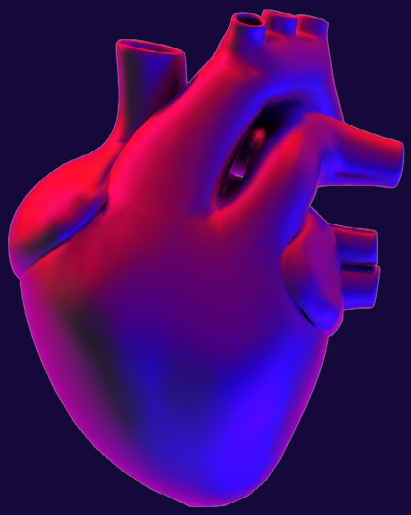
DESIGN OF A
MULTIDIMENSIONAL DIGITAL SYSTEM
TO ENHANCE SELF-MANAGEMENT IN
CARDIOVASCULAR RISK PREVENTION PROGRAMS



MASTER THESIS

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MSc. Design for Interaction

Delft Design Labs - CardioLab

Delft, August 2018

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This master thesis was written in the context of the master Design for Interaction at the faculty of Industrial Design Engineering at the Delft University of Technology in the Netherlands.

The project was developed as part of the CardioLab initiative with the assessment of Philips and the Dutch Heart Foundation (Hartstichting). The common goal of this collaboration is to explore and address the burden cardiovascular diseases within the field of technology and design, providing tools and strategies to achieve a healthier and longer life[1].

August 2018

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AKNOWLEDGEMENTS

I was very lucky to have a great supervisory team and people surrounding me during this project. Each perspective added great value and helped me fulfil my personal goal. I have grown both personally and professionally, and I would like to thank personally to everybody involved.

Valeria
Thank you for the constant motivation during the whole project. I really enjoyed working with you and learning from you. I know that at the start there was a lot to learn from both sides and uncertainty, but I truly believe that this made the project even more meaningful.

Maaike
Thank you for giving me the opportunity to integrate the Cardio Lab project and for your support and guidance. I hope that the final result fulfils the expectations of the Lab.

Dirk
Thank you for accepting being part of my supervisory team and sharing your knowledge. Your expertise added great value and new perspectives to the project that otherwise I would have missed.

Floor
Thank you very much for the support during the project and the materials provided. Your perspective and highly effective meetings were very helpful and made my perspective grow exponentially.

Hanneke
Thank you for your enthusiasm and for sharing your knowledge during the meetings. I was very lucky to have your expert opinion during the project.

David
Thank you for sharing your knowledge. This project wouldn't have been possible without your honest perspective and expertise. Thank you for reaching out when something needed to be added and in general for your constant feedback. Most importantly, congratulations on your new baby.

Ellen
Thank you for contacting me with professionals, for sharing important information and for keeping updated about the project. It was great to talk to you about my initial perspective and see the relevancy for the Dutch Heart Foundation.

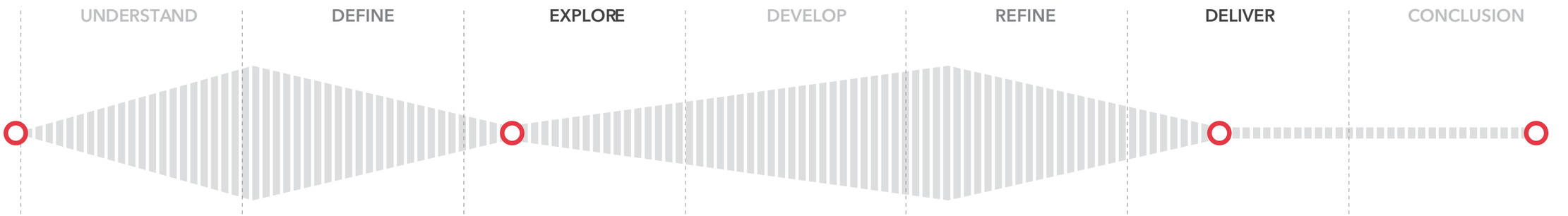
Melanie,
Thank you for putting up with me along the project and listening to my struggles. I am very glad that we can share different perspectives and built from them. I believe this makes everything stronger.

To my friends and colleges
None of this would have been possible without the people that surround me. Either by helping me with prototypes, test, opinions, encouragement or just sharing a cup of coffee; everything is very much appreciated. To name everybody would make a very long list, but I can say that I had the blessing of meeting great teachers, professionals and friends. This project is for you as well.

To my family
This wouldn't have been possible without my family. Even without being present, the constant motivation helped me when everything seemed to overpass me. None of this would have been possible without your support.

INDEX

PROCESS OVERVIEW



	CVD epidemiology	Research on individual roles	Design direction (definition)	Attributes and specs analysis	Design process	Validation of final design	Analysis on results and reflection
Factors	- Definition and characteristics - Epidemiology - Users and stakeholders	- Psychological and emotional factors - Triggers and motivation - Typology based on interaction with healthcare - Perception	Implications of design direction - Societal and personal factors - Current and future adherence Triggers and motivation	Planning on interaction phases - Risk assesment (SCORE) interaction - Longitudinal use - Personalization and adaptability	Planning on interaction phases - Stakeholder and user interaction. - Wireframing	Product design process - UX/UI design - Adaptability within stages	Product design process - Conclusion on complete project - Recommendations - Self-reflection
Methods	*Literature review* *Web search (Institutional/Statistical)*	*Design research methods:* *- Personas* *- Questionnaires* *- User journey*	*- Market analysis* *- Technical parameters (devices)* *- Creative sessions* *- Online surveys*	*- Iterative design concept phase*	*- Interactive digital prototypes* *- Role-playing tests*	*- Interactive digital prototypes*	

EXECUTIVE SUMMARY

Cardiovascular diseases (CVD's) are the main cause of death in both developed and low-income countries. CVD diagnosis and acute events are shocking for individuals; however, most of these conditions are progressive and can be detected and addressed in early stages. Several initiatives and strategies aim to diminish the burden of non-communicable diseases by giving an accurate prognosis. In the Netherlands, a systematic chart is used to assess the risk of individuals based on epidemiological data: The Systemic Coronary Risk Evaluation (SCORE chart) measures the probability of individuals suffering a cardiovascular event depending on contextual and biological measurements, giving health professionals an effective tool to reach potential patients.

This graduation project aims to improve primary prevention and adherence of individuals labelled with a high risk of developing a cardiovascular disease by tailoring an information platform for self-care management. The project considers both an institutional perspective of the health network and the behaviour change of the individuals from the moment of risk-labelling to a follow-up appointment, aiming to improve the numbers within this time.

PROBLEM

Although most of the CVD's can be prevented by addressing modifiable risk factors and several prevention strategies aim to assess individual risk in early stages, the prevalence of these conditions shows that there is a need to reinforce prevention actions. In the current system, individuals are categorized using specific markers and comparing them to an institutionalized chart. Once an elevated risk is detected, individuals are advised to follow a prevention program that changes depending on the individual risk factors.

There is a clear benefit in assessing and guiding individuals with a high potential risk of developing a CVD. However, prevention is not always effective and individuals find it difficult to adhere to doctor's indications in long periods of time. The attention span and initial shock are replaced by other immediate concerns from daily life. These programs rely heavily on the user's adherence and actions outside the healthcare system. Currently, caregivers intervene as an external guidance and assess individuals through define appointments. People usually find it hard to adhere to treatments or follow indications when they are left in control of their own care, especially in long-term programs. The current health system structure calls for a self-management strategy that increases individual adherence without reducing the availability of caregivers to treat other urgent patients.

The prevention of non-communicable diseases needs to consider both the capabilities of the caregivers and the users. Intrinsic motivation, resources and literacy levels play a major role when understanding and managing risk. A current trend of including patients in their own care needs to consider the way health messages are presented since they can affect the performance outside a consultation having no health professional present or available. By integrating individual traits and responding to intrinsic needs, adherence can be increased and the system can deliver a more tailored message that addresses individual concerns and motivators.

RESEARCH

Longitudinal risk management should adapt to self-efficacy, capabilities and events of daily life. Consideration of factors involved in the adoption of a risk-managing system result in broader complexity. Literature research, design thinking methods and empirical testing showed that individual factors are highly different and even antagonistic. It also showed that individual characteristics are difficult to determine in an initial consultation and, in longer periods of time, these characteristics can change. Therefore adaptability is needed.

DESIGN PROPOSAL

The project proposes a digital system to facilitate pro-active involvement and self-management of modifiable risk factors for individuals between 40 to 50 years old assessed with a high CVD risk. The characteristics of the concept are developed under a 2 axis model, focusing on intrinsic or extrinsic motivators and supportive or challenging message tones. The system filters out preferences based on an initial self-evaluation at the beginning of the prevention program and later on by analyzing the amount of interaction with the different triggers and system layers.

The final concept integrates the current healthcare state to improve response capabilities without compromising resources. The interaction measurement is meant to add granularity to user data and provide deeper understanding of the user. With this information, health professionals can address specific concerns and give a more tailored advice in further consultations.

EVALUATION

In the user evaluation participants perceived the system as adequate and helpful. The different styles were also perceived positively. Certain features had both postive and negative reviews. The concept was planned to asses this preferences and adapt, but this characteristic was not evaluated. In general, participants expressed a positive self-predicted adherence. Further research is needed to determine the effectiveness in a longitudinal use of this self-adapting characteristic.

UNDERSTAND

ABOUT CARDIOVASCULAR DISEASES

Cardiovascular disease (CVD) is an umbrella term for a set of conditions that affect the heart and blood vessels[2]. Depending on the characteristics and section, the world health organization (WHO) categorizes these diseases in[3]:

Coronary heart disease – disease of the blood vessels supplying the heart muscle.

Cerebrovascular disease – disease of the blood vessels supplying the brain.

Peripheral arterial disease – disease of blood vessels supplying arms and legs.

Rheumatic heart disease – damage to the heart muscle and heart valves from rheumatic fever (caused by streptococcal bacteria).

Congenital heart disease – malformations of heart structure existing at birth.

Thrombosis and pulmonary embolism – blood clots in leg veins which can dislodge and move to the heart and lungs.

EPIDEMIOLOGY

CVD's are categorized as non-communicable diseases, a group that represents the bigger cause of death worldwide (Figure 1). In 2016 it was estimated that 17.7 million people died from a CVD, which represents 32.26% of the world deaths. At least three-quarters of this population belongs to low- and middle-income countries, where CVD's affect the younger population when compared to high-income countries[4]. According to the WHO, this has to do with a lack of integrated primary care, a late detection of CVD's, and inability to cover the expenses of a condition by the poorest sector of these countries. In high-income countries, the investment on prevention and treatment of CVD's has led to a reduction of the mortality rate.

However, a high survival rate also increases the number of patients with a chronic condition. For example, patients who suffer a heart attack and survive might live until their eighties, but develop a chronic heart failure that will affect their daily activities and eventually kill them. Having a chronic CVD condition implies long-term and costly care procedures that are a burden both for the patient and society. In the European Union, €111 billion is destined to CVD care costs, €54 billion is related to productivity losses and €45 billion is used for informal care[5].

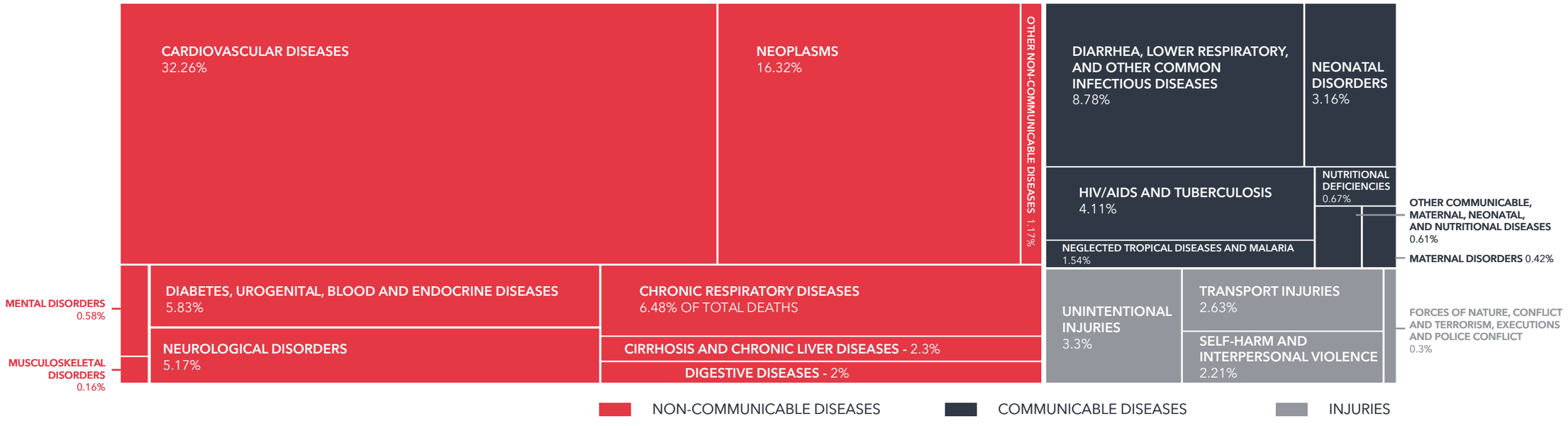
Causes of CVD deaths depend on the specific condition and cases of an individual. Metabolic and behavioural factors are the main causes of progression and death, but environmental elements such as quality of air or exposure to radon or lead can increase risk[6].

CVD PROGRESS

The progress of a CVD condition can result in acute events such as strokes and heart attacks. These happen when a vessel gets blocked and blood is unable to reach vital organs (brain and heart). The most common reason for these clots is atherosclerosis, an inflammatory condition where fatty plaques accumulate in the blood vessels creating a clot over time. A rapid development of atherosclerosis is related to an unhealthy lifestyle but can also be affected by ongoing diseases such as hypertension or diabetes. CVD's can also be a result of congenital conditions or alterations in the electrical output of the heart.

Depending on the condition characteristic and stage of the CVD treatments can be of behavioural nature, medication, surgical operations or a combination of actions. In early stages, some CVD's can be controlled with medication, non-invasive procedures such as beta-blockers, enzyme inhibitors or minimally invasive ones like pacemakers and stents.

Figure 1 Global causes of death in percentages (2016)



CVD PREVENTION

Although the progression of certain conditions is preventable, there are certain risk factors that are non-modifiable (Figure 2). These include age, gender, ethnicity and family history. Particularly age is the most important factor since it triples the risk for every decade of life. Therefore a CVD diagnosis can appear as a shock for people following a healthy life.

Outside these non-modifiable factors, most CVD's can be prevented by changing behavioural traits such as tobacco and alcohol consumption, unhealthy diet and physical inactivity. Certain CVD treatments might address these changes as a way to recover, stop the progression of the condition or prevent comorbidities. These modifiable risk factors are also used in the screening and evaluation of people with at risk of developing a CVD in the future. Worldwide, smoking represents the major individual behavioural risk (Figure 3). However, when stacking all of the risks related to food consumption, diet represent the major cause of death[7] (Figure 4).

Figure 2 Factors related to CV death. Non-modifiable risk factors (Metabolic) represent the highest value.

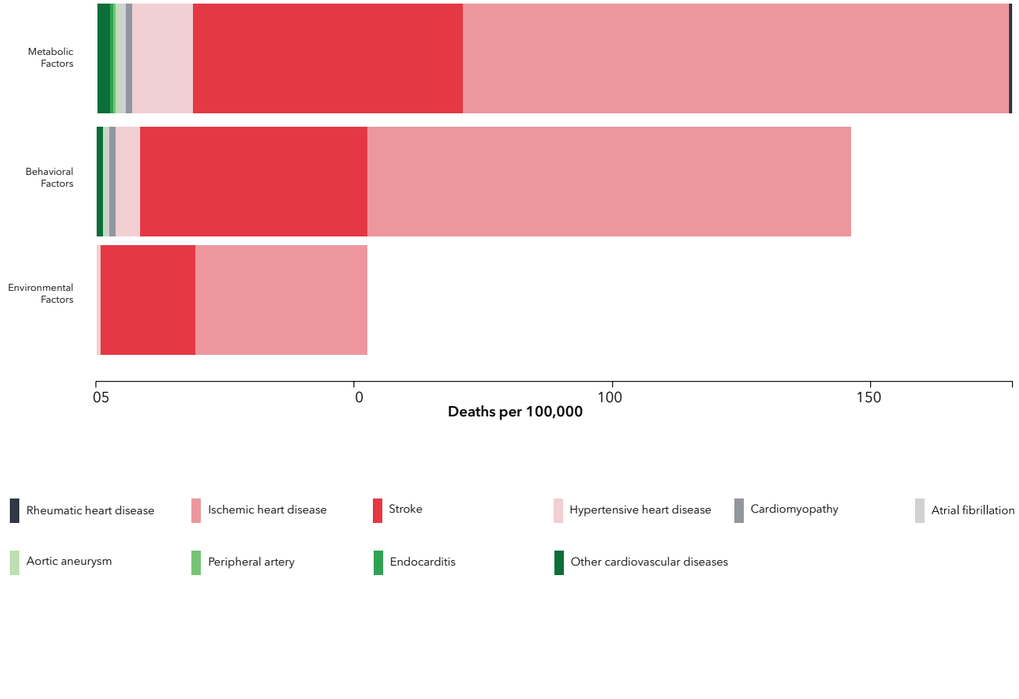


Figure 3 Death-relation to individual behavioral risk factor.

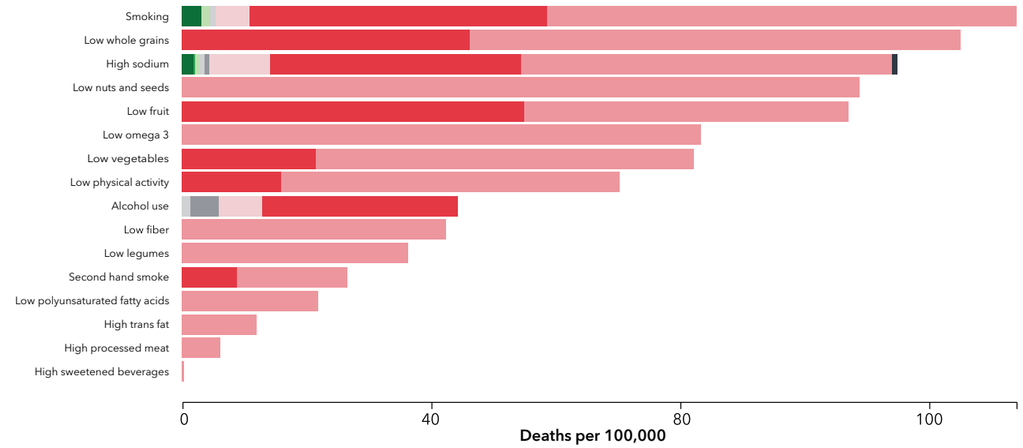
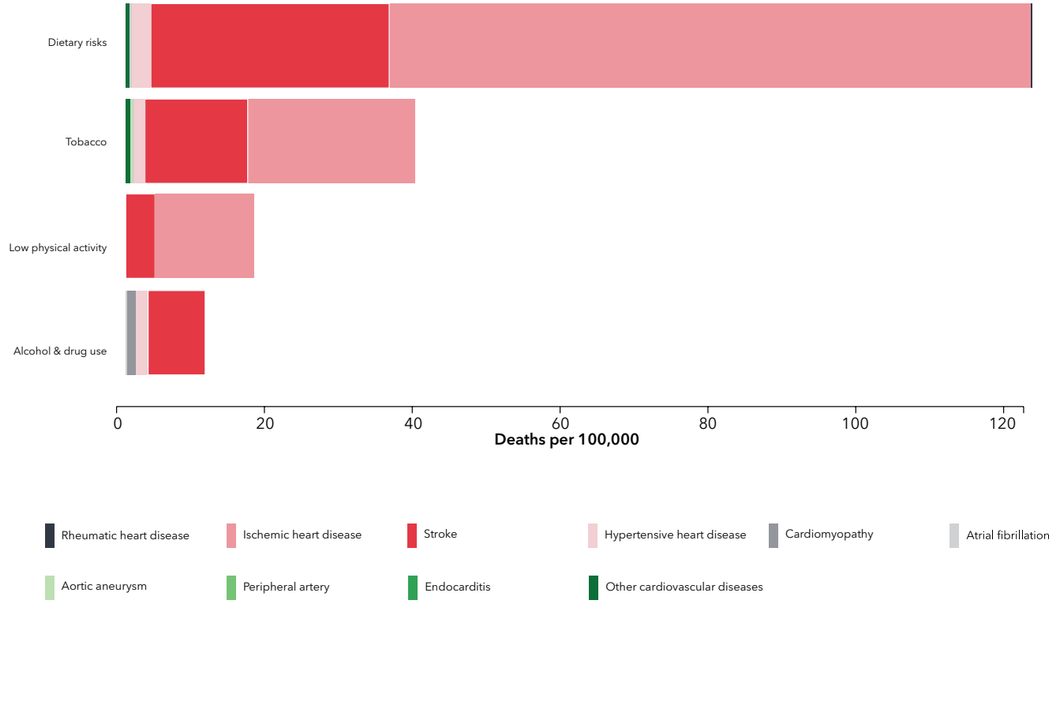


Figure 4 Death-relation to behavioral risk factor groups (adjusted).



