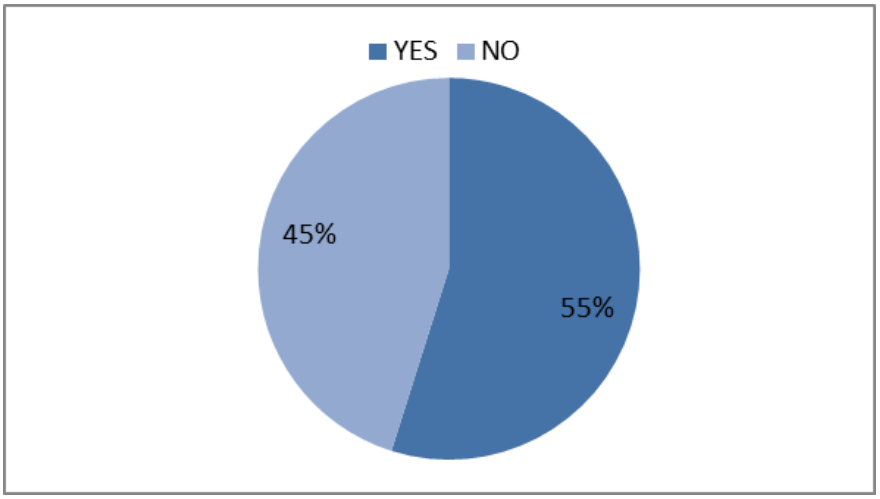
***If NO,** why?



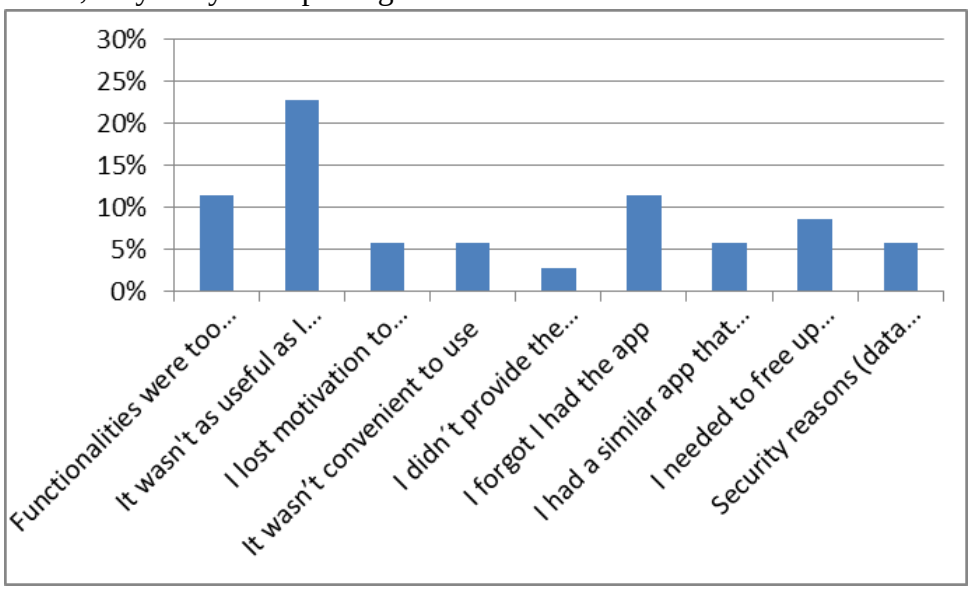
***If YES**, could you specify the longest period that you have used it?



- Do you still use it?

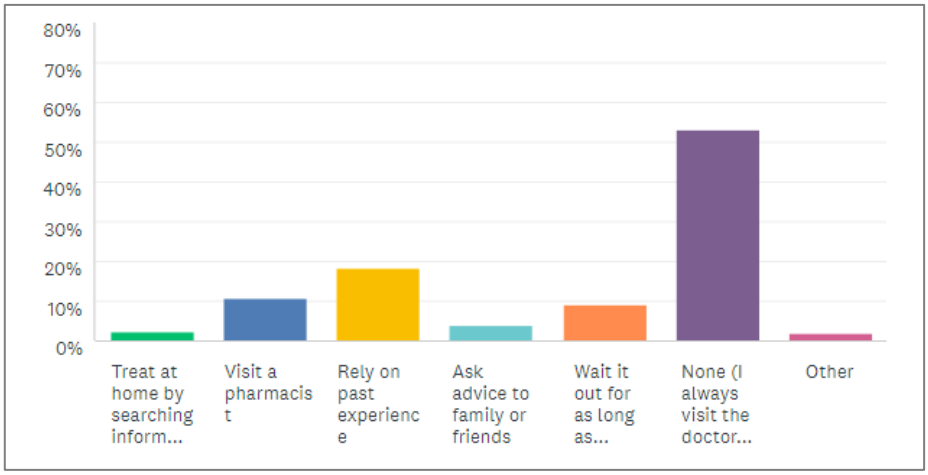


***If NO**, why did you stop using it?



8.2.4. Empowerment

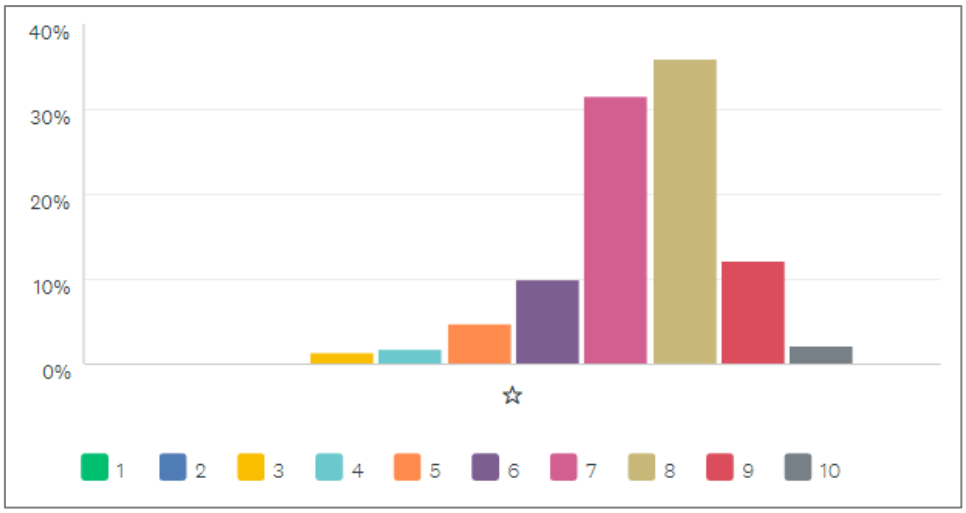
- Before addressing yourself to a doctor, do you…:



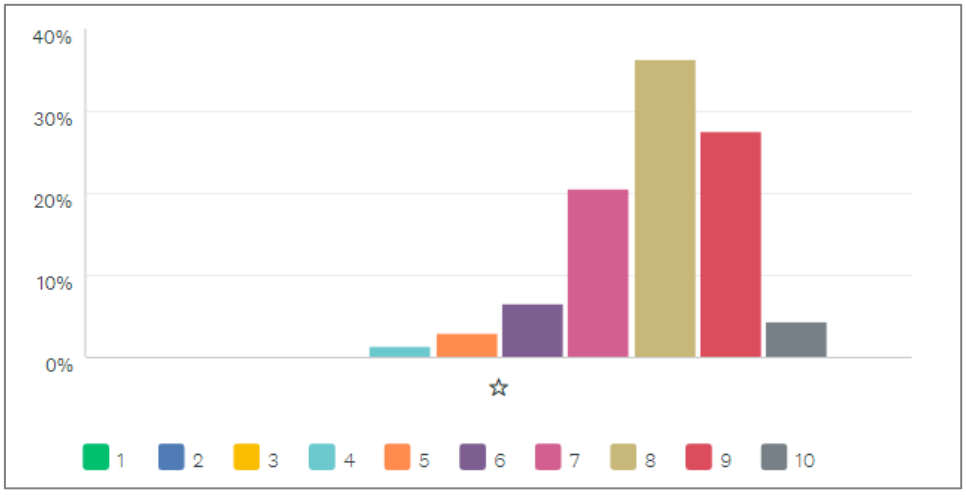
8.2.5. Prevention and healthy behaviour

Health

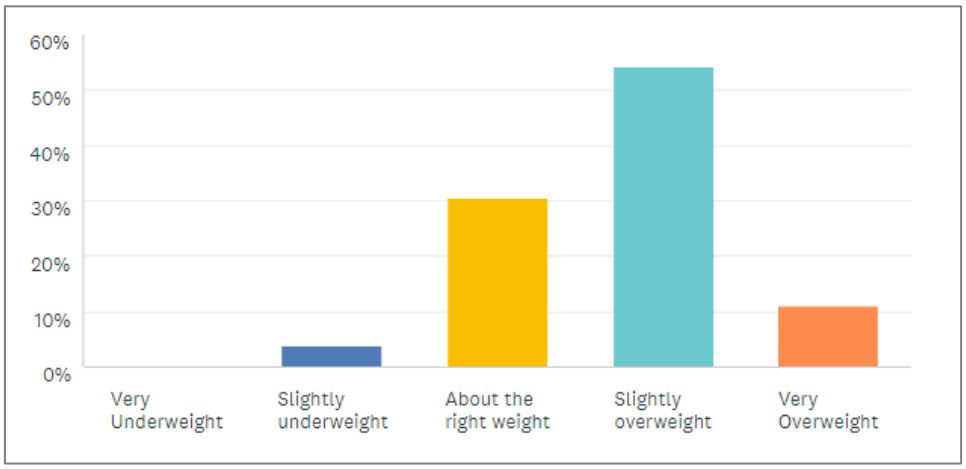
- On scale from 1 to 10, where 1 is "Very bad" and 10 is "Very good", self-assess your health condition:



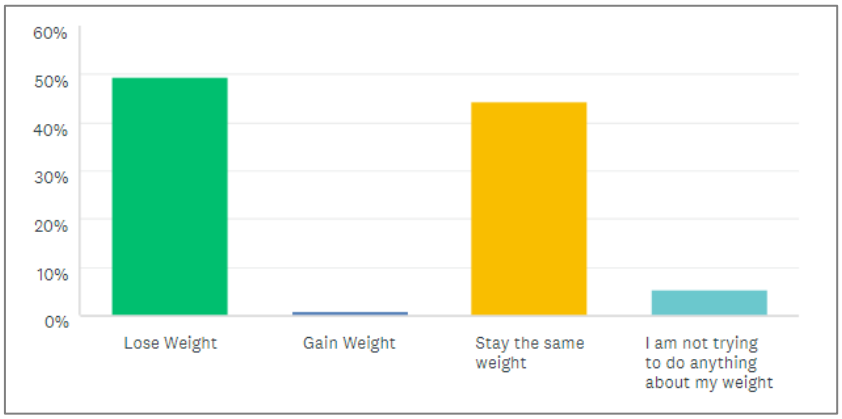
- On scale from 1 to 10, where 1 is "Very bad" and 10 is "Very good", self-assess your quality of life:



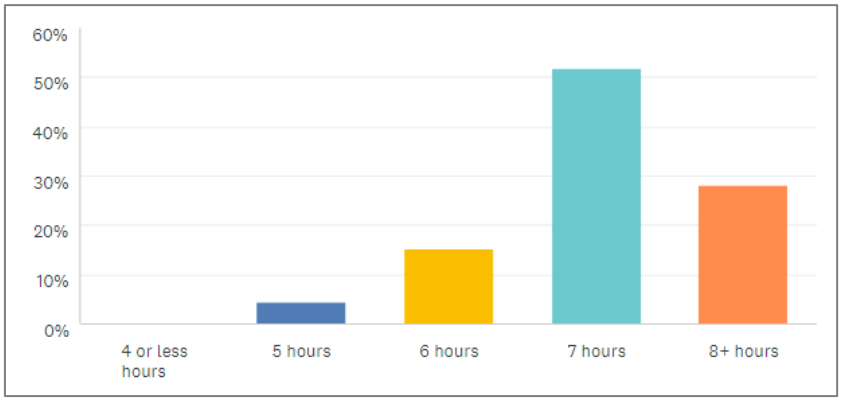
- How do you describe your weight?



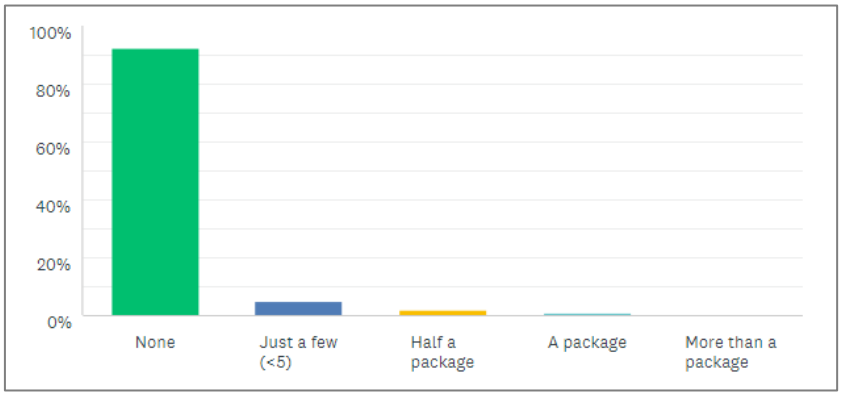
- Which of the following are you trying to do about your weight?



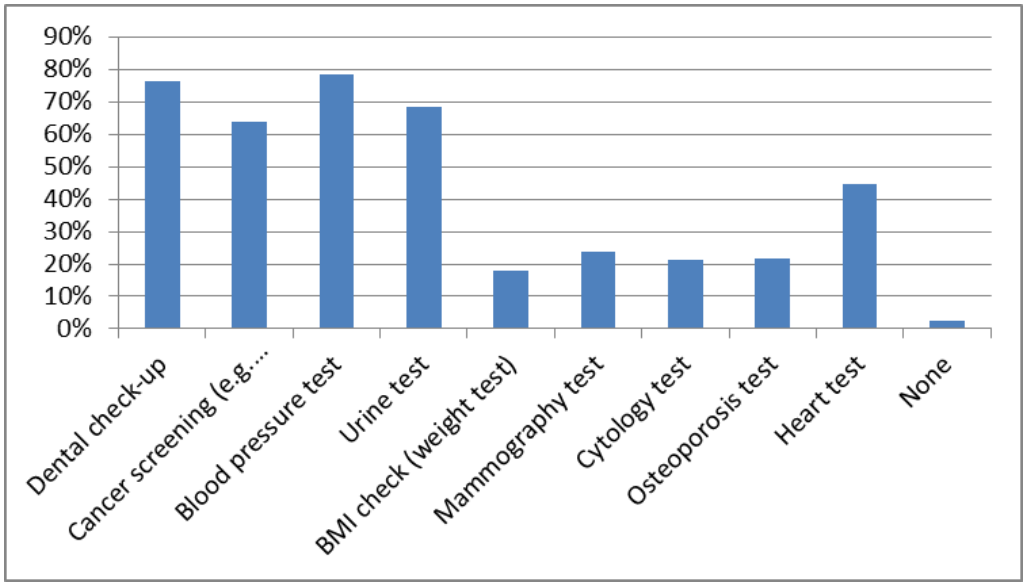
- How much sleep do you usually get each night?



- How many cigarettes do you smoke every day?