TYPES OF PREVENTION

Increasing ageing population and acute event survival lead to an increment of patients with chronic illness. Prevention is more cost-effective than chronic treatment. That is why risk factor management is the main focus on developed countries. The World Health Organization (WHO) estimates that over 75% of premature CVD is preventable and risk factor management can help reduce the growing CVD burden on both individuals and organizations[8]. Because CVD's have different development phases, markers and symptoms the type of prevention can be categorized in:

Primordial prevention: Avoiding the development of risk factors[9]. This type of prevention focuses on a young population to avoid the adoption of risk behaviours such as smoking or eating patterns. Studies show that preventing those activities and promoting healthy behaviours in early stages of life has a more lasting impact on the development of chronic diseases[10, 11]. These main interventions are on mass education and institutional applications.

Primary prevention: Treating risk factors to prevent cardiovascular disease. These are the actions that aim to avoid a disease appearance. It can be divided into health promotion among large groups and specific protection for individuals. While health promotion is more related to an institutional level, screening actions and advice occur on an individual level at the physician's office.

Secondary prevention and rehabilitation: Refers to the coordination of interventions to optimize the physical, psychological and social wellbeing of cardiac patients and stabilization/ decreasing atherosclerotic appearance, reducing morbidities and mortality. The aim is to prevent irreversible pathological changes. In CVD care this might include the use of aspirins, beta-blockers, angiotensin-converting enzyme inhibitors and lipid-lowering medication[12].

Tertiary prevention: Disease management programs that try to alleviate the impact of ongoing diseases and prevent future disabilities, improve the quality of life and life expectancy.

A stream pattern can be observed from this categorization (Figure 5), where an institutionalized-mass approach is used at initial stages and a more personalized advice is needed at later stages of diseases. While all of the stages are important to ensure the wellbeing of individuals, there is a general consensus about the importance of preventing small risks on larger populations since they can generate more risks than a small number of people exposed to high risks[13]. This apparent contradiction of reach and impact is called a "Prevention paradox"[14, 15]: In a longitudinal perspective, interventions targeting fewer risk individuals are more effective than the ones focusing on high-risk cases. For the creation of health policies the WHO recommends focusing on the first stages of prevention, involving general population and distal health risks[16].

The Netherlands has one of the highest rates of care expenditures in the EU. A 10.7% of the Gross Domestic Product (GDP) goes to this sector and is mainly attributed to expenditures in long-term care[17]. The epidemiological effect of these expenditures is complex worldwide[18]. In the Netherlands, there is a consistent reduction of cardiovascular mortality[19] and consumption of tobacco and alcohol is below the EU average[20].

Nevertheless, ischemic heart disease remains as the main cause of death in the country, followed by lung cancer and Alzheimer. In general CVD's are persistent within the population at disadvantage (income/education) and the life expectancy between high and low educated individuals has a 6-year difference. Although life expectancy has increased, people do not always live a healthier life. The National Institute for Public Health and the Environment (RIVM) expects that 7 million people will have a chronic condition in the Netherlands by the year 2030[21]. The RIVM also highlights the importance of early risk assessment to ensure a long life even with a chronic illness[22].

Figure 5 Non-statistical visualization of population reached in relation with type of prevention and care.

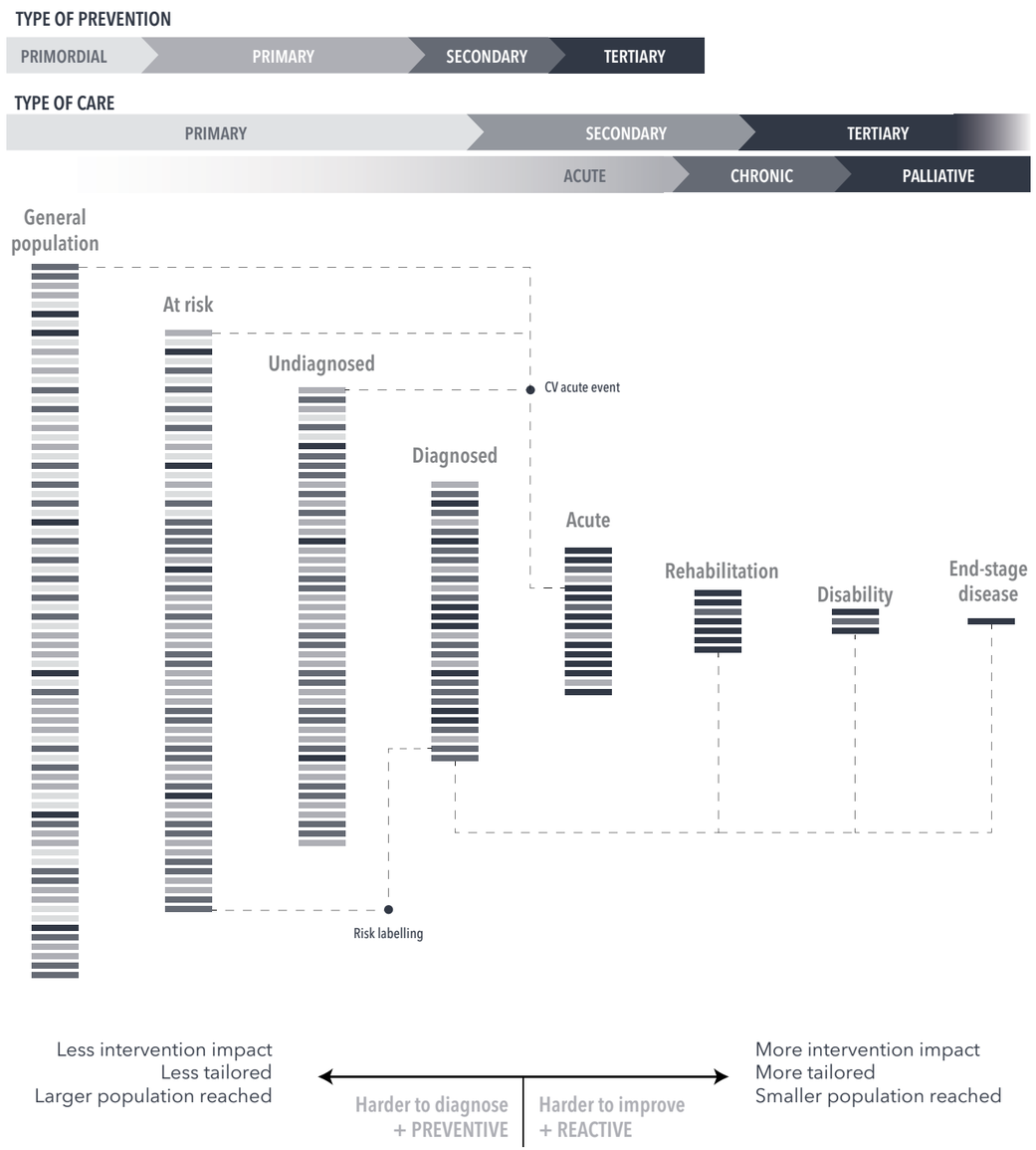
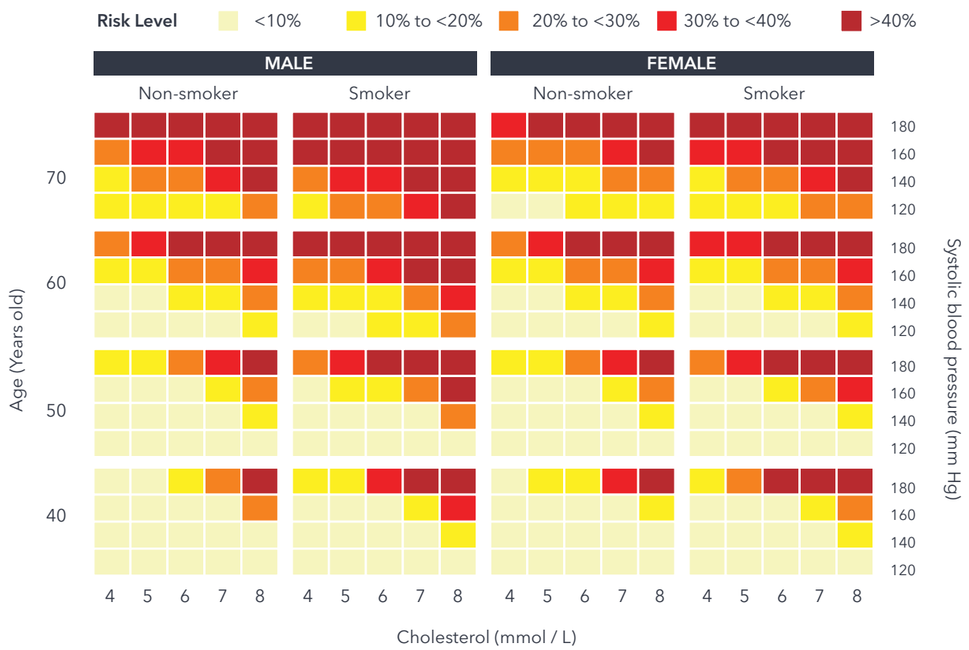


Figure 6 Risk prediction chart for sub-region Eur-A



RISK DETECTION – CVD RISK ASSESSMENT

Because of the epidemiology data, CVD prevention is one of the priorities in industrialized countries, having a general consensus that risk management must be part of the health prevention agenda. Institutions have designed assessment tools for practitioners to quickly screen and determine population at risk of developing a CVD condition[23]. The evaluation of risk factors through statistic-based tools and charts plays a major role in the prevention of CVD's. With them, asymptomatic individuals can be labelled and guided before a condition appears. Health professionals use tests and readings to obtain biomarker values than later are compared with a statistical incidence chart. Depending on the institution providing the tool, the demographic and epidemiological data and the available technology, charts might have variations between the amounts of markers measured and the categorization of the results but in general, individuals are categorized depending on five multipliers: age, gender, smoking status, systolic blood pressure and cholesterol readings.

In the Netherlands, the CVD prevention guidelines recommend the use of the Systemic Coronary Risk Evaluation (SCORE) in its calibrated chart for the low-risk European countries (Figure 6). These charts are based on the Framingham heart study[24], showing a 10-year risk of suffering a fatal CVD incident.

The usage and classification of the SCORE chart are divided into 14 epidemiological sub-regions that consider the available data from each country (Figure 7). For certain countries calibration of the charts is needed[25], however it is an effective tool to evaluate the level of risk for individuals above 40 years old in primary care[26].

Figure 7 Sub-region country classification

AFRICA	AFR D	Algeria, Angola, Benin, Burkina Faso, Cameroon, Cape Verde, Chad, Comoros, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Madagascar, Mali, Mauritania, Mauritius, Niger, Nigeria, Sao Tome And Principe, Senegal, Seychelles, Sierra Leone, Togo.
	AFR E	Botswana, Burundi, Central African Republic, Congo, Côte d'Ivoire, Democratic Republic of The Congo, Eritrea, Ethiopia, Kenya, Lesotho, Malawi, Mozambique, Namibia, Rwanda, South Africa, Swaziland, Uganda, United Republic of Tanzania, Zambia, Zimbabwe
AMERICAS	AMR A	Canada, Cuba, United States of America
	AMR B	Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Brazil, Chile, Colombia, Costa Rica, Dominica, Dominican Republic, El Salvador, Grenada, Guyana, Honduras, Jamaica, Mexico, Panama, Paraguay, Saint Kitts And Nevis, Saint Lucia, Saint Vincent and The Grenadines, Suriname, Trinidad and Tobago, Uruguay, Venezuela
	AMR D	Bolivia, Ecuador, Guatemala, Haiti, Nicaragua, Peru
EASTERN MEDITERRANEAN	EMR B	Bahrain, Iran (Islamic Republic of), Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, Tunisia, United Arab Emirates
	EMR D	Afghanistan, Djibouti, Egypt, Iraq, Morocco, Pakistan, Somalia, Sudan, Yemen
EUROPE	EUR A	Andorra, Austria, Belgium, Croatia, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Luxembourg, Malta, Monaco, Netherlands, Norway, Portugal, San Marino, Slovenia, Spain, Sweden, Switzerland, United Kingdom
	EUR B	Albania, Armenia, Azerbaijan, Bosnia And Herzegovina, Bulgaria, Georgia, Kyrgyzstan, Poland, Romania, Serbia and Montenegro, Slovakia, Tajikistan, The Former Yugoslav Republic of Macedonia, Turkey, Turkmenistan, Uzbekistan
	EUR C	Belarus, Estonia, Hungary, Kazakhstan, Latvia, Lithuania, Republic of Moldova, Russian Federation, Ukraine
SOUTH-EAST ASIA	SEAR B	Indonesia, Sri Lanka, Thailand
	SEAR D	Bangladesh, Bhutan, Republic of Korea, India, Maldives, Myanmar, Nepal
WESTERN PACIFIC	WPR A	Australia, Brunei Darussalam, Japan, New Zealand, Singapore
	WPR B	Cambodia, China, Cook Islands, Republic of Korea, Fiji, Kiribati, Lao People's Democratic Republic, Malaysia, Marshall Islands, Micronesia (Federated States of), Mongolia, Nauru, Niue, Palau, Papua New Guinea, Philippines, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu, Vietnam

Mortality strata:
A: very low child mortality and very low adult mortality; B: low child mortality and low adult mortality; C: low child mortality and high adult mortality; D: high child mortality and high adult mortality; E: high child mortality and very high adult mortality

CARDIOVASCULAR DISEASE CONTINUUM

The CVD risk label is the result of a synergistic relation analysis rather than an additive one; if a single risk factor is highly elevated or users suffer from chronic kidney disease or type II diabetes the subject should be labelled with a high risk[27], but this category can be influenced by the physician judgment and experience. In the case of individuals with a CVD condition, physicians can use the research-based model to decide the correct intervention and measure the effectiveness of it.

CVD's are developed through years and involve several observable risk factors and diagnoses. The sequence of events has been mapped to predict the future development of a condition and take action in advance. The chain of elements is called cardiovascular disease continuum (CVDC) and provides information about the actions needed in each stage or the effect a treatment has based on observable markers: test results, other existing diseases and biological markers[28]. (Figure 8)

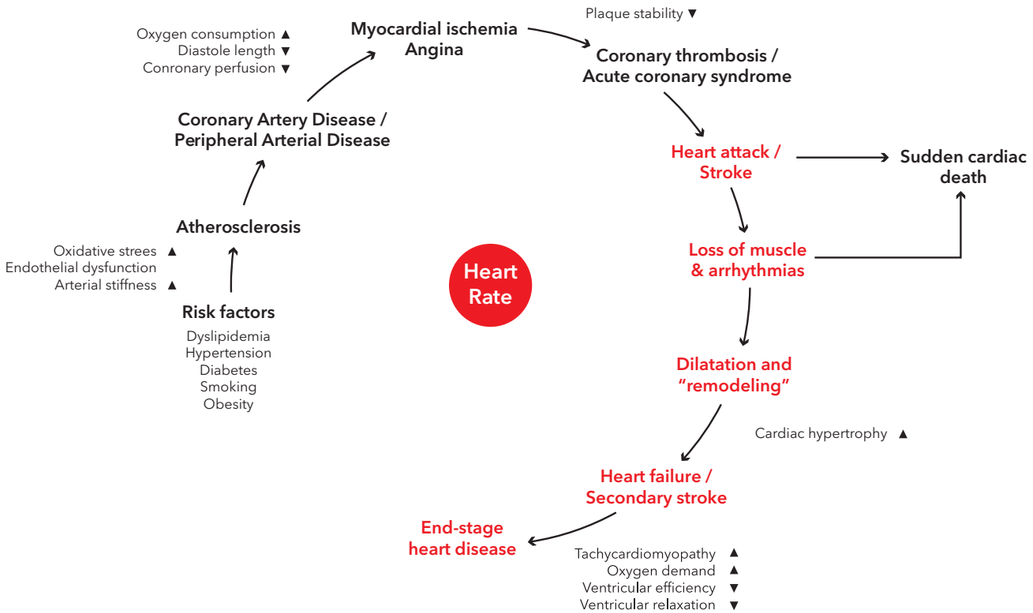
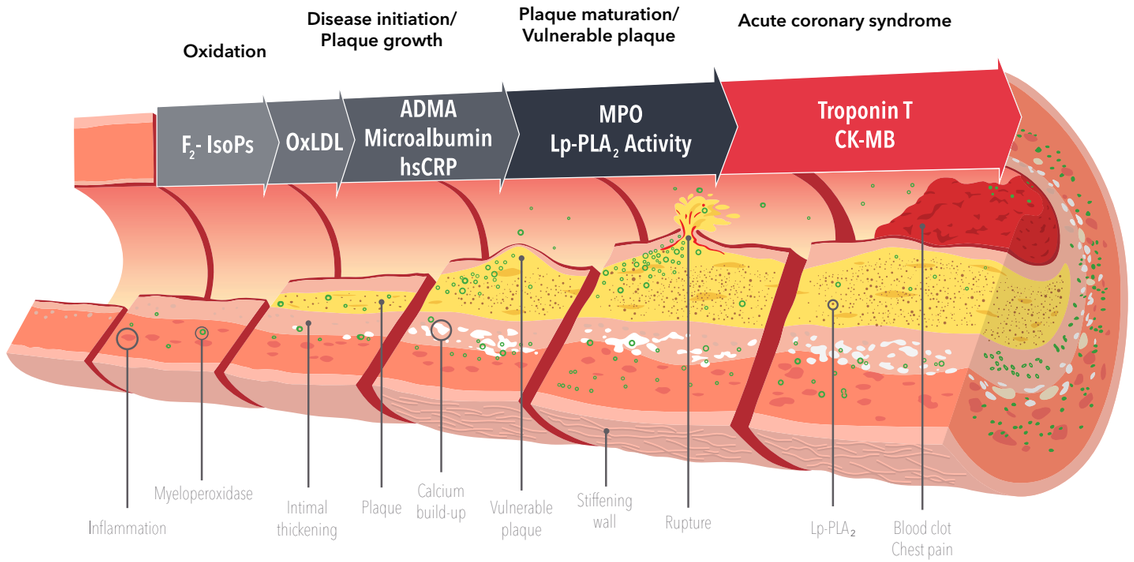


Figure 8 Pathophysiological effects of heart rate on the cardiovascular disease continuum.

Figure 9 Biomarkers in inflammatory process (atherosclerotic stages).



BIOMARKERS

While risk factors are characteristics of an individual that predict a specific outcome or disease progression, biomarkers are indicators that are involved in the process but by themselves are not causal of the disease.

According to the National Institutes of Health, a biomarker is "A characteristic that is objectively measured and evaluated as an indicator of normal biologic or pathogenic processes or pharmacological responses to a therapeutic intervention."[29]

A biomarker can qualify as a risk factor but this is not a mandatory characteristic for this categorization[30]. While biomarkers will not always predict a disease progression they can provide information on the illness stage, predict the effect of future therapies and measure the outcomes of them. These biological parameters need systematic backup evidence, have a clear use in clinical trials, provide feedback about the patient treatment or predict clinical benefit of it, based on statistical models[31].

Atherosclerosis is an example of a disease progression that can be mapped using different biomarkers. By measuring levels of specific proteins, enzymes and oxidation levels physicians can determine the stage of vessel damage and CVD risk in consequence (Figure 9).

Other tests that can increase accuracy in CVD assessments include coronary calcification levels[32, 33], advanced lipid and metabolic tests or aspirin response. Although combining multiple marker studies increases accuracy, increasing the amount and complexity of tests usually elevates costs in consequence.

COMORBIDITIES

In industrialized countries, the incremental rate of chronic CV conditions also increases the number of individuals living with more than one CVD or non-CVD[34]. This has to do with the correlation between diseases and risk factors, which can be sequential, independent or correlated while the symptoms and possible treatments can be of similar or even of an antagonist nature; a treatment can be effective for co-existing diseases or it can be the cause or progression of a condition[35]. This complex interaction can be observed in an etiological model where diseases and risk factors are mapped and streamed. (Figure 10)

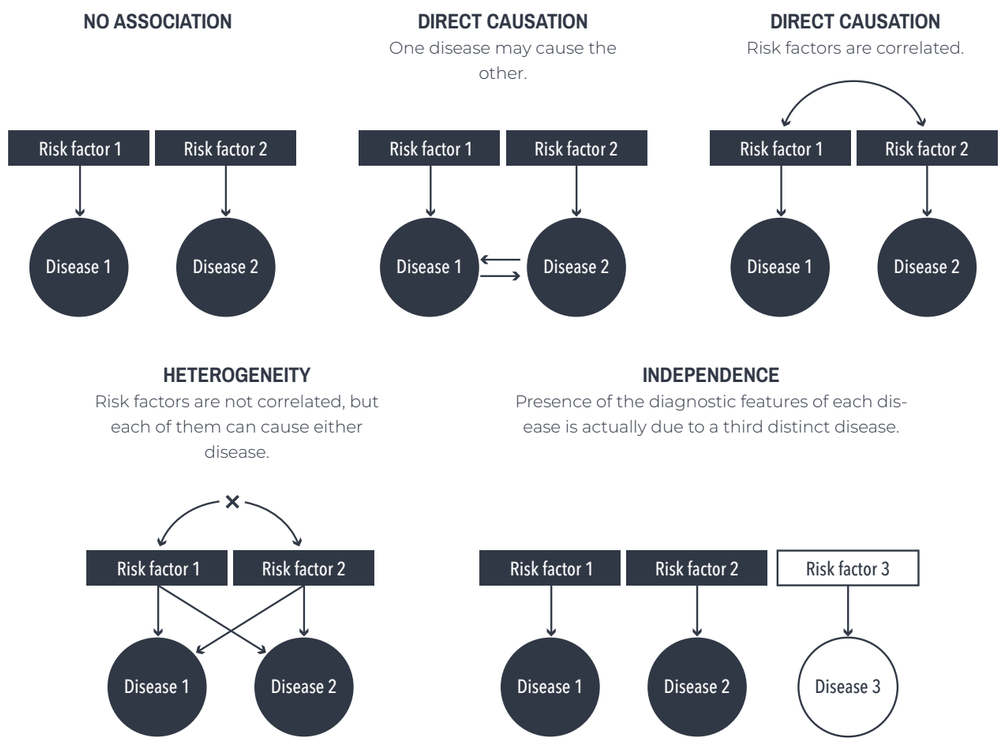
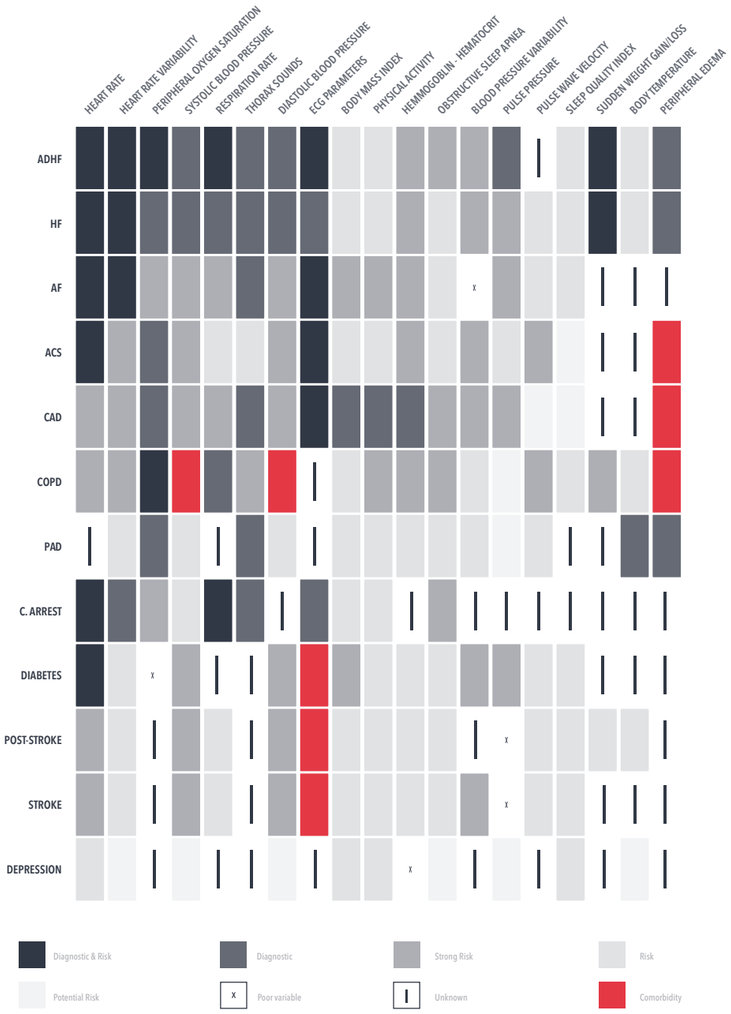


Figure 10 Etiological models of comorbid diseases. Interaction of 2 diseases and corresponding risk factors. All models are empirically valid but not mutually exclusive.

Figure 11 Potential comorbidity screening variables.



Because of these connections treatments and diagnosis of co-existing conditions can be difficult and costly[36]. It may that the comorbidity is mistakenly diagnosed by shared risk factors or that the characteristics overlap with the ones of another disease. The appearance of co-morbidities can go undetected since medical checkups are not constant: Complaints and clinical signs do not always appear during the examinations and symptoms of psychological conditions like depression are assessed based on personal traits. Previous CardioLab projects mapped the relation between comorbidity screening variables[37]. (Figure 11)

IMPORTANCE OF MOOD AND EMOTIONS

STRESS & DEPRESSION

Clinical and epidemiological research shows the role of psychological and social factors in the pathogenesis of cardiovascular diseases[38]:

Depression, anxiety and stress variables, as well as personality traits, economic and societal aspects, are related to the appearance and progression of CVD's. Longitudinal studies show a shared epidemiology and incremental effect of 80% on patient's mortality when a major depressive disorder (MDD) is diagnosed[39, 40, 41].

Within the cardiology field, MDD is an important co-morbidity since it affects the development and progression of other CVD's. However, it is hard to diagnose in individuals that suffer from cardiac conditions since symptoms such as fatigue and insomnia overlap between ailments[42].

MDD does not only affect the lifestyle of patients; it can increase treatment drop out, appointment avoidance and in many cases be a causal factor for CVD incidents. The connection between depression and CVD is bi-directional: Depression can predispose patients to develop a CV condition and a CV diagnosis and symptoms can depress the mental state of an individual[43]. (Figure 12)

Post-myocardial infarction depression is independently associated with cardiac mortality and in general, it increases the risk of a poor CVD outcome by a 2.5x factor[44]. (Figure 13)

There is a correlation between chronic depression and age, the strongest CVD risk factor but contextual factors such as income and social isolation can be related to this number[45].

On average 1 out of 12 individuals reported being chronically depressed in the EU, being women the most often affected group[46].

Figure 12 Vicious cycle stages of stress and depression.

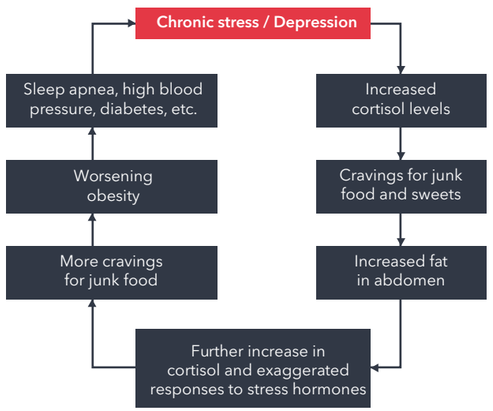
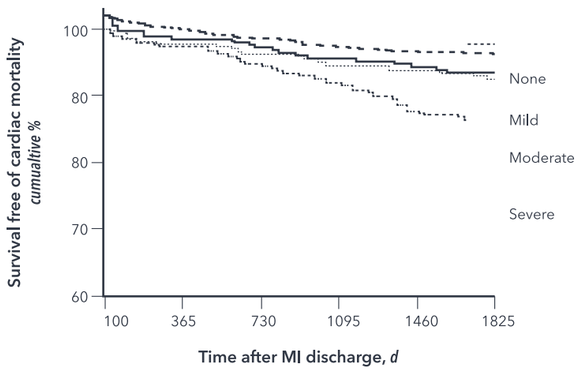


Figure 13 Freedom from cardiac mortality after myocardial infarction (MI) related to severy of depression.



Although there is growing evidence of the connection between depression and CVD, general practitioners are not prepared to identify mental disorders and even less to treat them (Figure 15): there is a chance of improvement if mental health is integrated or considered with somatic healthcare[47].

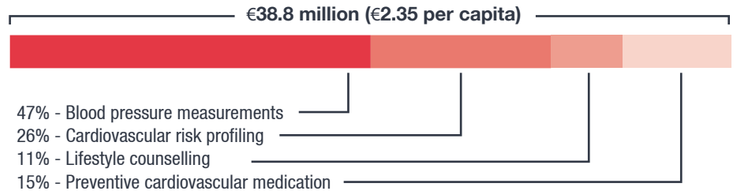
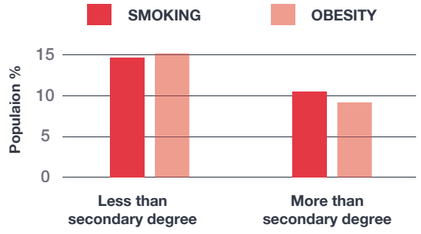


Figure 15 Expenditure on cardiovascular primary preventive activities in familiar practice (GP) in the Netherlands. Lifestyle counselling integrates behavioral change but no MDD detection (2009).

TREND ANALYSIS - SYSTEMIC AND INDIVIDUAL FACTORS

THE PATIENT

Because of the different developments that end up in a CVD, personal perception and rationalization of a diagnosis can involve positive or negative emotions. Situational aspects such as social isolation, marital status and personality can also affect prognosis. The relation to death can have positive connotations when there is a reflection about survival and an evaluation of the current stage of the condition[48]. At initial stages, people feel lucky for getting diagnosed before a strong deterioration occurs and patients in advanced stages expect to live longer than the realistic prognosis[49]. The survival perception also varies among individuals, having optimistic or negative predictions based on experiences and bias.



DEMOGRAPHICS AND HEALTH LITERACY

The ability to obtain and understand information in order to make appropriate health decisions and follow treatment instructions is defined as Health literacy[50]. This ability is multi-factorial and needs to be addressed from different angles and levels.

Demographics are heavily related to health literacy (Figure 14). Research shows that males with low skill manual occupations from any age have three times higher risk of a CVD premature death related than other professionals[51].

Culture and geographic data are related to risk as well. These factors affect self-care and treatment adherence[52] and are part of the Framingham risk classification. In some risk calculator websites, postal codes are used to determine low-income individuals and determine risk level[53].

Figure 14 Inequalities in risk factors according to education and income (2014)

ROLE OF THE GP-PHYSICIAN

In the Netherlands, general practitioners act as the first stage of the healthcare system providing primary care to simple conditions, referring to specialists in case of specific symptoms or if certain tests are needed and patients can contact emergency staff through a public service number (Figure 16). This gatekeeping system facilitates the procedures at further stages by filtering and referring cases, but causes saturation in early stages. Full-time GPs have an average of 2,350 individuals of all ages registered to their practice[54] and commonly perform between 28 and 30 personal consultations a day. The length of the consultations varies between 7 and 10 minutes on each appointment[55], and although assistants perform the measurement for risk assessment, general practitioners give the diagnosis and recommendations based on the institutional guidelines, personal experience and communication skills.

Therefore risk assessment can be influenced by the health provider. Competence of GPs is a blend of knowledge and personal traits resulted from training, education and experience. CVD risk can increase depending on local conditions, family history, social isolation and a sedentary lifestyle but these factors are not part of the SCORE measurements and they depend on the patient-doctor relation at an individual level.

OTHER HEALTH SPECIALISTS

Once a patient is referred to the health system different specialists get involved in the care treatment. Cardiologists, radiologists and nurses help in recurrent screenings and treatment follow-ups. In the case of acute events, emergency staff from ambulances and the intensive care units are part of the care journey as well.

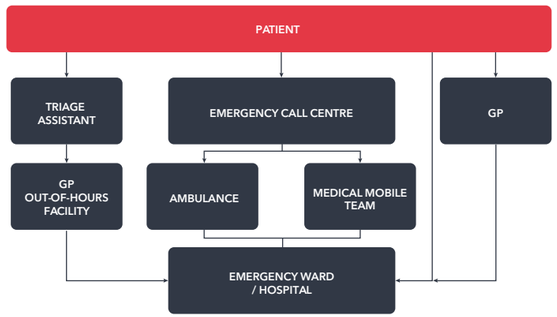


Figure 16 Flow chart for patient pathways in emergency care.

EHEALTH

Although there is no unique definition[56], the term eHealth generally refers to the use of technology in health services and commerce[57] and includes both systems and individual interactions. Within this umbrella term, the use of Smartphone technology, wearable sensors and telemonitoring devices to connect patients and doctors is defined as mHealth[58].

As the technology supported by mobile devices and wireless products evolve, the complexity of medical applications does as well. Complex sensors and instruments, as well as technology miniaturization, allow a constant exchange of medical information, facilitating positive health behaviours such as health promotion, treatment adherence and self-management[59]. Communication and information technologies (ICT's) make possible a new type of interaction between health providers and consumers where patients have an active role in their treatments. The current trend is to include patients in the management of their disease and to facilitate the connection with their health-provider network. The Netherlands government has set a goal for the year 2019: providing the majority of chronically ill patients with access to their digital medical records facilitate online connectivity with their health providers and provide tools to monitor certain biological measurements[60]. These actions represent improvements for both patients and physicians: By recording patient actions and biological markers health professionals can track the development of diseases, act in a shorter time and even prevent further diseases. Those are some of the reasons why global organizations are promoting the development of health technologies[61] and why technologies such as cloud-based databases and mobile health apps are becoming regular in the market. Its usage will continue to increase[62].

These data-based interventions are also of interest on an institutional and governmental level and are needed to sustain initiatives such as the Universal Health Coverage (UHC)[63] or to reduce administrative costs for health providers and insurers by inputting patient data in a digital record that is available for the health network.

ELECTRONIC HEALTH/MEDICAL RECORD

A simple explanation of an Electronic health record (EHR) or Electronic medical record (EMR) is that it is the digital version of the patient medical record[64]. By having this digitalized data health providers can access information rapidly, observe previous test results, the evolution of a current illness and prevent new conditions by mapping trends (CVD-Continuum). Having an easy-to-access record is important in the context of healthcare since patients are not always in a position to recall all of the information or might even be unconscious.

Another benefit is the collaboration between regional care providers and institutions, made possible by the electronic record. In the Netherlands, disease management programs are offered by regional care groups while the electronic medical record systems are predominantly driven by healthcare professionals[65]. Connectivity between professionals, both local and global, can be achieved by having the same database availability.

In the case of personal health records (PHR) the ownership of data is given entirely to the patients[66]. Compared to the EHR, individuals maintain their own data, decide when and to whom share this data with. PHR include patient-reported data, lab results, and data from smart devices such as connected weight scales or apps in smartphones. In principle, there should be only one PHR for each patient, while, in the case of EHR multiple databases can coexist depending on the provider.

These characteristics help patients become more active with their own health care and have a wider amount of information to take decisions related to prevention and treatment[67]. Nevertheless, increasing connectivity and data may not always translate into better health. Personality traits, education and beliefs can affect decisions regarding the treatment.

IMPLICATIONS

Although the implementation of eHealth initiatives has a large number of benefits, it is important to consider the characteristics of an "analogue to digital" transition.

From a systematic perspective, there is a need for alignment of governmental initiatives with the intentions and concerns of the individuals. Being CVD a global burden, public and private organizations have developed several tools and programs to help individuals in the different stages of a CVD condition.

Because of the difference between regions, the WHO and other institutions plan strategies with considerations on geographical and demographical differences[68]. An example is the use of biomarkers and vital signs to determine the risk level of individuals: while the categories might be similar between platforms, the parameters change between regions and countries[69, 70, 71]. When risk is calculated online this differentiation is not considered or remains unclear for the user[72, 73, 74, 75, 76, 77, 78, 7980]. This means that people can be labelled with parameters that correspond to another region or miss elevated single risk factors, leading to inappropriate labelling and misguidance.

Along these online platforms, several mobile applications are presented to screen, track and manage health-related information. According to a 2017 market analysis, there are 325,000 health-related apps available for the main operating systems in the market[81], and while the majority of these apps are downloaded less than 5,000 times, the offer is expected to continue increasing. Future predictions also expect a shift in distribution channels, where insurance companies will promote and provide these apps rather than caregivers, hospitals or general app stores.

Other distribution models can be presented for the adoption of eHealth technologies but they should be affordable for the consumer and still guarantee the sustainability of the system[82].

INSURANCE

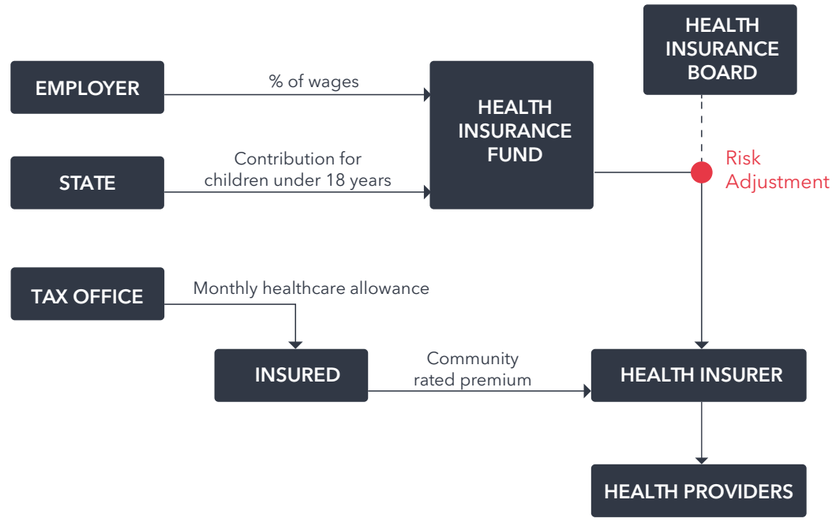
Since 2006, all individuals require to have a basic insurance for general medical expenses under the health insurance act (Zorgverzekeringswet, Zvw) in the Netherlands[82, 84]. Insurance companies work under a private market model regulated by the government to ensure quality care and certainty to healthy, unhealthy and at-risk individuals. The individuals can change providers every year and insurance companies are compelled to cover everybody regardless of their condition.

From the financial perspective, the cost of insuring high-risk individuals is bigger than the low-risk sector and providing the same premiums to all is financially unsustainable. To avoid preferred risk selection a health insurance fund provides financial contribution based on profiling and a risk adjustment plan. This fund is sustained by different providers and not directly from insured individuals (Figure 17).

The Health Insurance Board (CVZ) is responsible to regulate the activities of insurance companies as well as adjust and calculate the health insurance fund. The adjustment of the risk plan is based on values such as age, gender, medication, income, disabilities, among others.

An example of risk adjustment can be seen when comparing 2 patients with different situations under the same insurance provider[85]. Overall, this model translates into a secure market for the patient to perform health assessments without the risk of increasing premiums. It also involves several stakeholders that have an interest in the labelling of individuals to adjust financial funds and future policymaking.