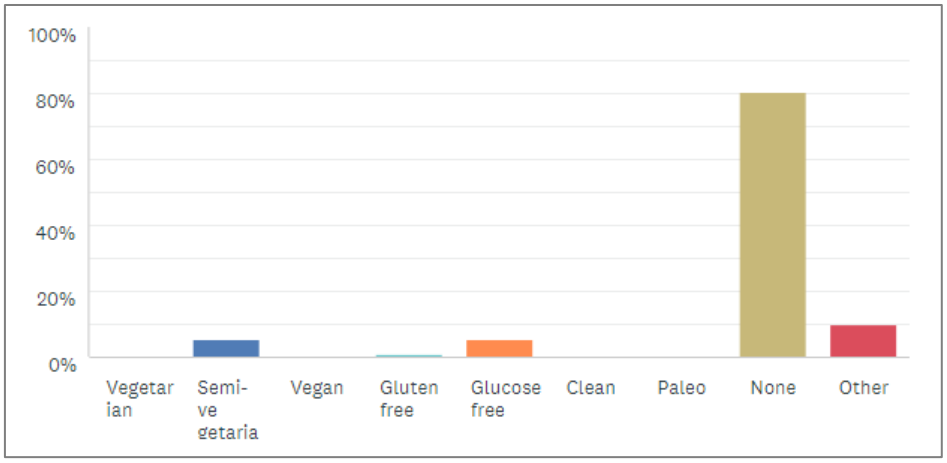


- Do you undergo regularly any of these health exams in order to prevent diseases or health problems? (Multiple selection)

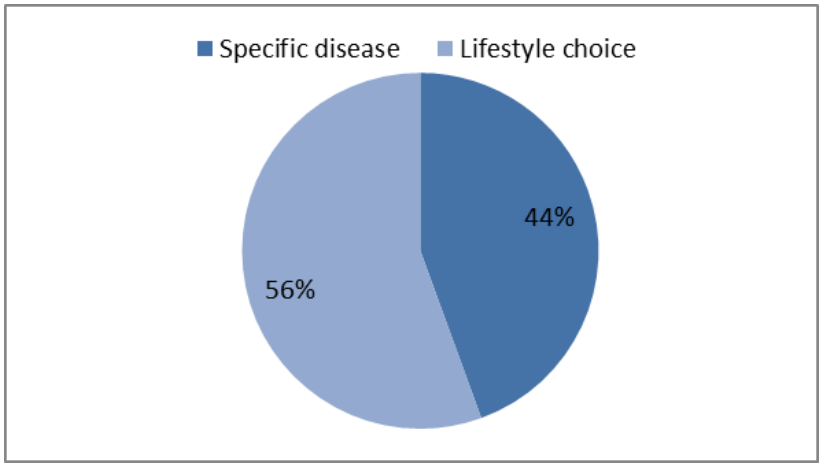


Food and nutrition

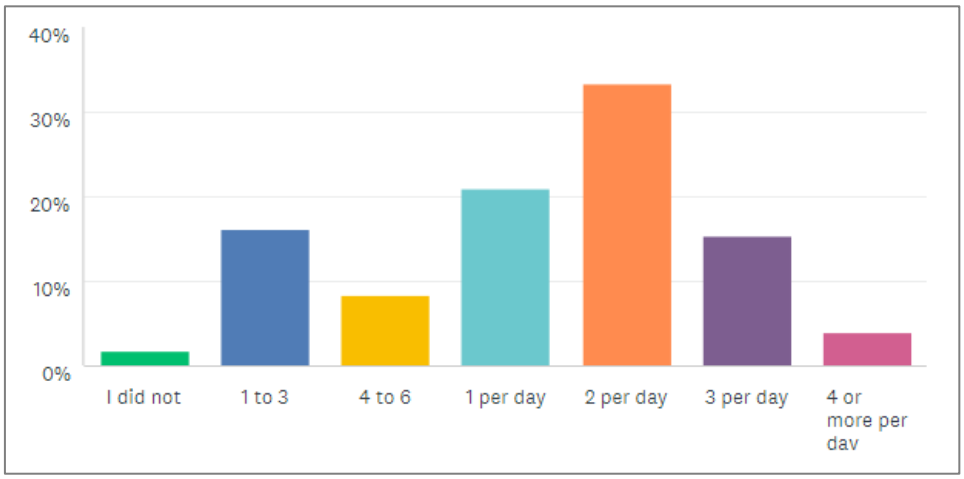
- Do you have specific diet (e.g. vegetarian) or eating style? Multiple choice:



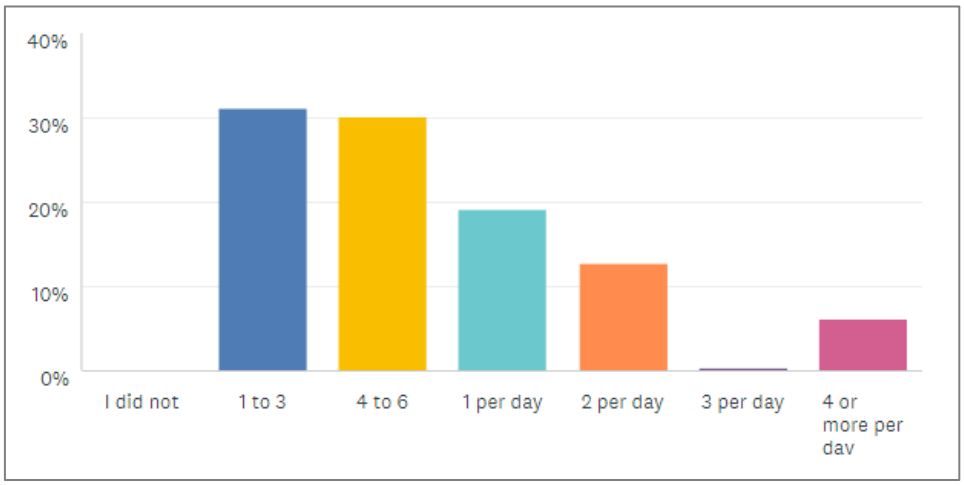
- Is it related to a specific disease or to a lifestyle choice?



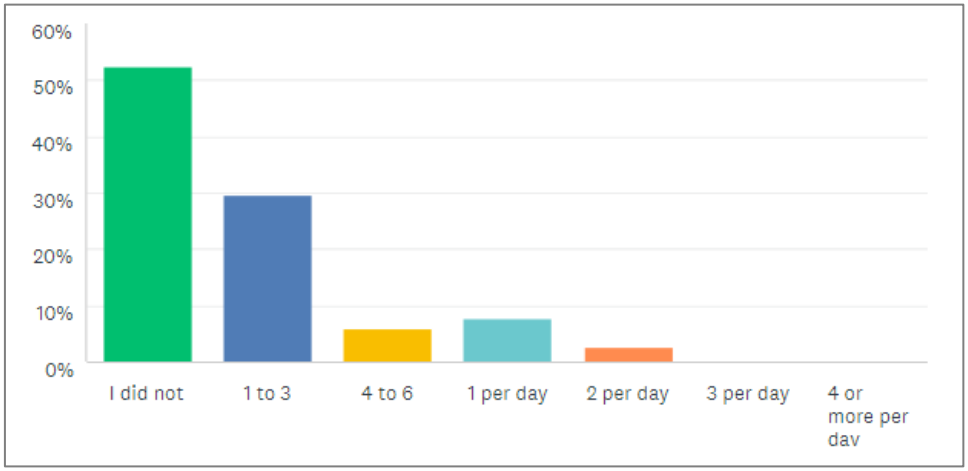
- In a normal week, how many times did you eat fruit?