Figure 17 Simplified depiction of financial flows under the Health Insurance Act (Zvw)



SECURITY AND PRIVACY

Personal data is a major concern for several institutions and individuals, being a discussion topic in recent years and has led to changes in the way data management[86]. Since 2018 companies that collect, store or process large amounts of information are legally obliged to be more transparent about their practices to their users. The discussion, however, has raised awareness and concern about the importance of data security. Nevertheless, the use of personal data in the health sector is seen as acceptable for the majority of individuals according to the Office of the National Coordinator for Health Information Technology in the U.S.[87] People are more open to share their personal information if the objective is to prevent diseases or improve health, having 7 out of 10 open to exchange data through their electronic health record.

From the individual perspective, presenting health applications with a consumer strategy can lead to misunderstanding or incorrect management depending on personal traits. People can become overwhelmed by negative screening results or overconfident and challenged, accepting more risks in the process[88].

Bringing healthcare outside the walls of clinics and hospitals also has negative effects. Most of the patients are not experts in medical fields and their involvement in management can produce emotional distress[89].

This lack of knowledge can also affect simple procedures in general. Home-screening devices may need previous training that CVD patients might be willing to follow because of their condition but will not have the same effect on a prevention stage.

While physicians might want a certain amount of data in order to provide good healthcare, patients that reach health providers want to obtain a positive feedback about their health. From their point of view, apps are a tool to obtain health and not healthcare. They will hardly want to interact with several devices at the same time. Also, physicians will not handle the increasing amount of data generated by those devices.

HEALTHCARE CONSUMPTION

Both prevention and treatment can be divided into different stages depending on the stakeholders (Figure 18) involved and the needs of patients, such as acute events, interventions, rehabilitation and palliative care. The patient decides over the treatment direction and the healthcare network act as consultants giving strong advice on what to do.

After a CVD diagnosis, individuals are referred to specialists to evaluate their condition and develop a treatment plan. When further tests are needed GP's can refer to facilities that are more specialized as well. If the user is not diagnosed but wants to follow further studies the costs are not covered by the insurance ("Eigen risico" excess fee principle).

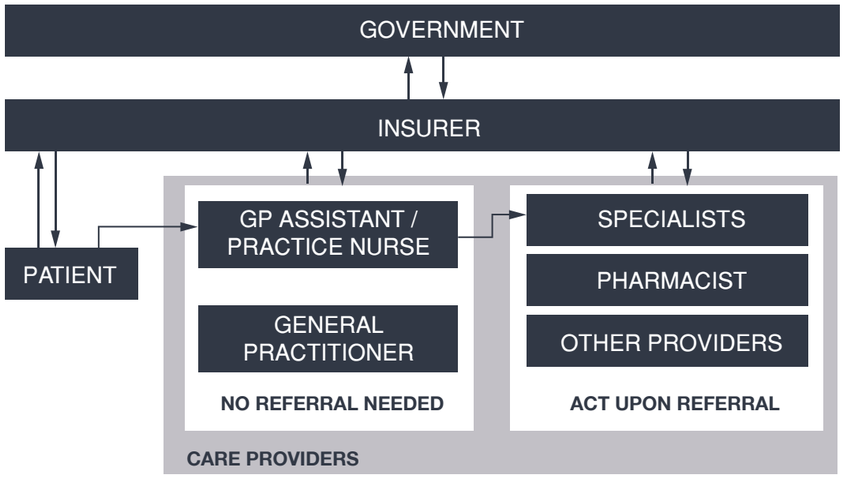
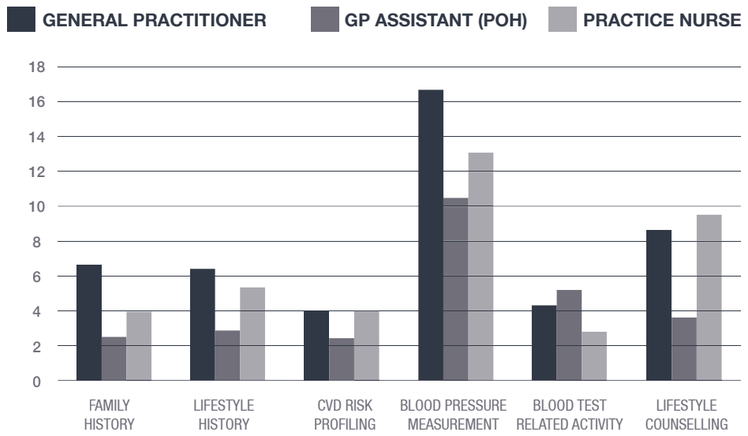


Figure 18 Healthcare systemic structure.

Figure 19 Frequency of primary preventive activities in family practice per week (2009)



CVD RISK ASSESSMENT ACTIVITY FLOW

In the case there is no CVD diagnosis but there are indications of potential risk, the GP has the capability to perform a risk assessment to define the risk level. If this is not inquired by the physician, the user can ask for this evaluation. In both cases, risk labelling depends heavily on the concerns of both parts. After the user is labelled as a high-risk individual, he is entitled to get advice and treatment from multiple specialized providers under a different type of insurance ("Ketenzorg") that does not affect insurance premiums.

In the Netherlands, risk labelling occurs mainly in the general practitioner's office by either the GP, the assistant or practise nurse (Figure 19). The GP can recommend other health promotion programs and specialists such as smoking cessation, nutritionists or specialists. The guidance of these programs is independent and can be contacted through channels outside the GP's office. In the case of smoking cessation the assistance or support, nicotine replacement therapies or other medication are reimbursed by the insurance[90]. Other lifestyle guidance professionals are expected to be included in the basic insurance cover by 2019[91, 92, 93].

While CV conditions are diagnosed during a consultation or an acute event, risk labelling depends on personal variables such as GP's expertise or patient's concern and can even be affected by social aspects and personality. Treatment can be affected by both biological readings and personal traits as well. Medication is recommended in cases with high levels of low-density lipoproteins (LDL), high systolic blood pressure, high creatinine and fasting glucose. Medication therapies are also recommended if there is a chronic condition such as AF or diabetes. Since in some of these cases, high levels do not define an illness, medication is only a recommendation and individuals can choose to avoid it. Risk programs are recommendations and guidance to avoid an acute event or the progression of a condition given to seemingly healthy individuals. The lack of a condition and symptoms make adherence to the program greatly dependant on the self-capabilities and motivation of the individuals at risk.

DEFINE

RESEARCH APPROACH

FROM GENERAL TO PARTICULAR

Because of the size and complexity of the problem, it was decided to start a research from a systemic to an individual level. The previous phase provided information from a macro point of view. The goal of this stage is to determine the parameters where a design intervention would be more effective and provide more benefits to the users and stakeholders. The outcome of this stage is a defined design goal.

Being CVD's a global burden there are several initiatives to treat and prevent these conditions, involving different platforms and stakeholders in different stages. To understand the local context 4 different approaches were followed:

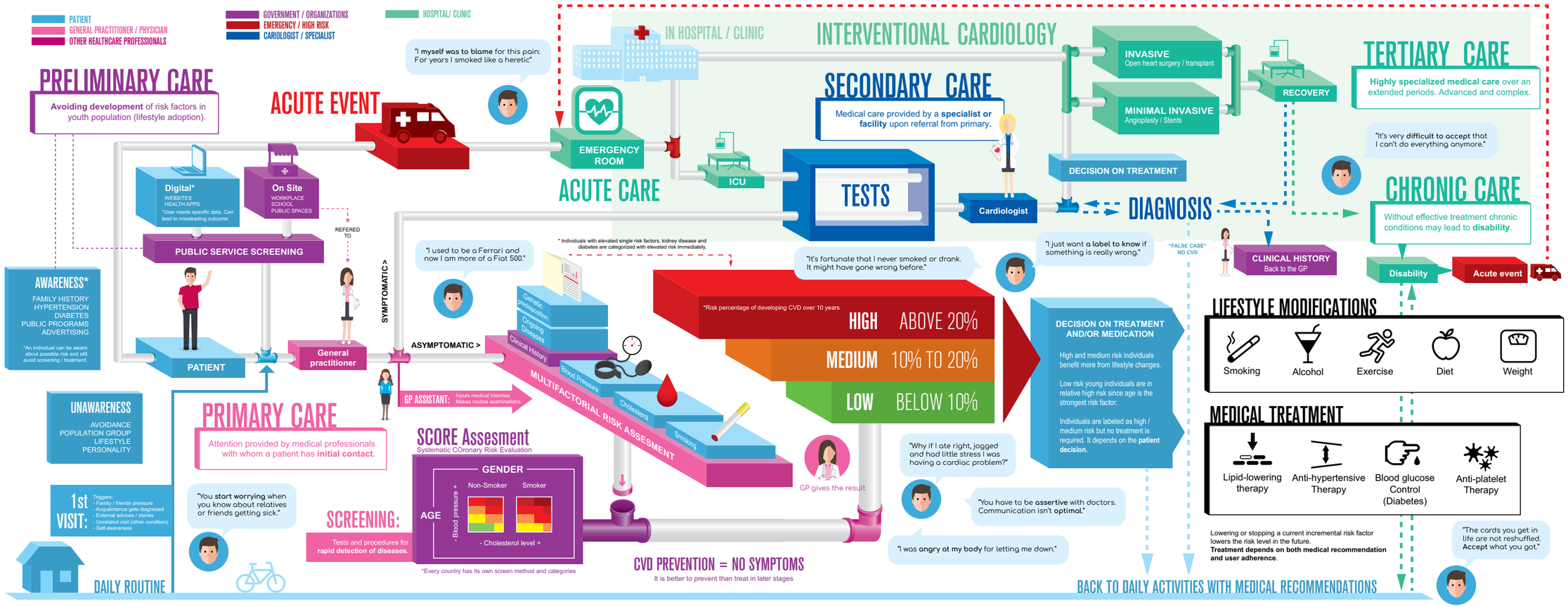
- User journey
- Personas
- Online questionnaires
- Interviews

USER JOURNEY

A first visualization of the patient experience was developed as a research tool to facilitate further co-creation stages considering the literature review. This visual tool was in constant evolution throughout the project and the final version can be later in the project. (Figure 20)

It was observed that individuals need to follow considerable lifestyle changes in the most advanced stages of the CVD's and are confronted with different types of limitations such as dietary changes, dependence on others and in some cases disability or life-threatening surgery decisions. The need to involve more health providers in further stages also increments the burden and complexity of treatments.

Figure 20 Simplified user journey for co-creation stages.



PERSONAS - USER CENTRED APPROACH

Although technological developments are constantly changing the way healthcare is delivered to patients, the first step of this phase was to understand the intrinsic characteristics of the patient and the relationship with their own health. Considering the relation between psychological and emotional factors and CVD prognosis and development, qualitative data was gathered from the potential user perspective.

Patient stories where consulted from online sources such as social media, blogs and public interviews shared on institutional websites[94, 95] 24 were used to create personas, pointing out demographic data, relevant quotes, emotion-related outcomes and a summary of their patient journey. This gave a meaningful first overview of the perspective of real patients and the process they had to go through. These sets were later cross-referenced with an interpersonal communication model to find major links and differences.

On a first analysis, the main insight was that people react differently to a first CVD diagnosis, regardless if it is made through prevention or through an acute event. Although the incident by itself is considered negative and shocking, self-reflection varies depending on factors such as psychological traits, capabilities and past experiences. Further actions and coping process change and, as consequence, treatment adherence increases or decreases.

These personas were later compared with a typology model and assigned a color based on their characteristics for further co-creation sessions.

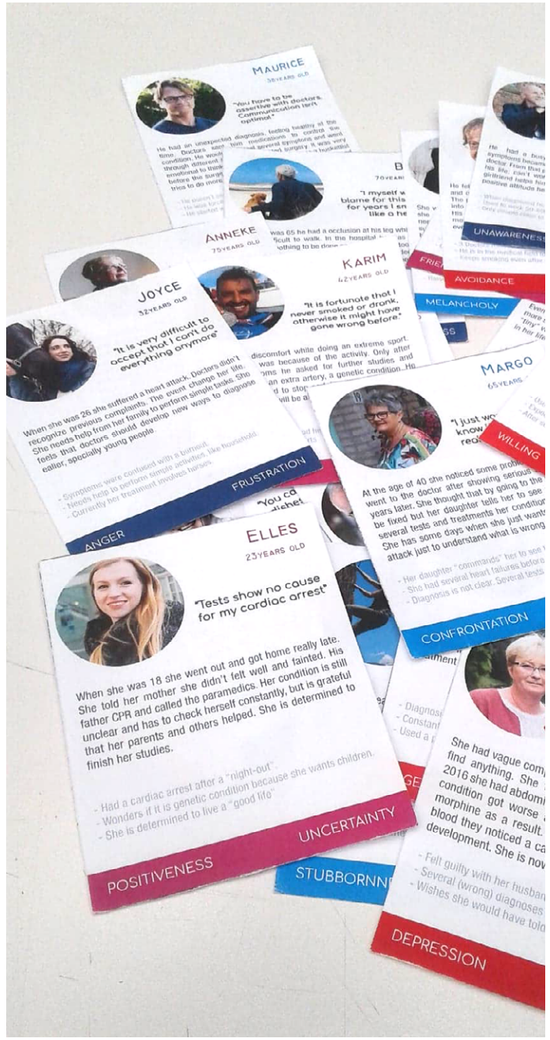


Figure 21 Examples of personas based on online publications. Each character was compared with previous typology model.

JACQUELINE

60YEARS OLD

"Now I enjoy every moment and I am very grateful"

Jaqueline was informed about a leak in heart when she was pregnant. It gave her headeaches and high blood pressure but it was acceptable. 10 years after she went into surgery but had to return within a week for another one. Her family convinced her to go through it because she was scared.

- 5 heart valve operations and a pacemaker.
- Her father died from the same condition.
- The 1st surgery made her forgetful and depressed.

CONTROL FAMILY

DAYENNE

33YEARS OLD

"I would like to help children with a heart condition"

She was born with a "single vault" heart. Because of this she needs to monitor herself constantly. Although she needed to learn this as a child, symptoms come as a surprise (even now). She wanted to be as any other child but couldn't, that is why she tries to help other children with heart conditions.

- Was born with a "single vault" heart condition.
- Had a long rehabilitation process but she remains positive.
- Raises money for heart fundations by running and biking.

MELANCHOLY EMPATHY

PAUL

50YEARS OLD

"I used to be a Ferrari and now I am more of a Fiat 500, such a classic then."

He had a busy life (work and travel). Only after the symptoms became strong he made an appointment with the doctor. From that point on he had to make strong changes in his life: can't work more than 2 days in a row and his girlfriend helps him when he gets extremely tired. He feels positive attitude helps.

- When diagnosed he already had 2 (unnoticed) heart attacks.
- Used to work 50-60hr a week.
- Only people close to him notice his discomforts/condition.

UNAWARENESS ADAPTATION

MRS. OOSTERWIJK

95YEARS OLD

"I want to relax and enjoy what I currently have"

Mrs. Oosterwijk used to help senior citizens when she was younger therefore she understands some of the upcoming stages and arranged everything for the moment she passes away. She has no family but a good old friend. She doesn't want this friend to be sad after she is gone.

- Used to cycle and travel a lot.
- Now she can only "walk fast".
- She arranged "her business".
- Used to be a volunteer.

FRIENDSHIP TRUST

Figure 22 Final patient typology model. considering communication models, personality types and drivers.

PATIENT TYPOLOGY

Keller et al.[96] categorized communication through a sequence of tasks and objectives that the physician needs to achieve in order to deliver an effective care. Their 4E model (Engage / Empathize / Educate / Enlist) provides steps that integrate personal characteristics of the patients to increase adherence and result in better care. Roter et al.[97] categorized patient interactions based on the level of control physicians had in communication and the intrinsic values of patients. They summarized these interactions into 4 types: Paternalistic, Consumerism, Default and Mutuality.

Based on these studies and other analysis in the healthcare context[98, 99, 100], a 2x2 matrix model was developed to analyze interpersonal interactions. The variables of the model refer to the patient and the physician and both change values depending on the level of involvement and control. The model considers the way communication is treated, how goals and expectations are stated and the role of situational factors and personal values. (Figure 22)

To facilitate the analysis, each section has a analogy for the physician and/or healthcare provider role as well as a name for the type of interaction the patient expects. It was observed that there could be either a rational or emotional response to a diagnosis or CVD event in each quadrant; therefore personal quotes were added to the model based on those values. (Figure 23)

Figure 23 Quadrant explanation

The Oracle

A highly empathic individual that compares personal contexts with stories from others. Storytelling-type references that aim for sympathy are more relevant than raw data. They are aware they are not perfect and can try to be better if motivated, focusing on the future benefits. Communication with this group should avoid negative or threatening tones that reinforce their condition. The medical approach can be less formal and open.

The Guardian

Individuals seeking immediate support and relief. Compares present developments with past events, usually resulting in a negative perception. They look for assurance that they are well, and avoid confrontation with raw information. Showing an increasing amount of information can be overwhelming and make them avoid health-related providers. This type wants certainty given by others and avoids changes or surprises. Confidence is important when approaching health information.

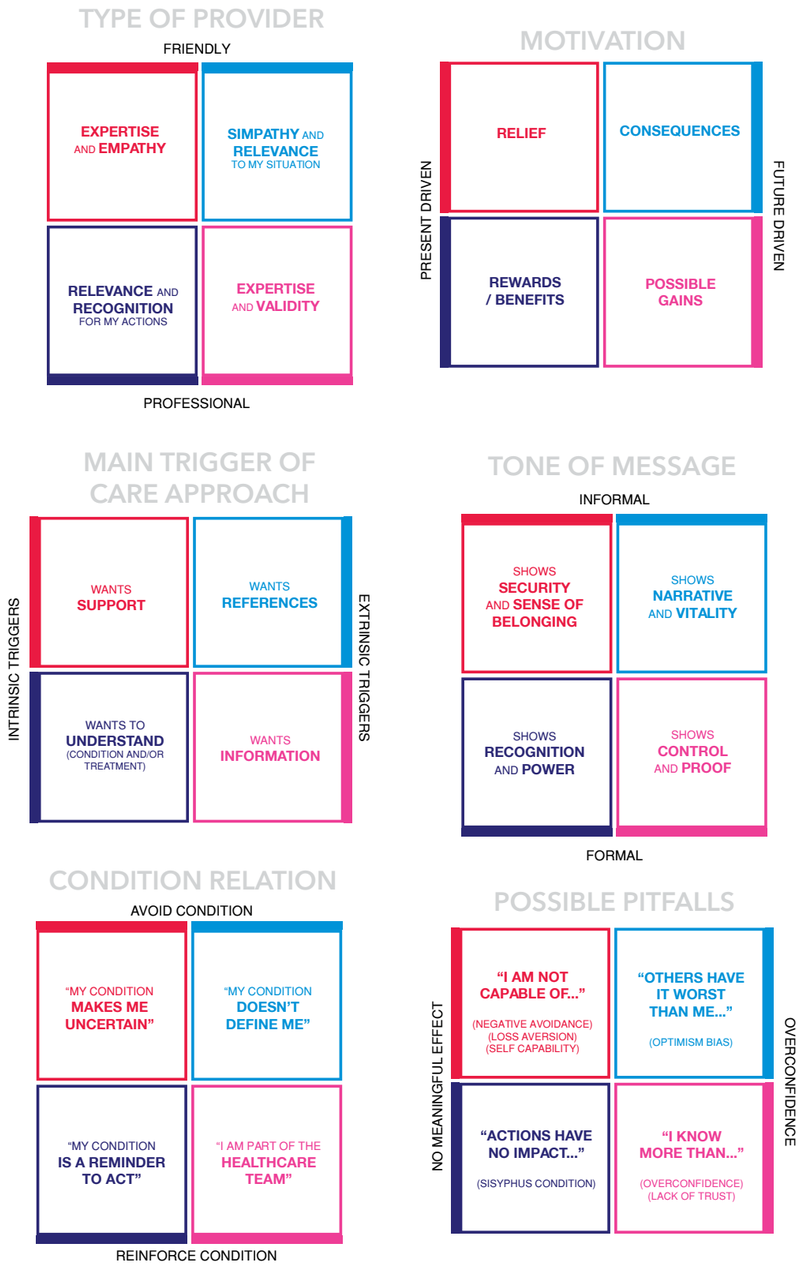
The Trainer

Dominant individuals. They generally not complain and dislike patronizing messages. Prefer clear and direct information and prefer summaries for practicality. They approach health providers to understand their condition and want immediate gains for their actions. They will eventually accept and confront whatever crosses their path. Can be overconfident.

The Advisor

This type is comfortable talking about their condition and is a way to learn more about it. Looks for additional information and triangulates sources. See themselves as part of the medical team and their opinion counts as much as the physician. This group might adapt their care to their routine and not the other way around. Focus on future consequences and provide clear guidelines and information. They might avoid action if the physician is mistrusted.

Figure 24 Design guidelines resulted from the patient typology model.



Philips developed a similar profiling method based on psychological and commercial models such as the Myers-Briggs Type Indicator (MBTI)[101] and the Censydiam model[102]. This model was discussed and the insights considered for an iteration of the first model.

Although profiling models have been highly discussed regarding their validity in psychology fields[103] and their subjective validation outcome, the axis and guidelines gave characteristics for the design concept that would be used in the developing stage.

The personas created previously were cross-referenced with the communication model and their typology was included in the cards. The analysis showed that the four types of communication appear in prevention, chronic and rehabilitation stages. It also showed that an incident can be perceived as challenging and trigger a positive behavioural change or could be overwhelming and people would tend to avoid medical-related topics. (Figure 21).

The persona-based methodology provided a set of manageable data and highlighted differences in preferences and perception (Figure 24). The sets were used to share ideas during work sessions to connect with the mindsets of individuals. During the ideation process, these personas were used to filter and categorize products in the market and to evaluate the possible impact of concepts.

"Spiritually I have not yet recovered"

- **Theo, 63 years old.** Heart attack and surgery. MDD as a result of overwhelming social support.

"I just want a label to know if something is really wrong"

- **Margo, 65 years old.** Symptoms appear early but goes to the doctor 20 years later.

"I felt 80 years old while I was only 50"

- **Annemiek, 75 years old.** Believed she was hypochondriac. Was ore concerned about her family.

"I used to be a Ferrari and now I am more of a Fiat 500"

- **Paul, 50 years old.** Had 2 unnoticed heart attacks. He relies on people close to him.

"I thought the symptoms were a result of a night out"

- **Elles, 23 years old.** Wonders about genetic condition for future children. Determined to live "a good life".

"I was anry with my body because it let me down"

- **Julia, 35 years old.** CV diagnosed when she was 18 years old .

QUALITATIVE RESEARCH ON PERCEPTION

ONLINE QUESTIONNAIRES

Online questionnaires were used to explore perception and preferences of visual styles and cues related to health messages and products. 61 individuals filled out the 2-part questionnaire. On a first section, people were presented with 5 animated illustrations shifting in levels of abstraction of a heart[104]; from an anatomical (real) representation to a recognizable symbol (iconic)(Figure 25). People were asked to select the best fit for an icon that depicted:

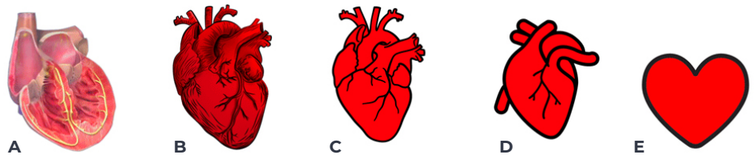
a) Progress in health. (Positive feedback)

b) Monitoring of heart. (Security)

c) Call of attention. (Negative feedback)

While high abstraction levels were generally selected as a positive feedback, people had different preferences for constant monitoring and motivating trigger (Figure 26).

Figure 25 Animated illustrations with different level of abstraction presented in online questionnaires.



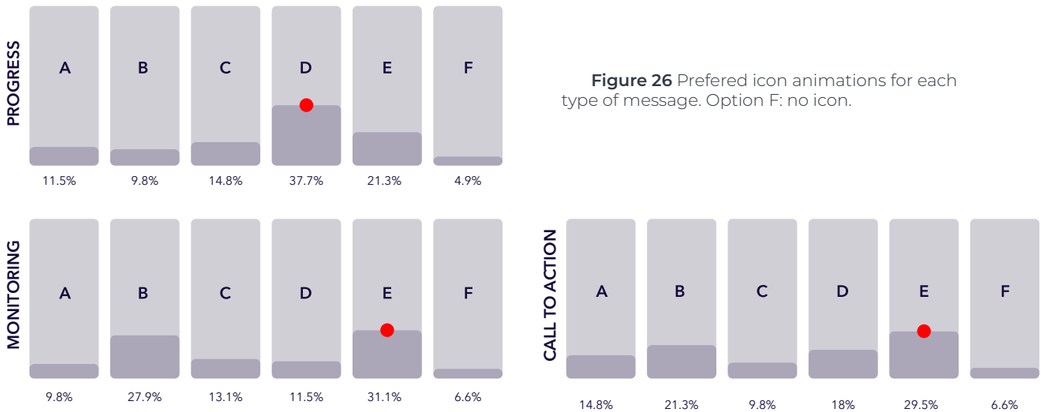


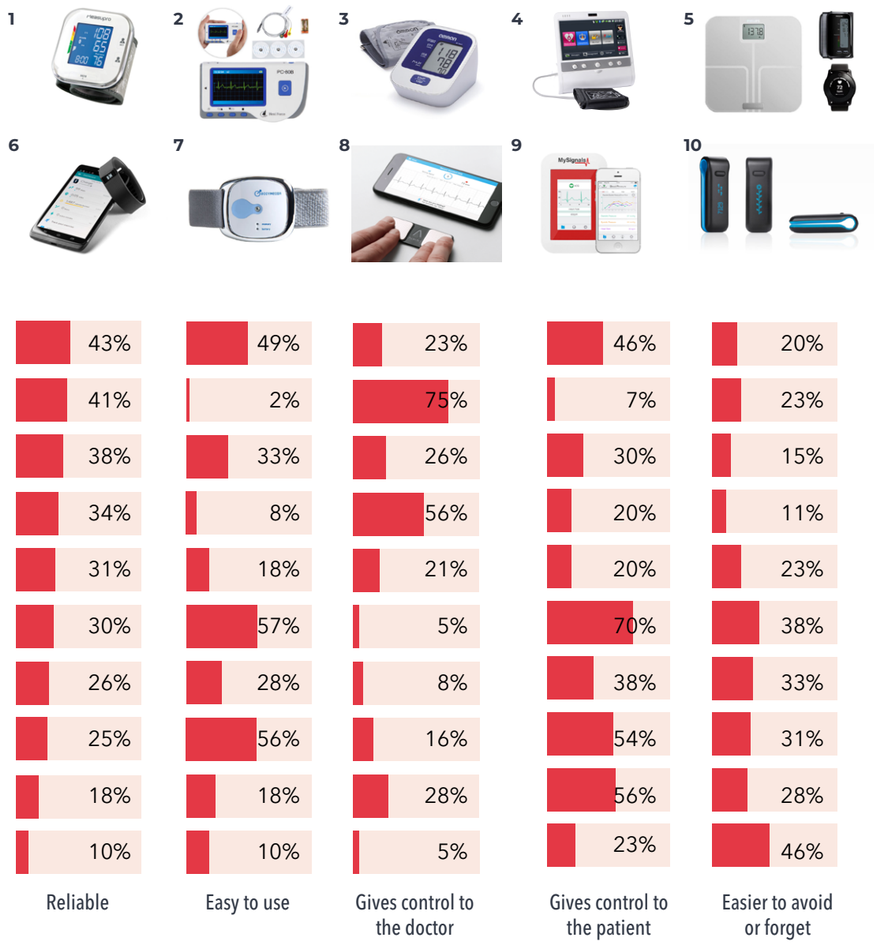
Figure 26 Prefered icon animations for each type of message. Option F: no icon.

In the second stage, a randomized group of 10 health-related products was shown in a multiple choice format. The products were presented with descriptive information or name to focus on the perceptual effect of the embodiment. People chose the products that applied to 5 different areas: Reliability, easy to use, gives more control to the patient or user and easy to forget or avoid. (Figure 27)

There was a correlation between avoidance and patient control as well as the size of the device. No correlation was found between icon preferences and product perception.

It was unclear if the effect of the animations or health literacy affected the results, but a conclusion was made that a health-related message can be affected by aesthetic characteristics.

Figure 27 Randomized health-related products and results on perception (61 participants)



INTERVIEWS OUTCOME

CARE PROVIDER ROLE

During unscripted interviews, 3 specialists shared their opinion on CVD diagnosis, risk assessment and treatment follow-ups. From these conversations several points were highlighted:

- SCORE charts and guidelines are clear for the evaluation of risk factors and results are open for the physician to interpret the results. When an individual is between age groups or high individual value is detected, the physician can choose to use the guidelines for the next group.

- The perception of a CVD diagnosis is affected by personal traits and the communication skills of the physician. A high-risk result can be overwhelming and stressful for certain individuals while for others it can be can a challenge and reason to improve. In both cases, indications can be followed or avoided.

- It is the role of the physician to evaluate the best way to approach each individual.

- Physicians are willing to talk and assess patients about their emotions but they expect an instigator to start. Patients need to be open to share their emotions.

- Efficiency is a concern for the GP's.

FROM AN EPIDEMIOLOGIC TO AN USER-CENTRED SYSTEM

Traditional medicine treatment and prevention is derived from statistical measurements, study results and an "average patient" definition. This "one-size-fits-all" allows an implementation of interventions for bigger demographic groups but fail to apply on an individual level. The distance between tailored treatments and the stage of a condition proportionally reduces the impact of those interventions. While primary prevention is meant for the general population it doesn't consider individual factors that could affect the CV condition. On the other hand, secondary prevention involves a patient-tailored treatment once a condition has been determined and there is a need for a stronger intervention.

Although focusing on early stages of prevention would mean the use of bigger resources to filter a bigger amount of individuals, there have been initiatives to include individual factors in healthcare using technology to detect, simulate and adapt treatments to the individual's need[105] driven by the idea that not every strategy is suitable for each individual[106].

PRECISION MEDICINE

Differentiating patients to increase the success rate of interventions is by no means a new method. The use of biological markers to categorize patients such as blood types secure treatment efficiency and safety. However, in recent years there have been initiatives to integrate individual's differences to have better health outcomes[107].

In this initiative, genetic, environmental, and lifestyle factors are included in the field of medicine to determine the best path for each patient. Just as in any other disease, no two CVD patients are alike. Since the success rates of a prevention program are related to patient involvement there is a need to include more individual characteristics in the strategy.

PRECISION PREVENTION

While precision medicine focuses on delivering the best intervention to patients, prevention is still reactive. Precision medicine uses data of current patients to determine the best prevention practices[108]. Considering the characteristic of CVD prevention programs of being a longitudinal effort outside the physician office it is clear that contextual elements need to be included in the plan. It is acknowledged that health-related messages need to be addressed in a certain tone and that delivering all clinical information to patients can be overwhelming and give negative outcomes.

PROBLEM DEFINITION

CVD risk labelling is an effective tool to determine who needs attention and guidance. However, individuals that are labelled with potential risk find it difficult to adhere to the program indications since there are no clear symptoms or reminders of the possible disease. Lifestyle stress factors and routines affect adherence since they are perceived as urgent matters while the CV condition is inexistent at this stage.

The involvement of health professionals in the guidance of risk individuals is highly beneficial and involves lower care costs in the longitudinal perspective, translating in less future chronic patients. However, to monitor patients constantly, caregivers would need to use valuable time and resources that could be used in other patients.

The use of technology to involve patients in the management of their disease can be beneficial but needs to align with the user needs, understanding and intrinsic motivation.

DESIGN BRIEF

The desired design should cover three themes:

1.- The product should give the medical staff insights from the performance of users outside the prevention program consultations.

2.- The product should help individuals self-manage their personal program by providing information, feedback on actions and by tracking activity in an understandable way (literacy dependant).

3.- The product should be part of the overall healthcare journey and enhance interactions in different stages: risk labelling, self-management and follow-up consultation.

Four types of patients are defined, each with their own causes for adherence and avoidance. It is preferred that one product fits each heart failure patient type and will be able to stimulate each patient to adhere instead of having different products for each individual. In addition, the concept should consider a longitudinal use, considering that the time between consultations can be as long as one year.

EXPLORE

DEFINING THE CONCEPT DIRECTION

COVERING THE PREVENTION GAP

The previous phase constructed an overview of CV conditions and the implications of interventions at different stages. Considering the data it was decided to focus on a primary prevention stage for 3 main reasons:

- The actions of the user have a strong potential for the future health status while there is still a possibility to test, iterate and adjust treatment plans without heavily affecting the condition of the patient.

- Behavioural changes and treatment adherence is still within the user capabilities. Most of the time individuals have no disabilities or strong burdens limiting their performance. The main concern at this stage is to reduce modifiable risk factors.

- From a systemic point of view, investment at this stage can translate into less chronic care costs, a more active population and a reduction of the expenses from the health adjustment fund.

LIST OF REQUIREMENTS:

Based on previous stages a set of characteristics were stated:

- The concept should be part of a system that integrates health providers and patients, prioritizing the interaction and adherence to the program without incrementing the time and effort of the health network.

- Should be part of the risk assessment consultation and help in the classification of high-risk individuals at a prevention stage.

- Accessibility to information about CVD risks is desirable for the general population to increase health literacy but the main users should be individuals already labelled with a high CVD risk.

- It should provide information during and after diagnosis in a way that is easy to understand for the user. Therefore, consideration for different literacy levels must be part of the concept process.

- Motivate individuals into the self-screening process, lifestyle changes and treatment adherence after the consultation (without the physician being present).

CREATIVE SESSION

While there are institutional guidelines and recommendations for physicians to share and guide patients, once they go back to their daily lifestyles different factors affect their decision making and adherence. This is a major problem in both prevention and CV conditions: although there is a general consensus on what is an unhealthy behaviour in the general population, some people tend to keep unhealthy behaviours even after going through an acute event.

Drivers and triggers were analyzed in different stages of the journey using the personas created previously (Figure 28); raising questions about what would be a good instigator for behaviour change and a good way to deliver a health-related message. This analysis also made clear a gap between the risk-labelling consultation and the follow-up meeting, where patients are obliged to adapt their lifestyle to their new condition.

The main motivators in the patient's stories were the acute events or the wish to comply with the indications of the physicians and family.

It became clear that there was a need for tailored information since individuals had different backgrounds and perceive risk differently, even when they had the same condition, motivational elements or social support. However, more information was needed.

Figure 28 Creative session - Printed personas and typology models.

FROM REACTIVE TO PREVENTION CARE

IMPLICATIONS AND POSSIBILITIES

Time investment is the most costly factor in prevention programs since, in general, patients use part of their productive time for the consultation which adds to the caregiver's practice costs[109].

Segmentation models can be wrongly perceived as tailoring mechanisms[110] and while epidemiological data requires this segmentation, tailoring prevention for individuals requires other categorization methods.

VALUE OF LONGITUDINAL SCREENING IN SELF-MONITORING

Although goals of prevention programs aim to reduce CVD risk of individuals through behavioural change and medication, this project starts from the premise that these changes occur in a sequential form, where awareness and motivation start the cycle. Although in different intensities, being labelled as high risk is shocking for individuals, especially when is unexpected but also when the prognosis was suspected by the patient. This shock increases the adherence at the initial stages. People are more inclined to follow the physician's indications immediately after the consultation but this trigger fades out and information can be forgotten.

Combinations of specific variables detect health decay or specific diseases and can be managed in a digital platform; however, the usage of this platform needs to consider the capabilities of the user. The needs of patients outside the GP office call for a new perspective on both care and design[111] that considers both the relation with a design concept and a medical condition.

SELF-MANAGEMENT & TELE-MONITORING

Digital healthcare and the involvement of patients and physicians can be observed in a three-stage circular model. In it, activities can be described as an analogy for reason and action. The way we receive and perceive information gives us guidelines to act. We process this information using our knowledge, references and beliefs.

INTERPRETATION OF SELF-CARE

The incremental connectivity of institutions outside the healthcare system and the national goal to provide individual control over health data requires an active involvement of the patient in their care. This also ensures the prevalence of treatments and prevention programs. The stages related to self-care are described with an action analogy below (Figure 29):

SELF-MANAGEMENT (THINK)

When diagnosed or labelled, individual's can take an active role in their treatment planning, implementation and adjustment. The consideration for symptoms, treatment, physical and psychosocial consequences to take decisions is the main goal of self-management[112]. Self-management is highly related to health literacy and personality to translate the given information and adapt it to the self.

SELF-MAINTENANCE (ACT)

An important part of self-care is to follow the actions needed to secure a healthy condition, including medication intake, exercise and diet. Changes depend on condition, phase and recommended treatment. This phase is affected by the motivation to follow the treatment and capability.

SELF-MONITORING (OBSERVE)

By constantly measuring and comparing markers such as weight, blood pressure and glucose the patients have more information to make adequate decisions. To obtain this information, patients can use devices and tools. These can be part of the primary care, rehabilitation, palliative care or another stage. Because of their complexity, some devices might require a reference for the given data or previous training for given values. Consumer products that do not require the involvement of the health network such can also provide information on vital signs and exercise amount.

Figure 29 Defined stages of self-care.

MARKET RESEARCH

In the market, there are several devices with different prices and characteristics, and their development is forecasted to reach 222.3 million shipments in 2021 according to IDC's Worldwide Quarterly Wearable Device Tracker[113]. Although not all products in the market are health-related, most of the wearable sensors can provide information relevant to health practices.

WHAT TO MEASURE:

It is decided to use blood pressure as the measurable element of the concept since it is perceived as an excellent biomarker for hypertension and other CVD's[114], and is one of the CVD risk assessment values. Its measurement is non-invasive and provides relevant information for the patient, therefore is convenient for primary prevention.

Many devices that measure blood pressure can provide feedback on blood rate and other health-related values such as calorie burn, step count, etc. This is particularly important in the prevention context since the selected device should not be limited to the information of a disease.

A benchmark analysis was performed to understand the current scenario, technological and interaction possibilities (Figure 30).

The user typology model was used to compare each device and map the characteristics and features given to the user (. Portability, data interpretation and the use of an app to track readings were categorized as elements that gave control to the user while high costs, the location of measurement and FDA approval were taken as variables for perceived security. The number of users was only added as a note since it can be tech-dependant.

20 devices were mapped in the typology model and scaled depending on the user cost. It was observed that most of the products are meant for a treatment plan and not for prevention. The ones that could be used in prevention stages have higher costs or require a bigger understanding or health literacy.

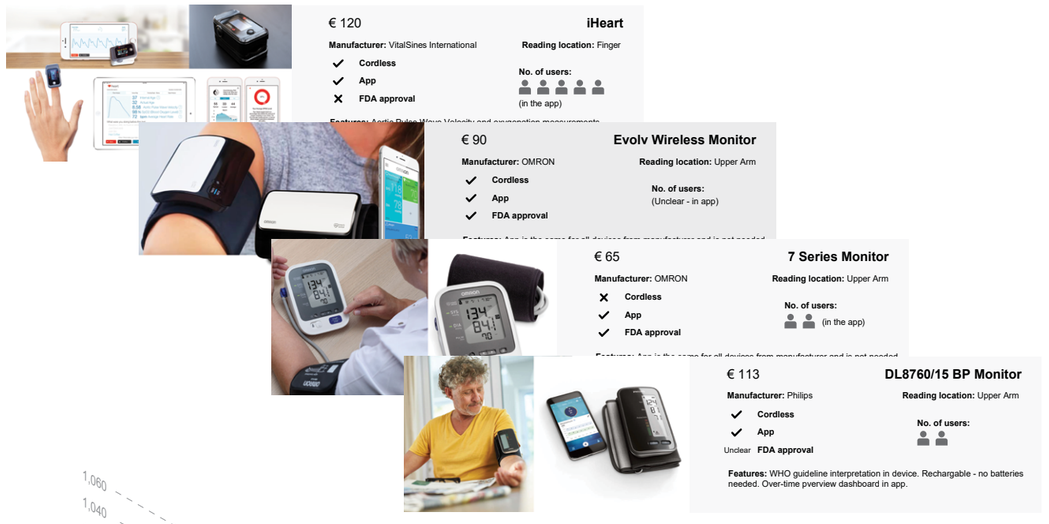


Figure 30 Market analysis of blood pressure reading devices (top).