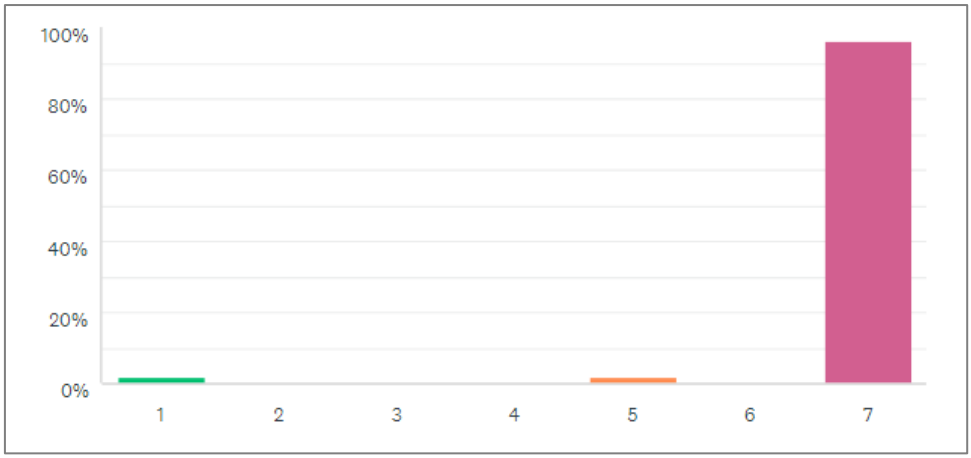
- In a normal week, how many times did you eat vegetables?



- In a normal week, how many times did you drink a can, bottle or glass of soda or pop?

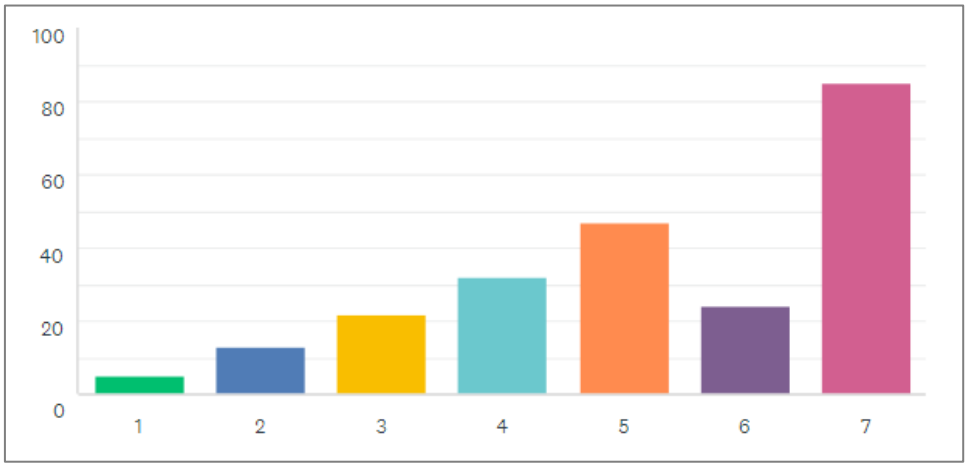


- In a normal week, on how many days did you eat breakfast?

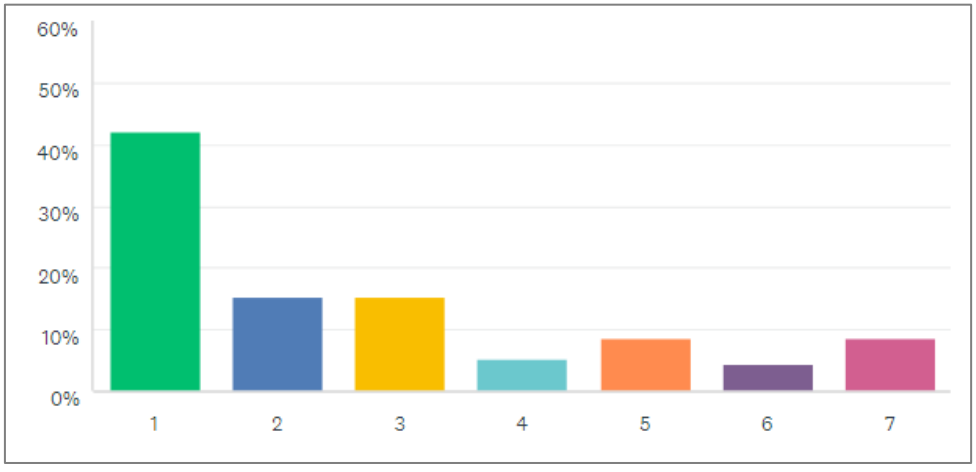


Physical activity

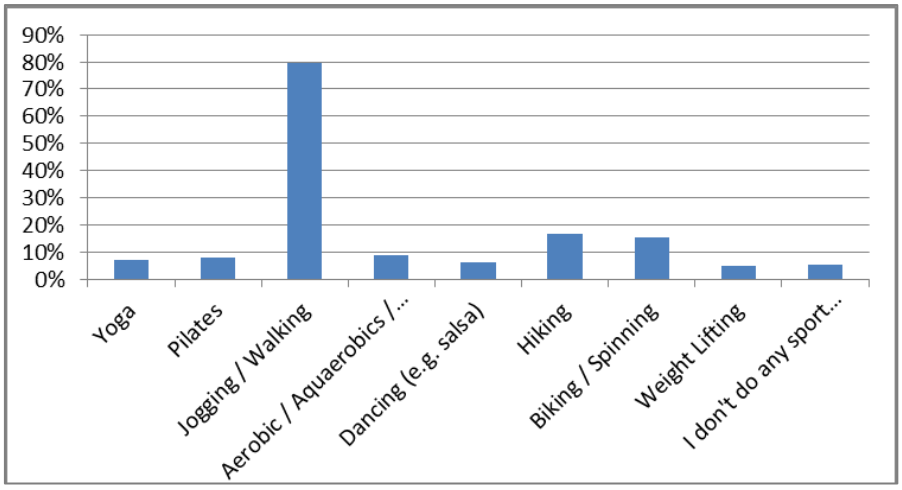
- In a normal week, on how many days were you physically active for a total of at least 30 minutes per day? (e.g. climb stairs, walk)



- In a normal week, on how many days do you perform any gymnastic or aerobic exercise (e.g. weight lifting, push-ups, sit-ups)?

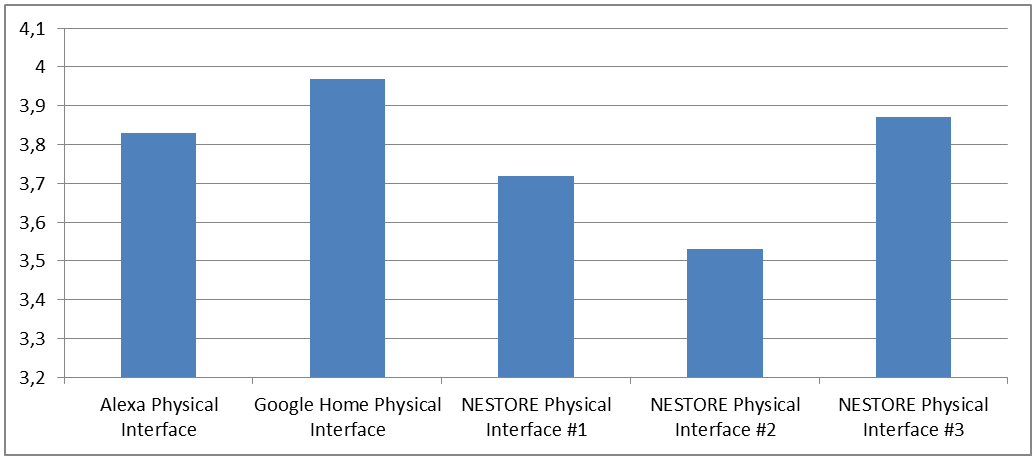


- In a normal week, which type of sport exercises do you usually do? Multiple choice:



8.2.6. Tangible object

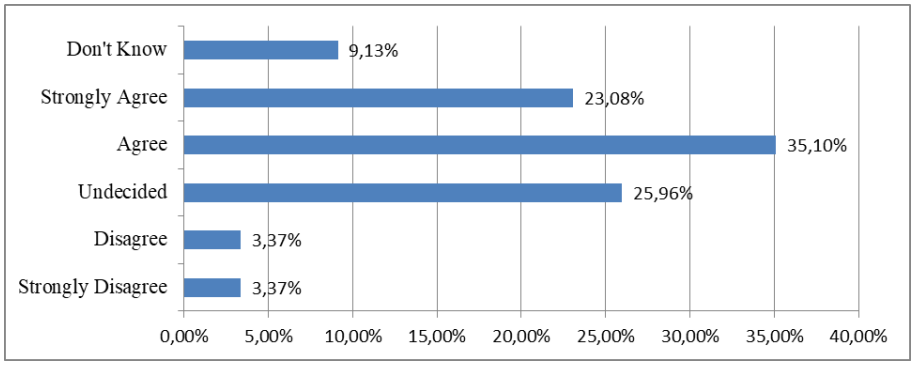
Thinking about NESTORE system and its functionalities, on a scale from 1 to 7, where 1 is "Dislike Very Much" and 7 is "Like Very Much", how would you rate the following product designs?



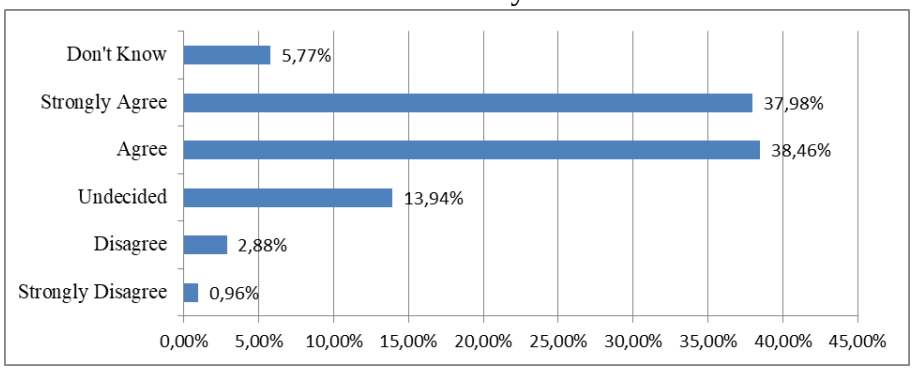
On a scale from "strongly disagree" to "strongly agree", how would you rate the following features?

CONTROLLABLE:

- I would like to understand which data will be collected and how it will be treated in order to be in control of such parameters and be able to change privacy settings.

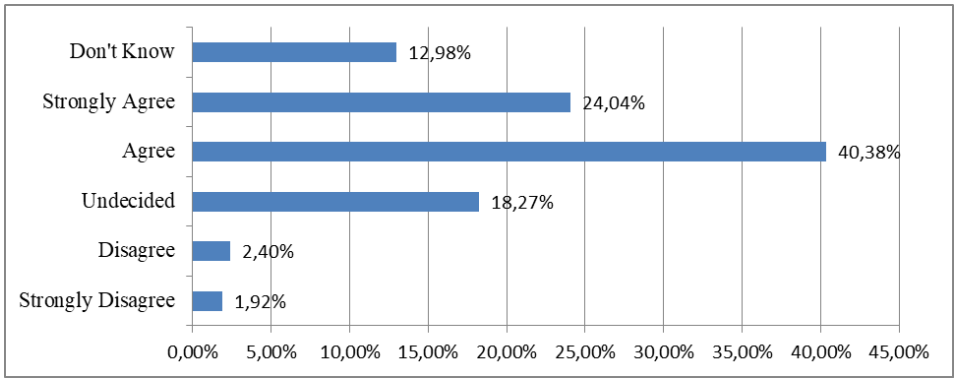


- I should be able to disconnect the system whenever I want.



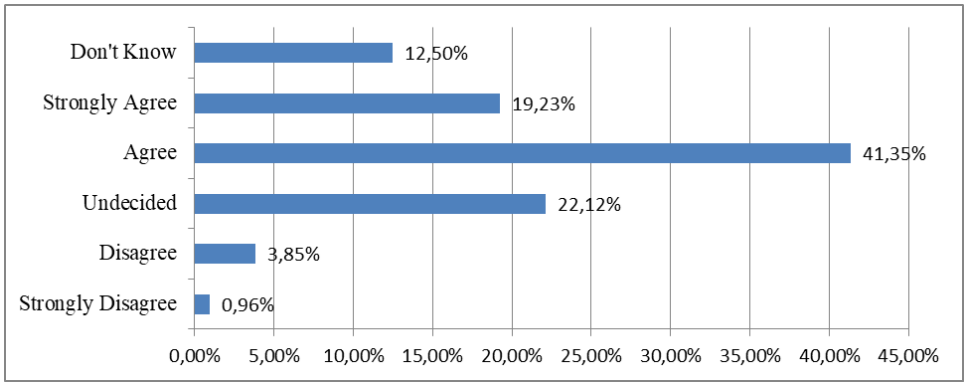
ROBUSTNESS:

- The system should withstand everyday use.

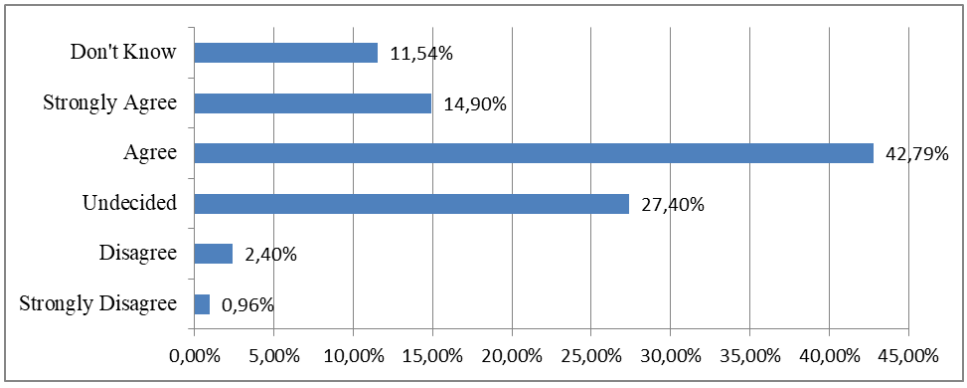


PERSONALIZATION:

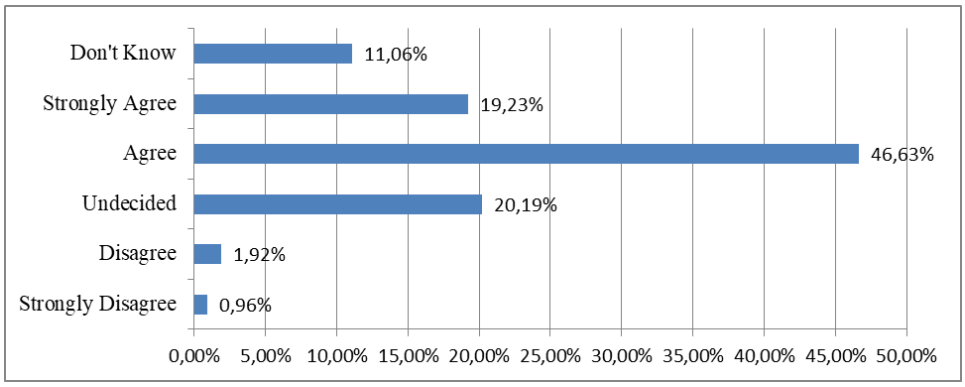
- The coach's behaviour (attitude and personality) should be manually customized by each user.