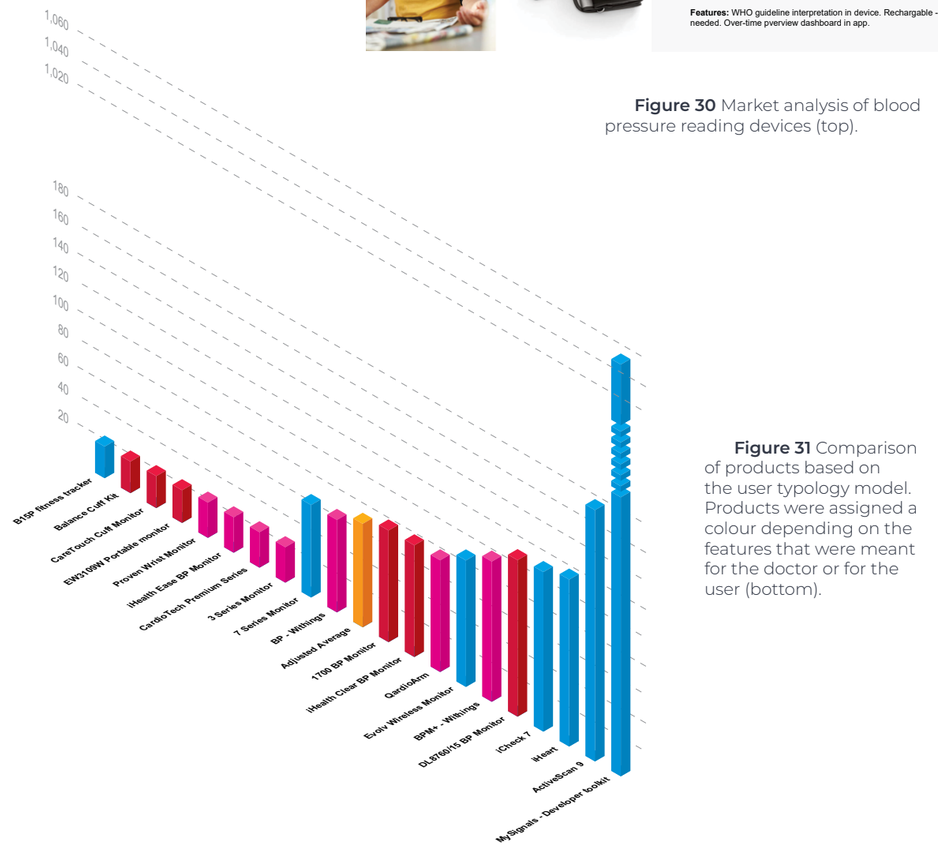


Figure 31 Comparison of products based on the user typology model. Products were assigned a colour depending on the features that were meant for the doctor or for the user (bottom).

EMPIRICAL RESEARCH

A longitudinal analysis was made to determine the characteristics of self-monitoring with a wearable device (Figure 32), focusing on usability. The usage was self-reported, focusing mainly in the usability problems such as legibility, accuracy, battery life, app information and synchronization with other devices. This log helped further decisions and system requirements, considering the possibilities and limitations of the devices.

LOCATION OF MEASUREMENT

From the market analysis, it was seen that there are different body locations and methods to read the blood pressure of a patient such as arm and wrist cuffs, wrist-wearable and finger clips. For this project, it is decided to use a non-invasive ambulatory device that facilitates people into screening themselves outside the practitioner's office. Considering the cost-effectiveness and value of devices, a wrist monitoring device is preferred over an arm or wrist cuff. Although portability is inversely related to accuracy[115, 116, 117], it is desirable to achieve persistence of use over accuracy in a prevention. Individual factors that affect adherence are prioritized in this project since devices are in constant development and measurement accuracy increases along technological development.

CONSIDERATIONS ON SELF-SCREENING BLOOD PRESSURE

To determine high blood pressure physicians compare readings to a standard, where systolic and diastolic pressure should remain below 120mmHg and 80mmHg respectively[118].

Blood pressure fluctuates around the day, typically increases when the person is active and decreases when at rest, but it can be affected by external factors such as stress, activities and caffeine or tobacco consumption.

Figure 32 Wrist blood pressure monitor for longitudinal empirical test. (Bozlun B15P fitness tracker with blood pressure).

WHITE-COAT EFFECT (WCE) AND WHITE COAT HYPERTENSION (WCHT)

The presence of medical staff and the healthcare environment can influence blood pressure measurements. When readings in the clinical environment are above 140/90 mmHg in at least 3 occasions but the readings outside is below that number it is determined that the reading is related to the healthcare environment: hospital context or physician presence[119].

While this effect is well-known, the only way to filter out these false negatives is to perform a reading outside the medical context; most likely through self-screening.

PSYCHOLOGY PRINCIPLES

When giving patients the control over their own treatment, personality, fears and bias should be considered, especially when a product is meant to be used in different moments over a long period of time. People can have different reasons to seek a healthier lifestyle and other priorities might affect this desire, consequently reducing adherence to the health plan.

Factors and principles that can affect the interaction with a self-management design intervention:

HEDONIC ADAPTATION

People get used to changes in lifestyle over a period of time. This can work as a coping mechanism for diseases but it also can reduce adherence in a longitudinal intervention. We interact with something until it becomes predictable or we give no more value to the output. The initial shock of a prognosis fades after some time, especially when is compared with other immediate triggers and cravings.

BEHAVIOURAL ECONOMICS

The core idea of behavioural economics is that we are not rational beings and that our behaviour is affected by emotions, cognitive bias and environmental factors. This concept antagonizes the concept of rational economics and describes the unusual behaviours related, among other topics, to healthcare and how individuals make decisions that attempt against their well-being[120].

HEURISTICS & COGNITIVE BIAS

Heuristics are mental shortcuts that we use as a way to make decisions without using too much mental capability. These "rules of thumb" are not always precise and can lead to bias. More importantly, not all heuristics are related to the same domain and some can be contradictory. They are context-dependent and the characteristics of triggers can affect them[121].

Some behavioural principles that are relevant for this project are listed below:

BEHAVIOURAL ECONOMICS CONCEPTS:

- **Availability Bias** – Giving more importance to recent or memorable events to take a decision.
- **Anchoring** – Figures presented at initial stages will affect judgements and decisions.
- **Decision Paralysis** – People select the easiest option when given several options or even avoid choosing.
- **Default Bias** - Defaults are a cognitive shortcut and are perceived as something that has to be followed.
- **Implementation Intentions** – People are more likely to comply when they clarify when, how and where they will.
- **Disposition Effect** – Individuals hold poor investments for a long time finding it hard to detach even when there is a clear need to do it.
- **Ego Depletion** - The ability to make good decisions can be worn out by decision overload and fatigue.
- **Endowment Effect** – Individuals give more value to the things they own.
- **Goal Gradient** – When a goal gets closer, people will work harder to achieve it.
- **Herding** - People tend to follow what others do.
- **Hyperbolic Discounting** - People put an unrealistic value to the present and a low one on the future.

· **Lack Of Self-Control** - Delaying gratification is extremely difficult. Having the possibility to satiate a craving or fulfil an immediate satisfaction is very hard, even when we know it is not in our best interest.

· **Loss Aversion** - People react to losses more strongly than to gains. The pain of losing is greater than the joy of receiving something.

· **Mental Accounting** - People categorize and spend financial resources differently depending on where it came from and where it is going.

· **Losing Mindset** – People tend to be riskier when having the possibility the possibility of losing in mind.

· **What-The-Hell Effect** - People give up on their goal once they've fallen off track.

· **Omission Bias** - People consider harmful actions as worse than equally harmful inactions and avoid them.

· **Opportunity Cost Neglect** - People tend to ignore what they give up when they make decisions.

· **Ostrich Effect** - People who worried about falling off track in a program don't want to know how they're doing and avoid the program overall.

· **Overconfidence** - Individuals believe they are right and that they have above-average skills.

· **Pain Of Paying** - Some purchases – such as incremental payments or paying with cash – are more painful than others, so people will tend to avoid them.

· **Payment For Effort** - People place a greater value on services and products if they see that there is a big amount of effort put into them.

· **Planning Fallacy** - When planning, people underestimate resources such as time or level of commitment.

· **Regret & Counterfactuals** - Satisfaction depends both on actual outcomes and ideas about what could have happened.

· **Relativity** - People evaluate options by comparing them to what else is around and their point of reference.

· **Reward Substitution** - Immediate rewards, which appeal to people's impulsive nature, can be used to motivate behaviours that are beneficial in a longitudinal way.

· **Pre-Commitment** - When people actively commit to a goal from the beginning, they are more likely to achieve it.

· **You Are What You Measure** - People repeat behaviours that are rewarded, regardless of whether those behaviours lead to success.

· **Optimism Bias** - We overestimate the probability of "things going right for us" and underestimate the probability of "things going wrong for us". This also means overestimating chances of surviving a negative prognosis or living long periods of time even when validated models show otherwise[122].

· **Substitution** - It is easier for people to substitute behaviours than to completely eliminate them.

· **Social Proof** - People want to be like their peers and are heavily influenced by what they perceive everyone else is doing.

· **Identifiable Victim Effect** - One identifiable individual described in great detail evokes deeper emotions and sympathy than a large group of anonymous individuals.

· **Friction Costs** - People can avoid taking action when small barriers appear.

· **Self-Signaling** - People behave in ways that reinforce the type of person they believe themselves to be even if there is no one else around to witness the action.

NUDGE THEORY

Leonard et al.[123] explain that although we do not always make decisions that are immediately beneficial for us, environments can be designed to make it more likely for us to act in our best interests. The way choices are presented affect our decisions and under that idea, the nudging theory presents positive reinforcements as a way to motivate an attitude or action using the behavioural economics principles.

CONSIDERATION OF COGNITIVE BIAS PRINCIPLES

Just as healthcare research, cognitive bias and behavioural economics are the result of generalization and averaged data. Some of them can be avoided by changing the information style or the elements to which people interact. Nevertheless, they provide strategies to motivate behavioural changes and in this case, adherence to medical programs in the general population.

BEHAVIOURAL CARDIOLOGY

MDD is not the only psychological factor involved in CVD progression. Strong adverse emotions such as stress and hostility are related to an increased CVD risk and can be a result of environmental elements. The goal is to integrate behavioural traits in the analysis of patients to better address care, under the understanding that not every individual performs the same and is affected by the same factors[124]. This concept is related to precision medicine, risk management and behavioural change, as discussed previously[125, 126].

IMPORTANCE OF INTERFACE FOR HEALTH LITERACY

It was discussed that for patients the search for health information is to ensure their own security and not to learn about health-related topics. However, health literacy is important to further stages in life and therefore recommended to include in the concept development. This information needs to be presented gradually and adequately for the target audience (Figure 33). Facts and figures can have a negative result if wrongly perceived as an effect of the behavioural economic concepts. For example, while single event probabilities might be perceived as a low risk by showing them as a 1% chance, the same information could be presented as 1 out of a 100 events, having the final user's literacy into consideration[127].

Figure 33 Example of different visual representations for one hypothetical condition.

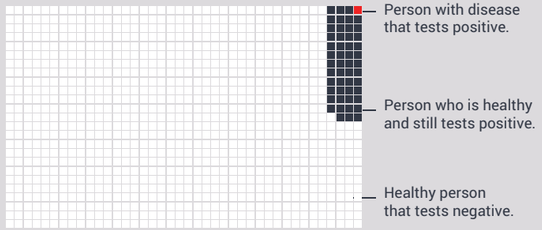
Question: **0.1% of the population has a disease, and a test detects it 99% of the time but falsely identifies 5% of healthy people as sick. What is the likelihood of a positive test result being accurate?**

SINGLE-EVENT PROBABILITY FORMAT (Bayes' Theorem)

P (disease)= 0.1% prevalence of disease
P (positive test / disease)= 99% true positive rate
P (positive test / no disease)= 5% false positive

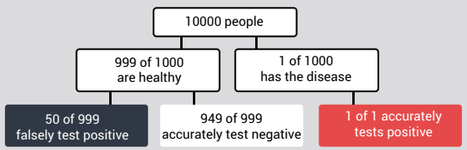
$$P(\text{disease/positive test}) = \frac{0.1\% \times 99\%}{(0.1\% \times 99\%) + (99.9\% \times 5\%)} = 2\%$$

PICTOGRAM FORMAT



NESTED SET FORMAT

$$P(\text{disease/positive test}) = \frac{P(\text{disease AND positive test})}{P(\text{positive test})} = \frac{1}{50+1} = 2\%$$



HOW DO WE PERCEIVE RISK?

We are uncertain about the future and tend to rationalize or avoid negative prognosis based on available information and personal bias. In the case of tobacco consumption, smokers tend to minimize or deny self-risk by thinking about the condition of others. By comparing themselves to others, individuals set wrong standards for health risk[128, 129] self-exempting themselves and consequently denying their own risk.

Although the goal of the design intervention is to increase proactive health management with a health platform, the output should not decrease the perceptual risk.

CRITICAL POINTS

Although the technology can reduce the gap between physicians and patients, personal traits affect the human-computer interaction (HCI) and in consequence, the outcome of design interventions. An immediate feedback of negative prognosis can result in discouragement or avoidance, while complex information can be misunderstood or lead to cognitive biases.

While technology allows more information being delivered to the patient and the possibility of self-monitoring, the involvement of nurses and GP assistants as head of the CVD prevention program should not be overlooked. In the SPRING trial, 3 different groups were analyzed to determine the effect of pro-active counselling on self-monitoring. While there were no between groups with and without counselling, the involvement of a person responsible for the prevention program improved the program results[130].

Increasing availability to reach a physician can affect the relationship in a negative way. Using constant health reminders might translate into concerns and more office visits, augmenting the amount of work of practitioners[131]. The role of a system should focus on self-management with health guidance rather than telemonitoring the activity of the patient or enable consultations calls.

TAILORING IN THE HEALTHCARE CONTEXT

An important part of tailoring a health-related system that gives information to the user is to differentiate which information should be provided and when. The evolution of sensors and devices increases the possibility to detect vitals, lifestyle characteristics and activity. But the ability to track does not immediately mean that the user needs or want feedback about it. This project aims for a tailoring strategy that considers not only the content of the message but the tone and nudging elements.

CONTENT AND STYLE TAILORING

Kreuter, et al.[132] defined tailoring as the combination of strategies and information intended to reach one specific individual based on the personal characteristics derived from an individual assessment.

Medical information can be tailored in content and style. Changing the content of a message is dependent on the stage of a disease. Patients receive different information to support difficult decisions or prevent deterioration. In general, messages for people learning about a disease for the first time will have different content than the ones aiming at chronic patients.

Style tailoring refers to the adaptation of the same information for the different types of individuals. A simplistic example would be the phrase “An apple a day keeps the doctor away” working for prevention-oriented individuals while the advice “improve your health by eating fruits daily” works for promotion-oriented ones. While the content remains the same, the style aims to address personal beliefs and goals.

Personalization is defined as the ability to decide the characteristics and embodiment of products and services. These characteristics can be changed by the end- users, stakeholders or even by the product itself. Self-adaptation as a result of interaction or “Use-dependent adaptation”[133] can result in an adequate motivation by balancing challenging messages and support information but depends on a constant interaction with the product.

DESIGNING WITH DATA / DESIGNING FOR DATA

Data gathering systems use parameters to obtain and compare input. In the case of an adaptation based on interaction, the tailoring effect should maintain these receivers to have a comparison.

DATA GRANULARITY

Having a constant input of data that is contrasted with a second dimension such as mood or filtered by questionnaires filled by the user can provide deeper insights regarding the efficiency of the program.

By knowing more about the patient’s perspective, physicians can give a more tailored advice in a follow-up appointment, addressing specific concerns or drop out moments of the patient.

Having this added interaction with the CV-related data also enables a proactive behaviour inside and outside the consultation, increasing the control and self-efficacy of patients, as long as it is fitted to the specific concerns of the individual as previously discussed.

PROACTIVE BEHAVIOUR

PROACTIVE PRIMARY PREVENTION

One of the most complex goals of prevention is to proactively engage individuals into becoming self-conscious. In general, people know that they will age and are aware of the age-related constraints, but hardly see themselves as sick individuals when they are healthy. “We underestimate future changes in the present, although we are aware of how much we changed from our past selves.” [134]

DEVELOP

INSIGHTS & IDEATION

The developing phase started with a list of insights that summarized the previous stages:

INSIGHTS:

- Social pressure is a strong motivator for some people and is not always perceived by the user.

- Elevated risk is not a disease; therefore, there are no symptoms.

- At the moment CVD risk guidance depends on the physician.

- What is currently shared in the consultation depends on the communication skills of patients and doctors.

- Behavioural changes should be gradually implemented.

- People need different levels of information and control.

- Excitement and interest fade over time (Hedonic adaptation).

- A service app constrained in a mobile phone might be easy to avoid for individuals with a high locus of control.

- Risk factors and prevention programs change among individuals.

- People can enjoy “negative” emotions as long as they are secure.

- Perception of health-related terms and graphics can be stressful.

- A constant reminder becomes predictable and boring. This can decrease the sense of importance towards a situation.

- External devices are perceived as more “professional” than mobile apps and make them harder to avoid.

- Multiple individuals react differently to the same trigger based on their personality.

- It is hard to pro-actively think about our future situation as a patient when we are healthy.

- There is a time limitation during consultations at the general practitioner’s office even when there are assistants and nurses.

- Citizens are obliged by law to be registered with a family physician that works as a gatekeeper of the healthcare system. The aim of this gatekeeping ihas to do with efficiency by avoiding unnecessary specialist treatment[135], while the aim of patient registration is to enhance continuity of care.

These perspectives are added to the developing phase, considering the interest of both parties. Government and health-related institutions are part of this phase as well for feasibility.

HOW TO SPOT DEPRESSION AND STRESS?

As many comorbidities, it is difficult to determine a patient's depression from a single reading. Contrary to popular belief, depression is not translated uniquely into sad emotions. It has to do with lack of interest and can affect people's abilities and performance at work or home. To spot depression in a single consultation is especially difficult if there is no long relation between physician and user. While triggers for sadness can be spotted and described by the user, depression is hard to explain and needs a professional assessment.

Users can self-assess through psychiatric measuring instruments[136, 137, 138, 139, 140] that can be integrated into a digital system. Suggested open-ended questions to screen psychosocial risk factors are[141]:

1) How would you describe your energy level?

2) How have you been sleeping?

3) How was your mood been recently?

4) What kind of pressure have you been under at work or at home?

5) What do you do to unwind after work or at the end of the day and do you have difficulty unwinding?

6) Who do you turn to for support?

7) Are there any personal issues that we have not covered that you would like to share with me?

8) Have you felt so sad, discouraged, or hopeless that you wondered if anything was worthwhile?

By tracking the amount of activity of individuals, the platform can determine when to deliver these questionnaires and possibly discard false positives by filtering with randomized confirmations; users could determine if the lack of improvement is related to intrinsic or extrinsic factors.

CONCEPTUALIZATION

Considering the different factors involved in self-care, several ideas and directions were explored, focusing on the user interactions with their treatment. Two main directions were explored:

Individual Traits - Communication skills, health literacy and personal preferences.

Since personal characteristics such as communication skills, literacy preferences affect the adherence, the developed concepts consider an open-ended approach where the interfaces adapt to these characteristics.

Emotional Response – Different reaction to similar triggers among individuals.

The effect of triggers in cognitive decisions is very important in a longitudinal approach. The lack of symptoms makes it difficult to adhere to a medical program. The data given to the user should not only be understood by different literacy levels but enhance interaction and motivate actions towards well-being.

These factors were combined into 3 concepts:

CONCEPT 1: COMMUNICATION PLATFORM

Digital tool for co-planning treatments, give prognosis and set future actions.

Using a communication app, people can be guided during the first screening and diagnosis consultation. The app provides information on exercises and treatment plans that the user can select depending on personal preferences and needs. By selecting and discussing actions the user will perceive more control over the treatment, commit at the beginning of it and plan lifestyle adjustments gradually.

CONCEPT 2: STORY-DRIVEN SYSTEM

Cross-platform motivation (game).

The concept uses a pay-to-win model but instead of making a money transaction the platform asks to manage and check risk factors. Through different actions, the user will be able to explore characteristics of the game such as levels and hidden plots.

Although anybody could use the app, checking biomarkers and exercising users can get to higher levels more quickly and enhance the experience. Triggers in the app would be both intrinsic and extrinsic. The story must convey interest through interaction and different plot directions.

CONCEPT 3: RISK FACTORS ANALOGY

Extension of the initial negative trigger

A visual analogy of a heart disease. The user starts from an idea of “cleaning” rather than “avoiding” a condition. People are motivated to act when they are screened and are told that they are at risk, but over time and since there are no symptoms or sickness (reminders) the motivation fades out.

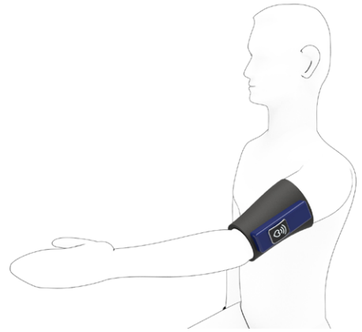
This concept aims to an abstraction and visualization of the patient’s heart while keeping control over it. There would be a screening app, this element focuses on the initial interaction.

The concepts were evaluated based on the possible effect on the prevention program, the implementation needs, possible benefits and pitfalls. A fourth iteration was developed, merging the possitive features of the first ideas.

A fifth iteration was developed considering the analysis of the four concepts, and integrating it in the longitudinal care starting from the labelling consultation.

This new iteration integrated a reward system and an easy to find measuring device in public locations while the other made the readings at home.

These concepts were presented to the public to get feedback. In general, people were in favour of receiving a device and use a reward system, but wouldn’t be enough to perform readings in public or at home. Even if it is for prevention, these devices are perceived as products for the unhealthy and monitoring devices are linked to ill individuals unless they are meant for exercise, such as wearable devices.



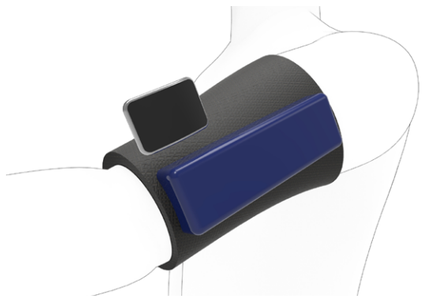
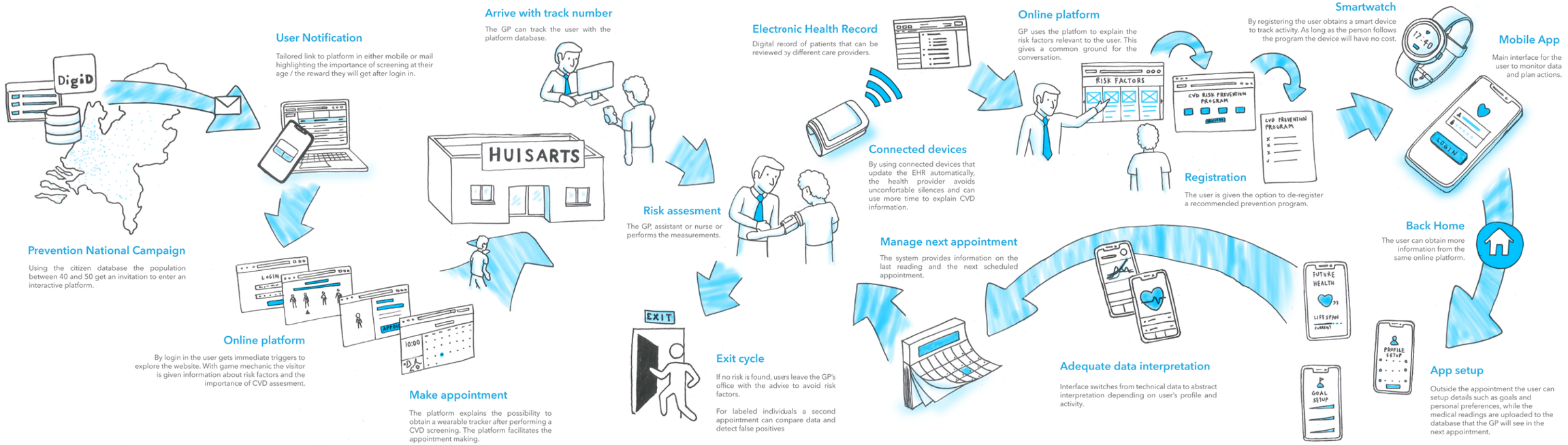


Figure 34 Final user journey with integration of government databases and prevention campaign.



REFINEMENT

It was decided to merge elements of the different concepts into one single service, adapting it to the current scenario and healthcare journey.

A final storyboard shows the desired interaction flow and consideration for the involvement of multiple stakeholders in different stages. Because of the time frame of the project, the focus remained on the mobile app and wearable technology, under the assumption that developments in technology will increase accuracy. The integration of other stakeholders and campaigns is part of the recommendations of this project. The final concept is analyzed in a 360° lens for future implementation:

IS IT DESIRABLE?

It is clear that the integration of a self-management tool aiming to self-manage non-communicable diseases is desirable for the different stakeholders involved with the CVD prevention program. It would provide caregivers with more complete information of the user and insights to give advice on following appointments. By monitoring the health and activity of individuals, false positives can be discarded and comorbidities like depression can be detected.

The main goal of the intervention is to motivate people to follow their program while making CVD risk understandable to increase adherence. Different intrinsic drivers affect the choices and motivation of users. The concept considers these changes and adapts to it.

IS IT VIABLE?

From an economic perspective, filtering and detecting a wider population section would translate into less acute events and chronic patients in the future. The current limitations are the limited resources from the health system such as time and professionals in the GP frontline. This project takes into account the need to facilitate log information and connecting this log to a database without increasing costs. That is why it is connected to the current infrastructure and health flows of the Dutch healthcare system.

IS IT FEASIBLE?

Since the accuracy of ambulatory devices is expected to improve in the following years, it was decided to focus on the interactive application rather than on a wearable device. An ambulatory sensor is still part of the overall concept since it is needed to track the activity and measure specific CV-related data.

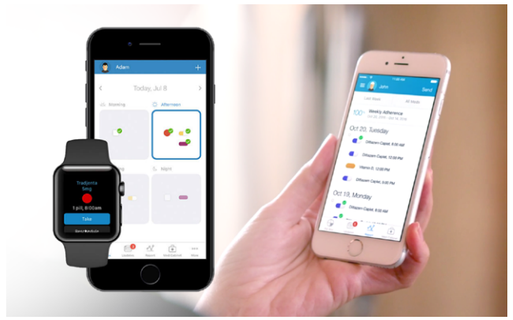
Other factors of the project such as a digital identification number or an electronic record database are already implemented or will be in following years. The main design is a digital app that tracks the activity of the user and adapts based on interaction.

BENCHMARK – MOBILE APPS

A market study was performed to see the possibilities of a mobile app in the management of risk factors and behavioural change. Special attention was put to e-health apps. No personal application was found with characteristics similar to the current design direction in the market.

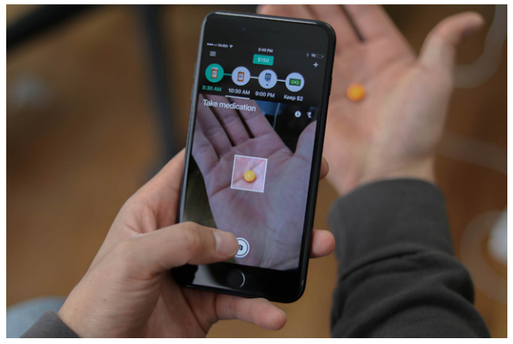
Medisafe[142]

A mobile application that tracks medication intake. It integrates the actions to the patient's medical report; this can be shared with the physicians, caregivers and family members. It syncs with other health apps and devices to track and give feedback on temperature, heart rate, weight, pulse, etc. It also integrates options to update family members and receive discounts for medications.



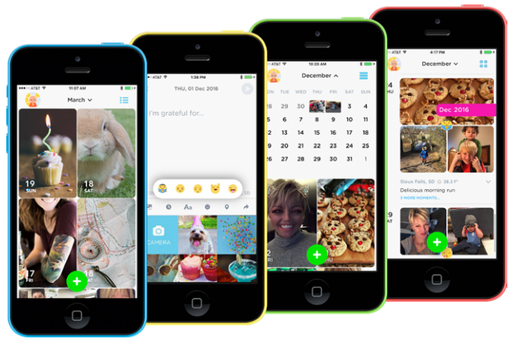
Wellth[143]

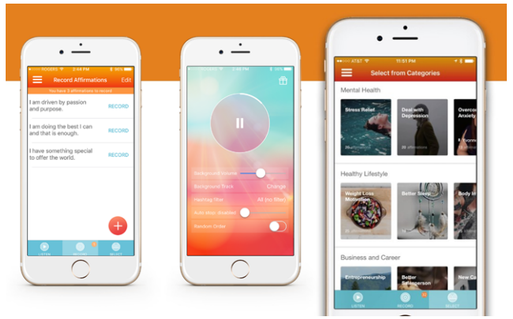
A behavioural economics-based app that gives user financial incentives for medication intake to avoid re-admissions to the hospital for patients with CVD's, diabetes, COPD or asthma. Users get an initial credit and their balance is reduced if they don't perform the stages of self-management related to their treatment. Users get reminders to use a connected device to weight themselves and take pictures of their medication before taking it. If they adhere to the program for 90 days they obtain 150 dollars.

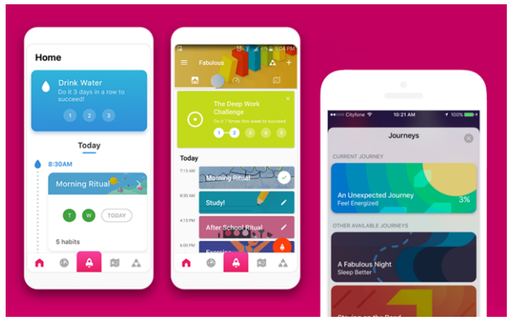


Gratitude App[144]

A journal-type app that gives users the possibility to write a positive reflection daily. Users can and add pictures to each entry. A monthly overview shows all of the moments together. The idea behind is to encourage people to come up with positive reflections and maintain emotional strength. Announced updates include social interactions and the possibility to export diaries outside the app.







ThinkUp App[145]

Enables a positive mindset by recording the user own voice reading affirmations related to topics such as health, success, happiness, etc.

Once recorded, the affirmations are played over a musical background when the user chooses to. The affirmations can be changed daily and the database is increasing constantly.

The fabulous App[146]

Motivation app based on behavioural economics to change and adopt new habits. Users select their "journey" (4-week program) from a possibility of goals such as reduce weight, sleep better or feel more energized. The set up of the goals use behavioural economic principles such as anchoring to reduce the perception of barriers and increase the effect of benefits and rewards.

It was observed that medical-based apps focus on specific illnesses or actions while motivational apps include more general goals. Considering that CVD's are multi-factorial and comorbidities influence in the development of them, it is desirable to integrate different measurements, sensors and guidelines in a single platform to better track performance and the possible appearance of comorbidities, but also consider that providing this information to users might negatively affect their performance.

This presents a different set of requirements when planning an intervention in prevention stages. It is desirable to give autonomy and control to the user over the prevention program, but this should not affect adherence by making the conditions less critical. The product should integrate intrinsic motivators so the users act depending on their individual qualities and preferences. This considerations were part of the testing phase for the concept direction.

CONCEPT DIRECTION TESTING

RESEARCH QUESTIONS:

- Which features enhance self-management of a CVD prevention program in a digital app?

- Do personality traits affect interaction with the features of a self-management digital system? Which tailoring strategy (personalization or self-adaptation) results in greater self-predicted adherence?

Figure 35 Concept features of a digital app focusing on the 4 different types of user:
A. - Guardian **B.**- Trainer **C.**- Advisor **D.**- Oracle

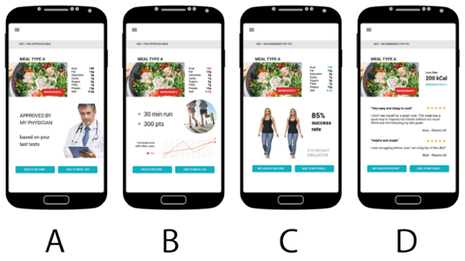
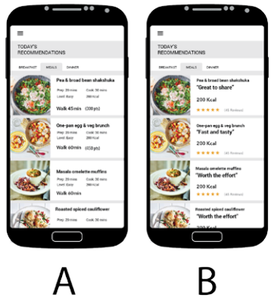


Figure 36 Similar screens with different content, focusing on control (user or system).



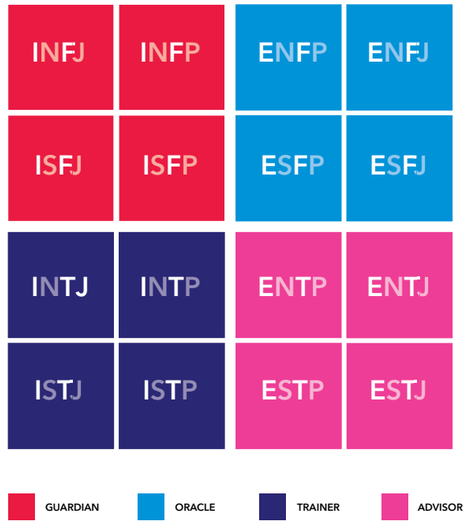
ONLINE QUESTIONNAIRE

Individuals were asked to perform a self-assessment on personality and indicate their preferences over a digital application. The personality test was mainly to determine if there was a relation between the values of extroversion/ introversion paired with the preferences for a behaviour change program.

After completing the self-assessment[147] participants were presented with different strategies to adopt a habit. A set of questions presented different tools of a possible app to adopt a healthy diet. The first set (Figure 35) presented unique strategies like a future body simulator, a “doctor approved” meal, and dishes recommended by similar users and a calorie reward system.

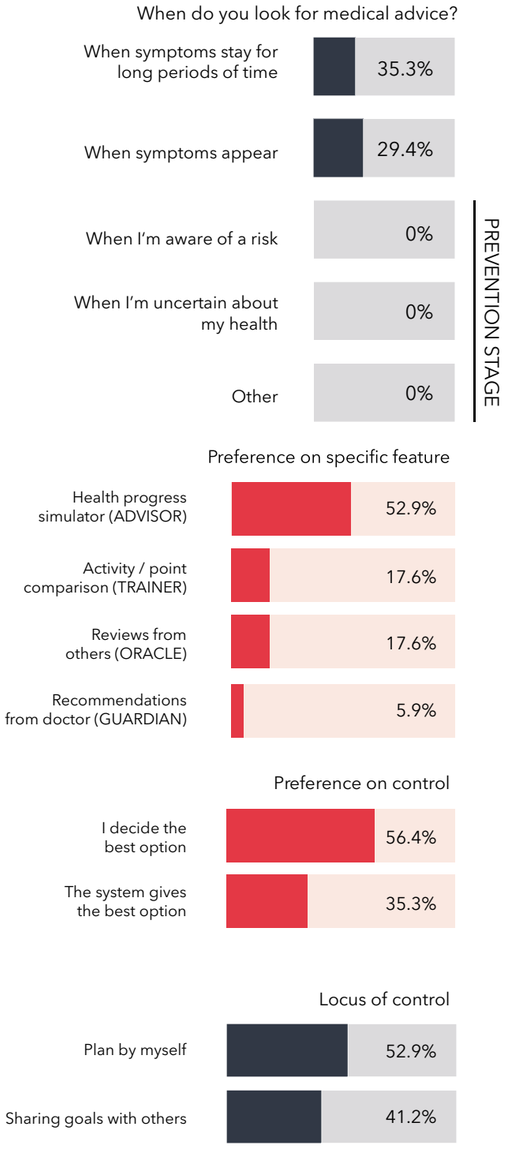
The second set (Figure 36) presented a combination of strategies highlighting intrinsic and extrinsic factors. In a first screen, individuals were given more information on the calories consumed, translating it to an amount of exercise needed to burn them. On the other screen, less challenging information was given and a supportive quote from a peer was given priority.

Figure 37 Comparison of Myers Briggs model with the one genereted in this project, highliting similar axis (Locus of control and cognitive response).



No strong relation was found between the personality type given with the Myers-Briggs scale and the preference for a specific strategy when comparing the results with the typology model of this project (Figure 37). Some individuals with an extrovert result preferred individual challenging strategies. On the other hand, people in the introversion area could be open to share their goals with others. All features were selected at least once control preferences were balanced among the 17 participants.

Figure 38 Results from online questionnaire.



TEST SETUP

In the current direction, the digital system helps the physician in the moment of delivering assessment results by providing information on modifiable risk behaviours. Also, the initial shock of risk labelling is used as a trigger for the adaptation of the application. Because of this, the test included contextual elements outside the digital interface to emulate a risk labelling appointment and initial guidance (Figure 39).

3 participants below 30 years old were invited to a role-played test. They were informed about the objective of the test and clearly informed that no information or measurement form the test had clinical validity and that the test was mainly to see which elements of the system would have a better chance of changing or adopting new behaviours.

Figure 39 Blood pressure reading during the role-play tests

APP MOCK-UP

A first interface was created using a sprint method to spot critical points of usage and information given. A prototype was built by wire-framing the complete app, following the user flow and spotting the critical touch points. The prototype integrated the main points of interaction that the platform should cover including risk management, notifications and instructions from the caregiver. Although it was a rough prototype with no animation and some non-active buttons, it gave the information needed to simulate a prevention program (Figure 40).

Individuals were invited to participate in a role-playing session. A GP consultation was simulated including measuring devices and risk assessment information pamphlets. None of the participants was in the parameters of the SCORE assessment (40 years old) as a way to ensure that no misguidance was given. They were also informed about the purpose of the test, the limitations of the information given and explained that any information that was given was not to be considered as medical advice and is not intended to replace a consultation with a qualified medical professional.

TEST RESULTS

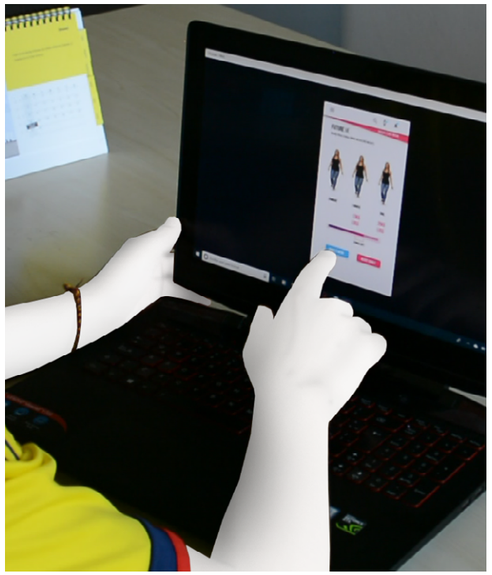
In prevention stages, individuals seek advice when there is a level of uncertainty. People usually overvalue their own knowledge to determine what is healthy and what affects their body. Some people place their knowledge above the physician's and want more control over the medical intervention. This was expected when defining personality types, however, certain characteristics had less impact than expected, such as physician recommendation.

In general, people have previous experience related to the adoption of new behaviours or avoidance of unhealthy ones. However, they expressed failure in some of these experiences, making it uncomfortable to talk about it for some. A defining outcome was that individuals can be categorized in certain personality types but when confronted with health-related topics the typology is not always precise. Individuals in the external locus of control area can prefer individual strategies and strongly individualistic people can prefer group activities as a way to adhere to a goal. In the role-play interviews, one of the participants was certain that integrating his children in activities would motivate him to do exercise, but he wanted to maintain control over how and when to do it.

A participant that already used an app to track exercise expressed that he would find it hard to use two apps. He would use the new system if he could integrate his history and achievements.

From the tested mock-up the physician representation was the least popular choice when assigning interface elements. People expressed that they don't want to be monitored or observed constantly. They would like to have the possibility to ask or reach health providers but only if they needed it. From the 17 responses of the online questionnaire, only one preferred the physician's approval as an active way to take a decision on a diet. The most popular feature was the simulator to see the effect of calorie-consumption on your body. Both social challenges and recommendations were the second preference.