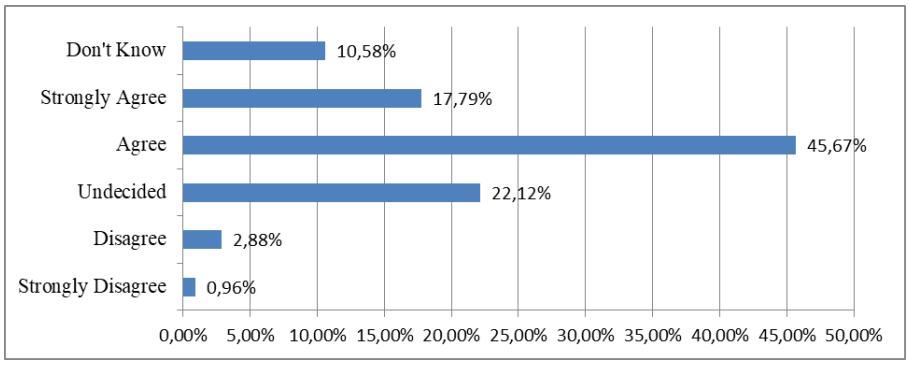
- The coach's behaviour should adapt itself to the user's mood.



- The coach's behaviour should adapt itself to the coaching domains (e.g. nutrition, cognitive, physical activity).

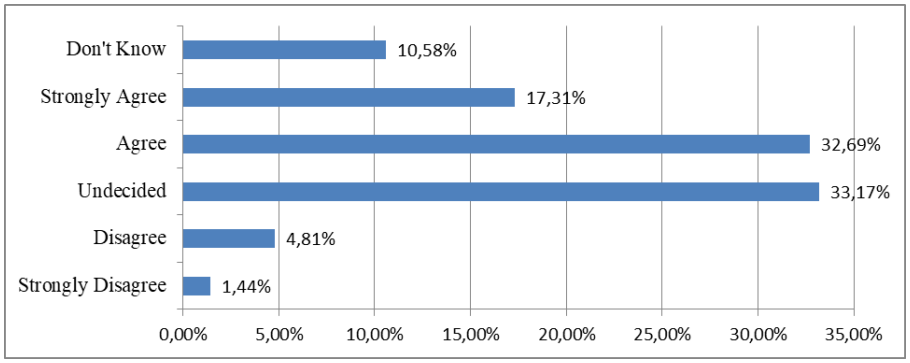


- The frequency of interaction and notification should be manually customized by each user.

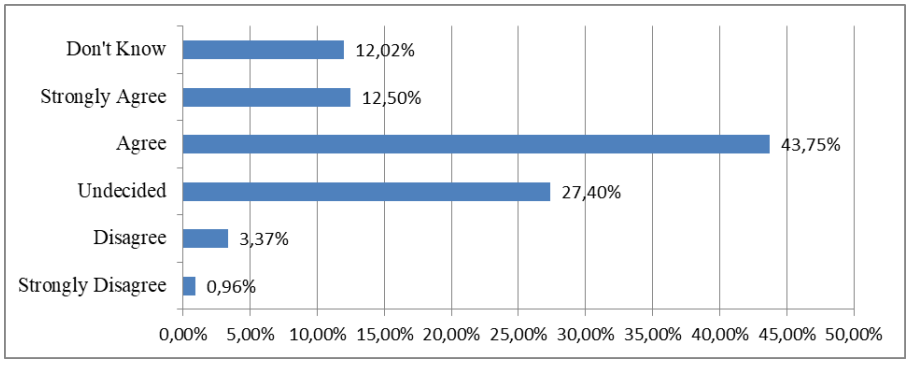


INTERACTION:

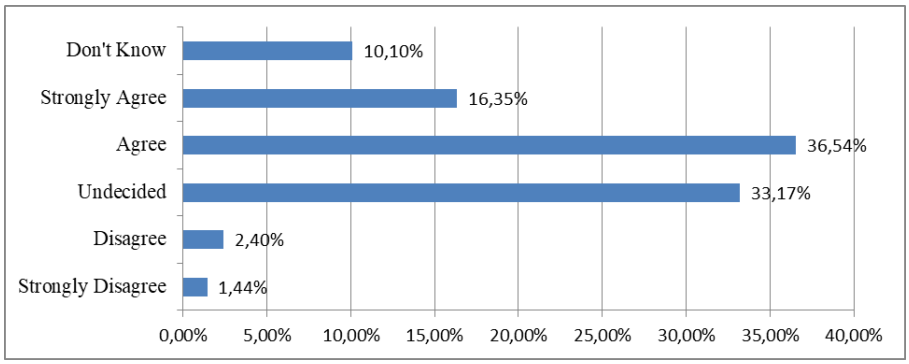
- I would prefer to interact with NESTORE using voice interaction rather than typing.



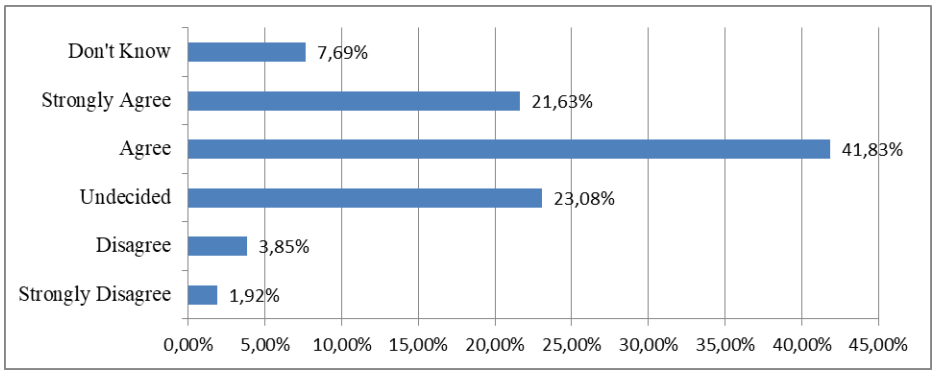
- In order to have an effective interaction with NESTORE, there should be a visual point of reference to identify the microphone.



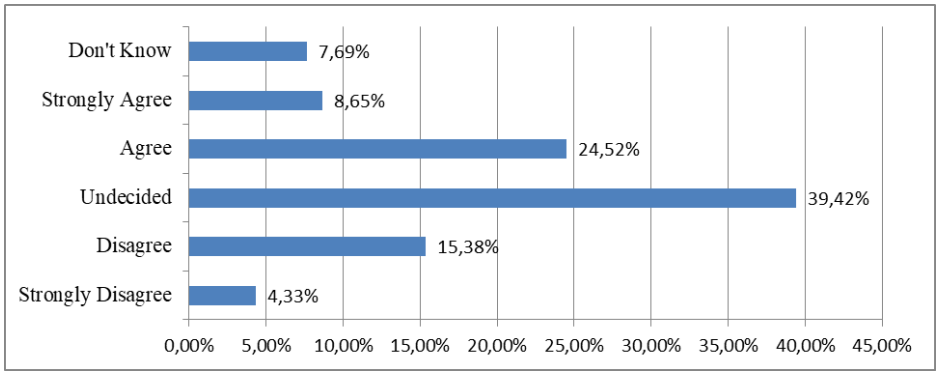
- I would like to be the one who invokes vocal communication rather than letting NESTORE interact with me independently.



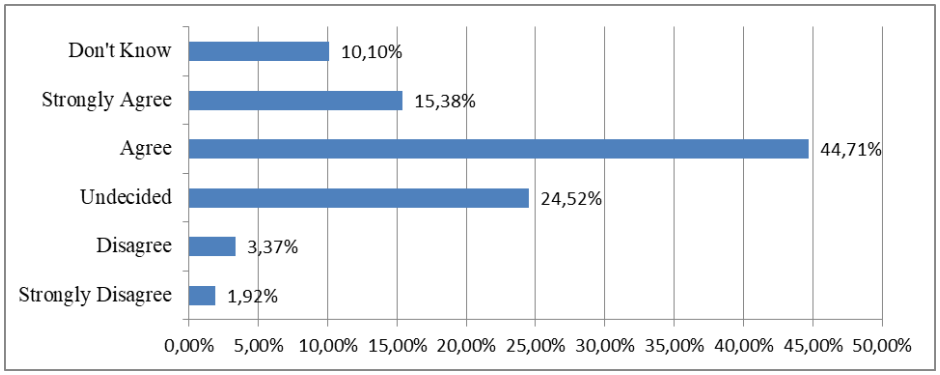
- I would prefer to receive notifications from NESTORE only when I ask for them.



- I would prefer to receive vocal notifications rather than text notifications.

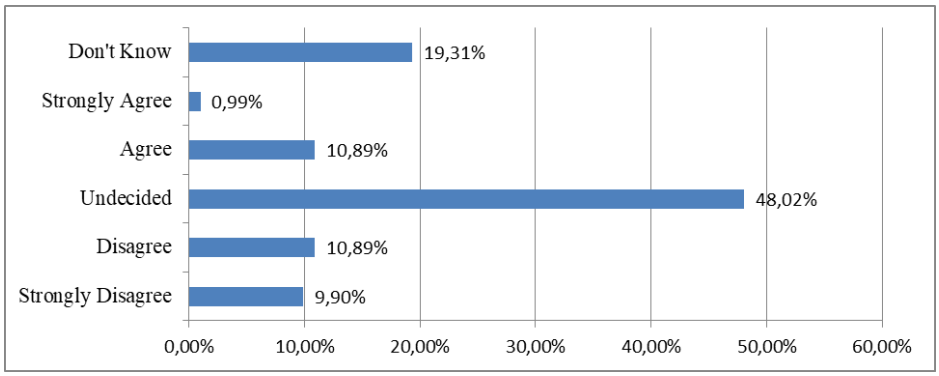


- Before starting any notification, I would prefer that NESTORE would make me a signal like a soft sound or a light signal in order to attract my attention.

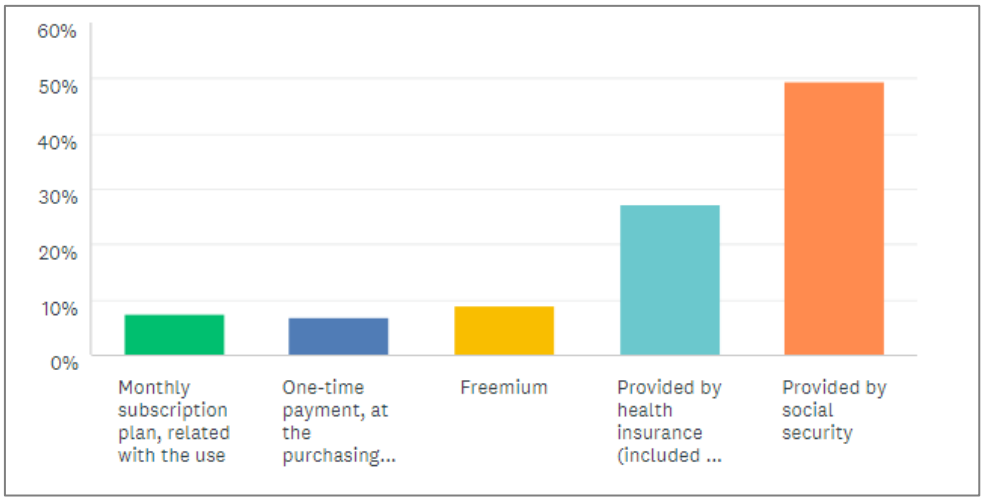


8.2.7. Willingness to pay

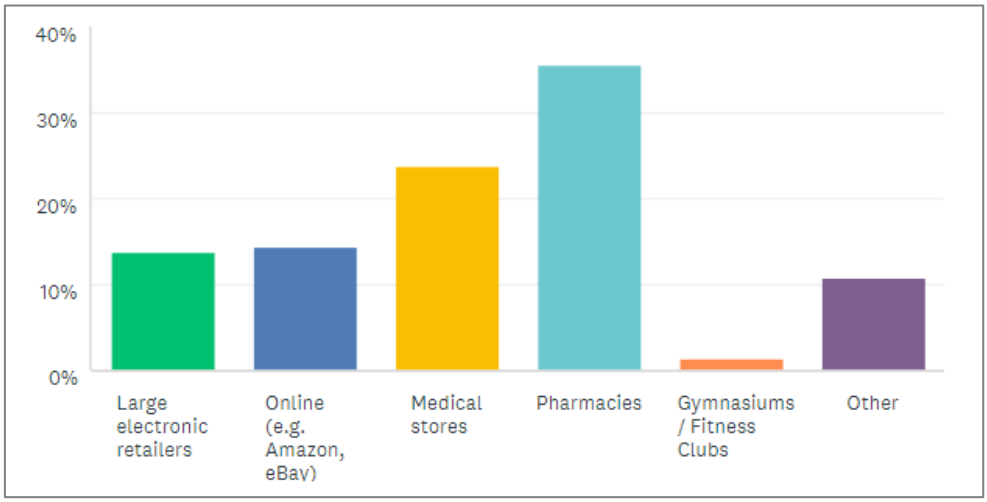
- I would recommend NESTORE to my friends and/or family.



- How would you prefer to acquire the product?

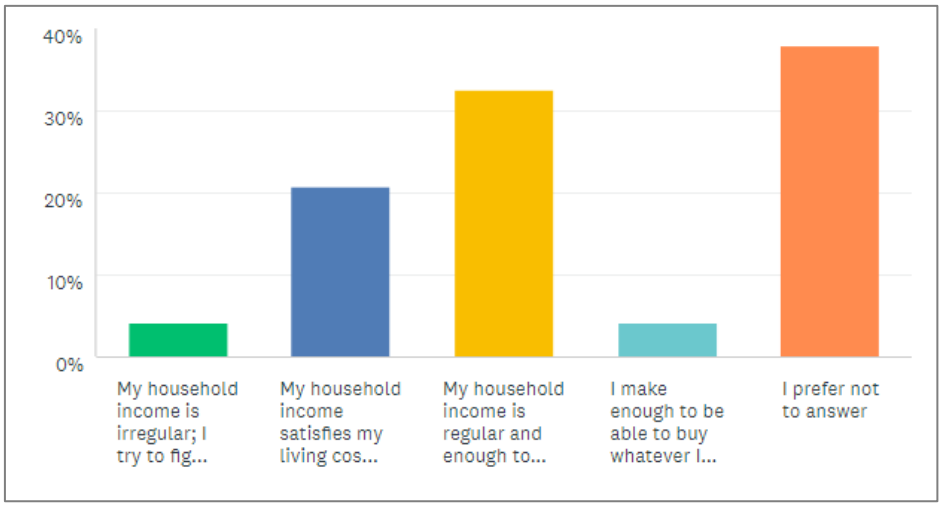


- Which would be the best purchasing channel?

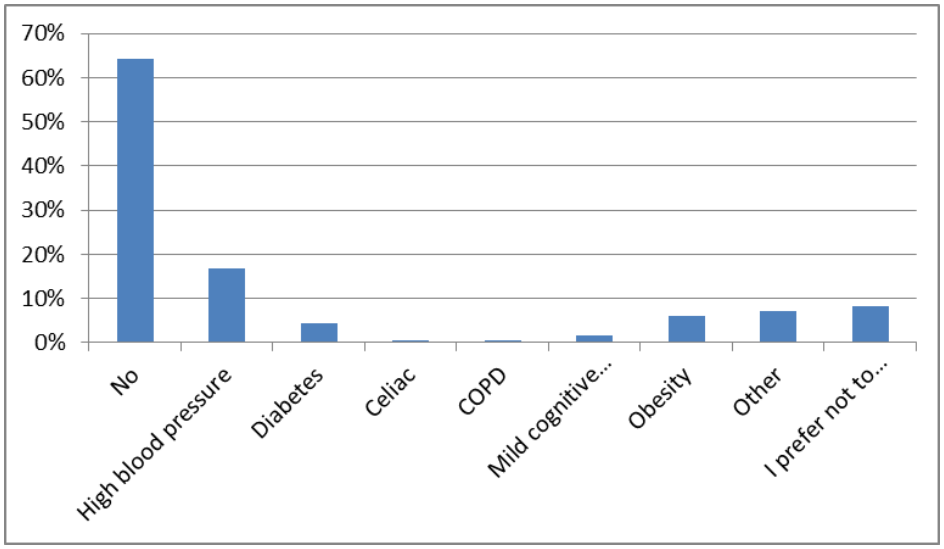


8.2.8. Socio-demographic variables

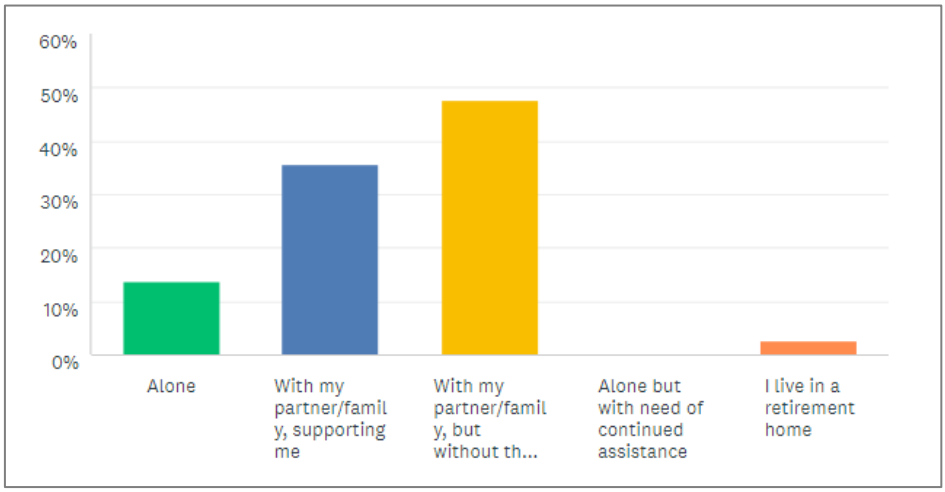
- Considering your monthly sources of income, what is your perception of your monthly household net income?

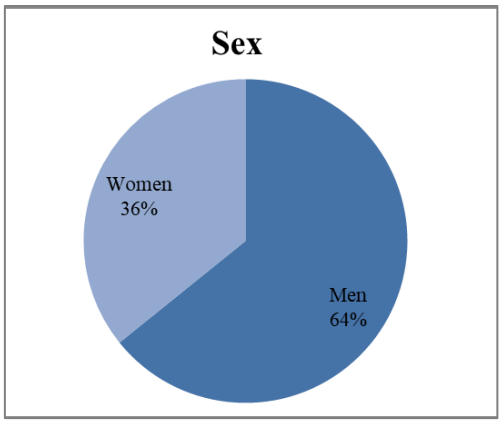


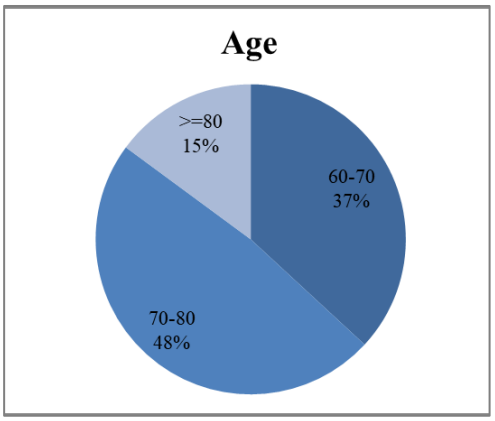
- Any serious health condition limiting everyday life?



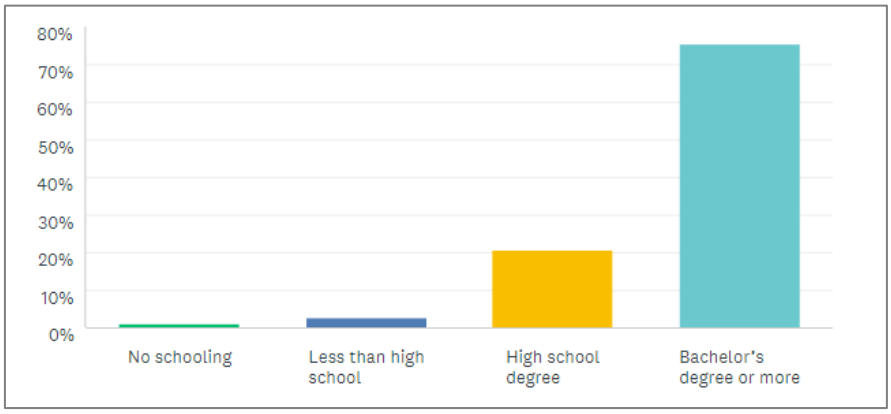
- Currently you are living:



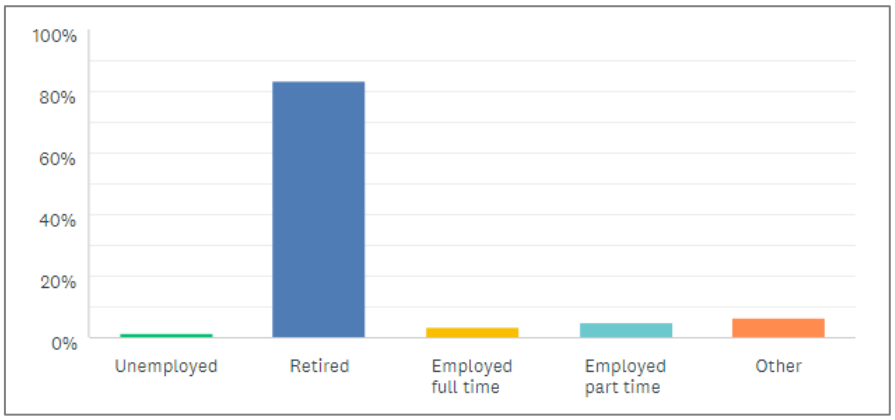




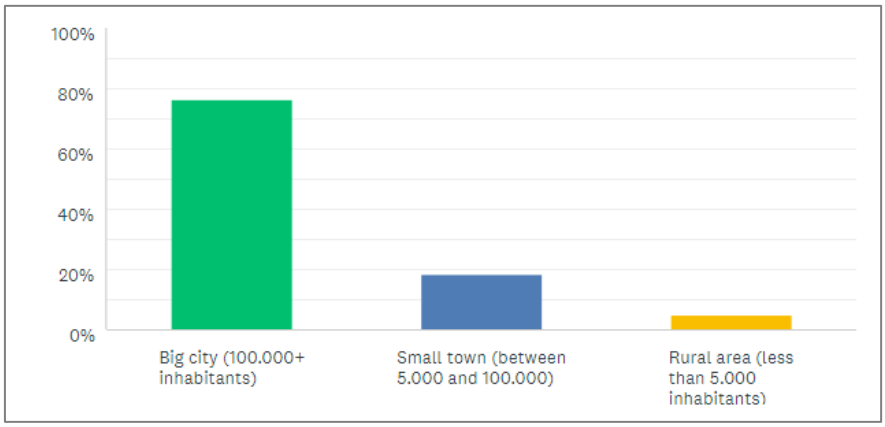
- Education level:



- Occupation:



- Place (residence):



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