Figure 40 Test with interactive prototype with different health-related screens and features.



TEST CONCLUSIONS

It is hard to determine which elements would have the most impact for all individuals since they expressed different desires and lifestyles. Adding to this, everybody has a different prognosis, risk behaviours and context. Nevertheless, they were interested in registering for a program to reduce their risk since the information was recent and shocking. Currently, this is dependent on the communication abilities of the physician and can be beneficial to have a tool to highlight the importance of registering into the prevention program.

Participants preferred different strategies to change their behaviour: social triggers such as family support or responsibility with others worked for some, while the idea of avoiding an unhealthy future predicted more adherence for others. People also expressed interest in the wearable device and saw it as a positive nudging element.

FINAL DESIGN

LIST OF REQUIREMENTS:

1. Provide tailored information about CVD considering psychological traits and literacy.

2. Engage the user to actively manage their risk factors and maintain positive numbers towards a follow-up appointment.

3. Connect with the health network through the digital health record.

4. Multi-factorial tracking in a single application.

5. Maintain treatment adherence through different motivation strategies.

6. Give an immediate feedback on actions perform by the user and allow connectivity with devices that are part of the prevention program such as scales, blood pressure monitors or cholesterol.

7. Actively adapt to the input of the user and give an adequate guidance depending on the interaction.

8. Enable connectivity with other smart devices to enhance risk management.

THE PREVENTION PROGRAM CYCLE

The final system is meant to be used in 3 main stages of the prevention program cycle:

1.- CONSULTATIONS (GP'S OFFICE)

The system works as a tool during the risk assessment and follow-up appointments. In this stage, it synchronizes the ambulatory device (wearable) and application with the physician database. The care provider starts the cycle by entering information of the patient such as height, weight, cholesterol ratio and blood pressure. The system then determines the risk value using the SCORE charts. The physician can override the labelling if needed. Other notes can be added such as family history, comorbidities and recommendations for the prevention plan.

The system will provide information about risk factors that currently affect or are potential dangers for individuals. This data will be shown visually on an online platform that can be accessed during and after the consultation (Figure 41). This way, individuals can check the information after they leave the GP's office since there is a short period of time to provide in-depth information. In case they decide not to register during the initial risk detection, the information platform can provide a further motivation to enrol.

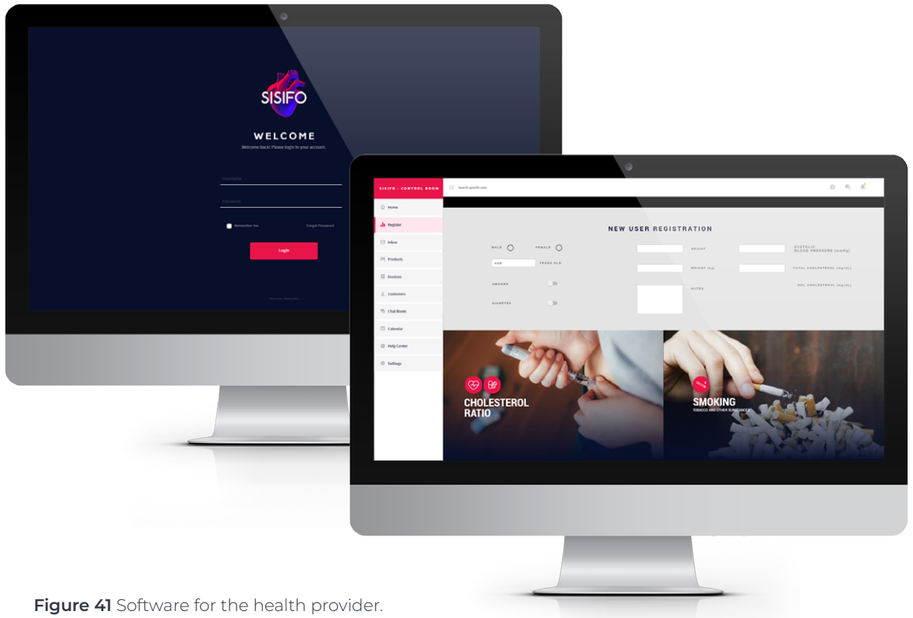


Figure 41 Software for the health provider. Information on relevant risks is shown to help with prognosis explanation.

2.- SETTING UP THE PREVENTION PROGRAM

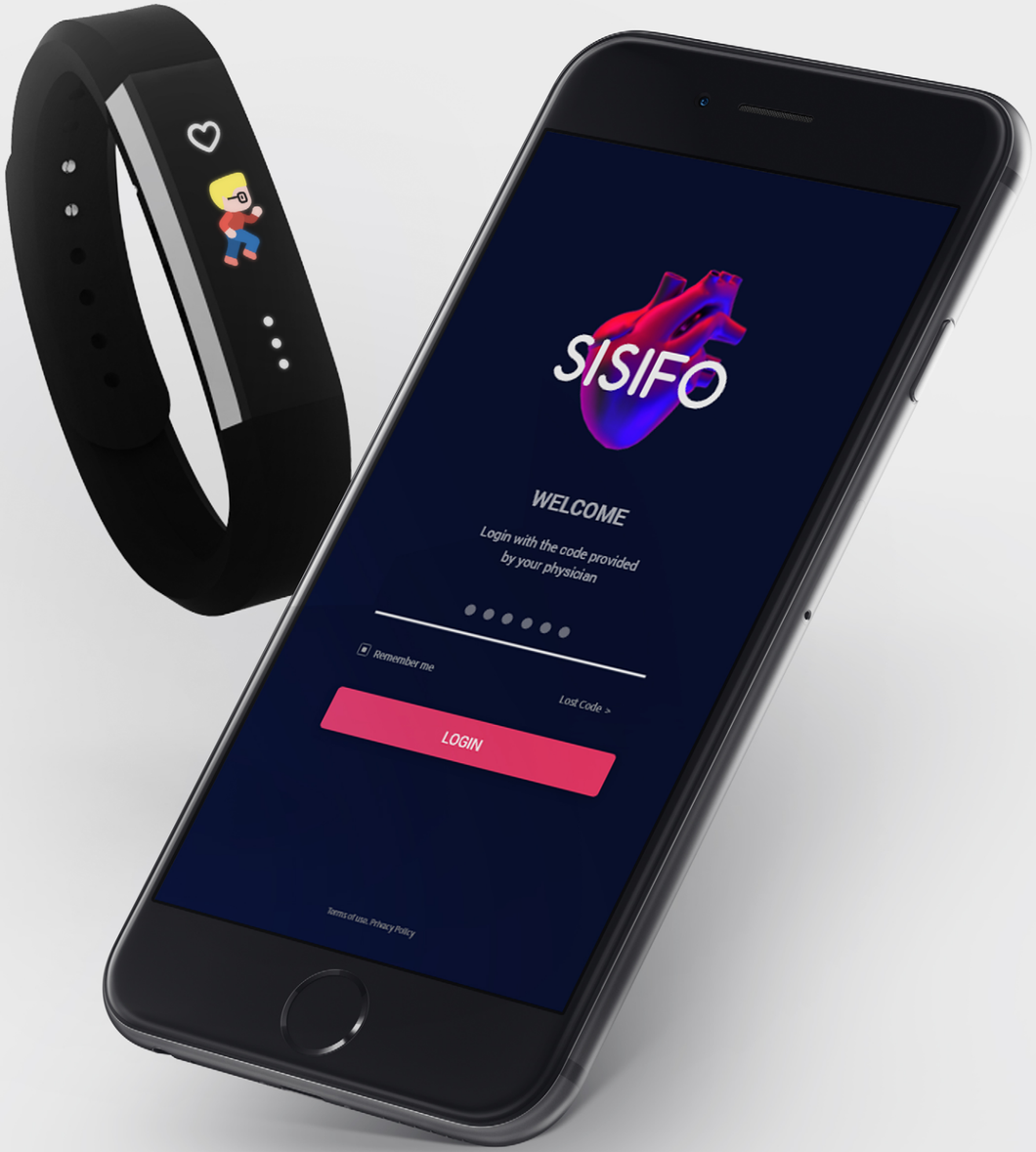
Although the objective of reducing CV event risk is clear, the steps and strategies to achieve this depend heavily on the patient motivation, understanding and adherence. Therefore, at the beginning of the program, the application has a setup stage that the user can fill out to determine preferences and nudging elements (user-dependent adaptation).

By setting personal preferences and previous experiences, the system can start determining which elements should be prioritized and the general tone of the system, shifting from supportive to challenging. This stage addresses each modifiable risk individually since people have their own set and experiences in changing behaviour. By setting this data at an initial stage, the system takes advantage of the initial motivation resulted from the labelling appointment.

3.- MAINTENANCE AND ADAPTATION

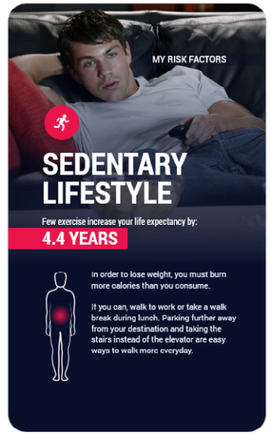
It is highly possible that in a long period of time the motivation and initial shock decreases. Also, individuals can shift from preferences after trying them and other priorities might seem more important in certain moments. In addition, depression and stress can decrease adherence to the program overall. Because of this, the application consists of different sections that change depending on the user's constant interaction (self-adaptation). The differences are based on the previous 4 quadrant matrix that defined the user typology. The system can send reminders with paternalistic or challenging tones depending on the type of user (Figure 42).

Figure 42 Risk factor reminder with life expectancy message.



VISUAL ELEMENTS

Apart from the interaction sequence, having a suitable graphic style for different types of users had a high level of importance. The system needed a balance between supportive and challenging outputs, as well as institutionalized and friendly approach. A high-contrast palette is used to improve readability, switching clear and dark backgrounds. A dark blue tone is used in the background of nudging elements such as risk information and a profile overview. In the management dashboard, the background is lighter. In both cases, the highlights are in red and pink hues to contrast the blue colours. The goal is to give a non-clinical perception without reducing seriousness.



USER INTERFACE DESIGN

FIRST SCREENS

Once the user downloads the application, he is asked to enter with a code provided by the physician. This ensures that only evaluated individuals use the system and that biological measurements are already in the system. The following screens ask for a self-assessment on behavioural change strategies and experience for each individual risk factor (Figure 43).

People are asked to include their preferences for recommendations and support network including family members, health professionals or third person references. The system does not need an active involvement of third parties, but this selection gives information on the personality type. By changing these preferences the system is able to suggest suitable goals that include, for example, activities with family members or ranked progress records with similar users. People can choose different parameters for every single risk factor (Figure 44) or skip the personalization phase and go directly to the next screen.

In the second personalization stage (Figure 45), the users change their personal avatar and write a personal commitment with the intention of motivating adherence in the future. This is based on the behavioural economic principles and answers from interviews and questionnaires. This text will be visible in the main dashboard (context-relate section) and can be set as wallpaper or lock screen.

This stage works as a pre-commitment phase and uses the initial motivation to increase the effect of reminders and increase adherence in further activities.

Figure 43 Initial self-assessment cards to determine personality type tendency.

Figure 44 Individual assessment for each risk factor that relates to the user.

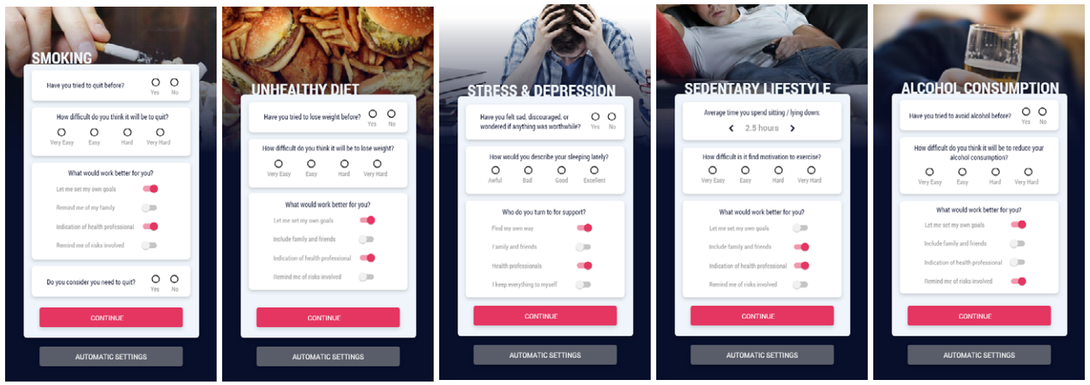
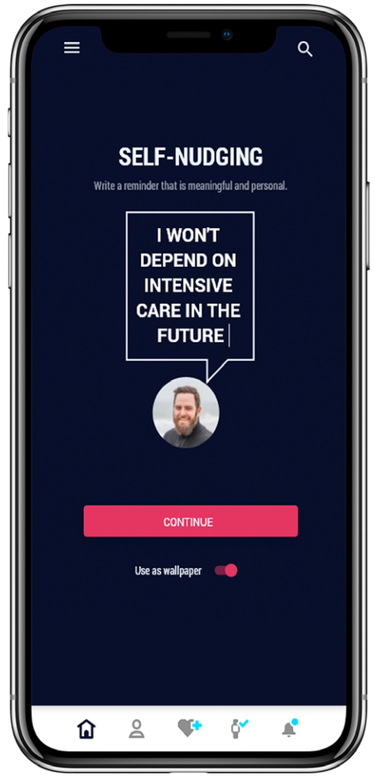
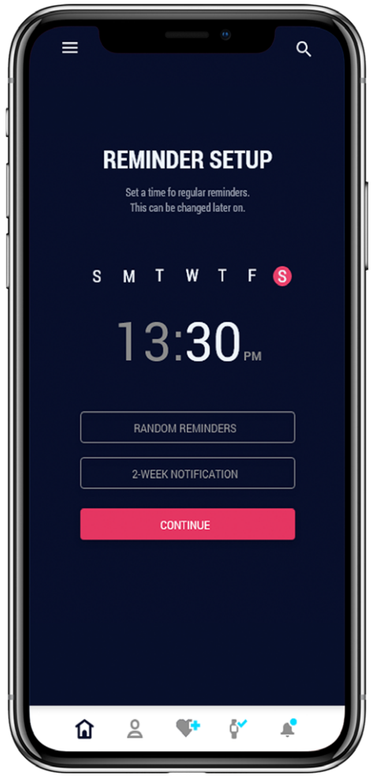


Figure 45 Personalization of nudging elements and reminders.





INTERACTION SEQUENCE (WIREFRAMING)

The major challenge of the digital system is to determine the best way to deliver information and guidance. Research showed that an increasing amount of information can be overwhelming and result in avoidance of the treatment, but having enough data to make decisions is important for certain type of individuals. Although it is an ambiguous limitation, it is important that people do not receive constant challenging feedback when they look for support or perceive a patronizing tone when they have a strong internal locus of control.

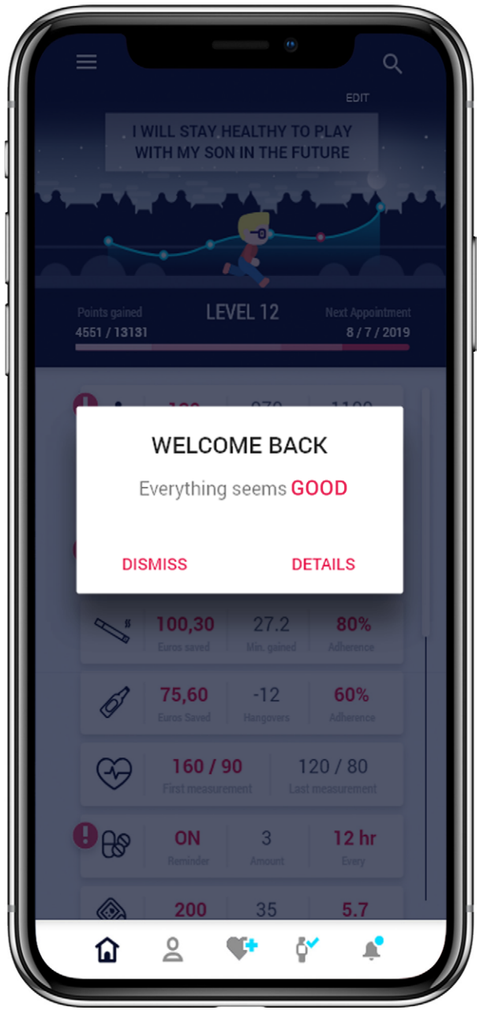
The solution is to adapt the complexity and tone of the information based on the number of interactions with specific areas; going from general to particular. The system, therefore, benefits from a constant activity input and data from the user to provide adequate information and make adjustments in a longitudinal usage.

MAIN DASHBOARD

In an initial state, the user receives a pop-up window after login in. In here, the text highlights the current state: normal when the user is adhering to the program and critical when immediate action is needed. Depending on further interaction this pop-up window can show more critical and direct information or abstract and supportive messages.

After this window is closed, the user arrives at the main dashboard overview. This screen is divided into two main sections, one for a detailed management of risk factor values and another one for a more abstract and narrative. Depending on the number of interactions with each part the system can adapt and provide different triggers and recommendations.

Figure 46 Welcoming message. The tone of the message will change depending on the user longitudinal input.



SECTIONS

CONTEXT RELATED SECTION

On the top of the dashboard screen, a personalized avatar and progress bar shows an animation meant to encourage action in a non-threatening tone using game-like indicators and interactive graphics including an animated avatar that emulates the user. By entering this section the user arrives at a screen with a set of progressive levels. Since we perceive our environments and events from a first-person perspective, the levels are named chapters as an analogy of one's own story and each chapter is "written" through actions and goals. Within each chapter, there are several activities and goals that the user needs to achieve to move to the next level and a short story-like text meant to give support and motivation.

HEALTH-RELATED SECTION

In the lower part, users receive general notifications and individual summaries of each applicable risk factor to enhance quick management. The system highlights numbers that should be modified and references to understand this data. The style is highly symbolic and meant to be easy to read for different literacy levels.

When a tab is selected, a drop-down screen shows more detailed information about the progress, graphics and recommendations. The user can interact with some of the subsections, registering information such as alcohol or tobacco consumption. If needed, these counting tabs can be added to the main dashboard for fast-access. At the end of this screen, a final button sends to another screen with information about the risk factor that affects the data section and information related to life-expectancy. By filtering the appearance of this information, the system ensures that it remains relevant and that the user does not get numb by death-related information.

Figure 47 Main dashboard.

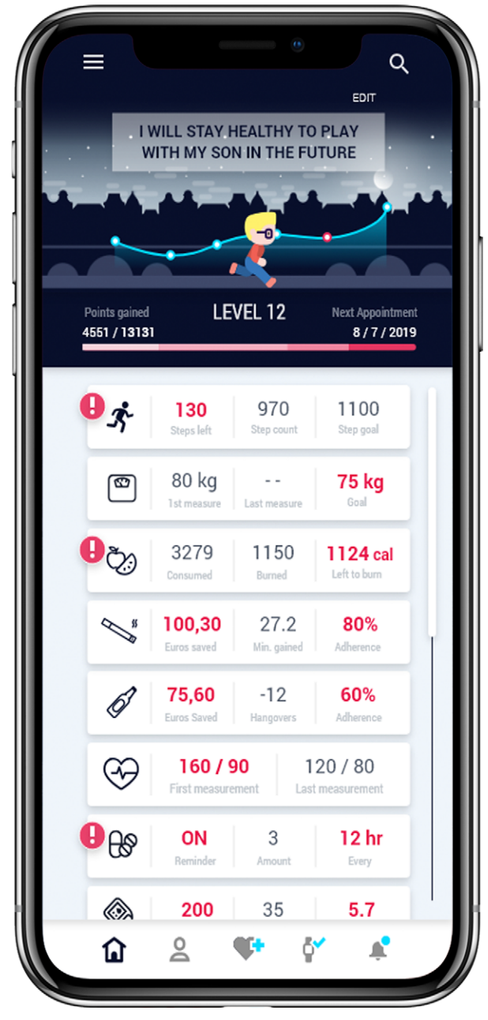
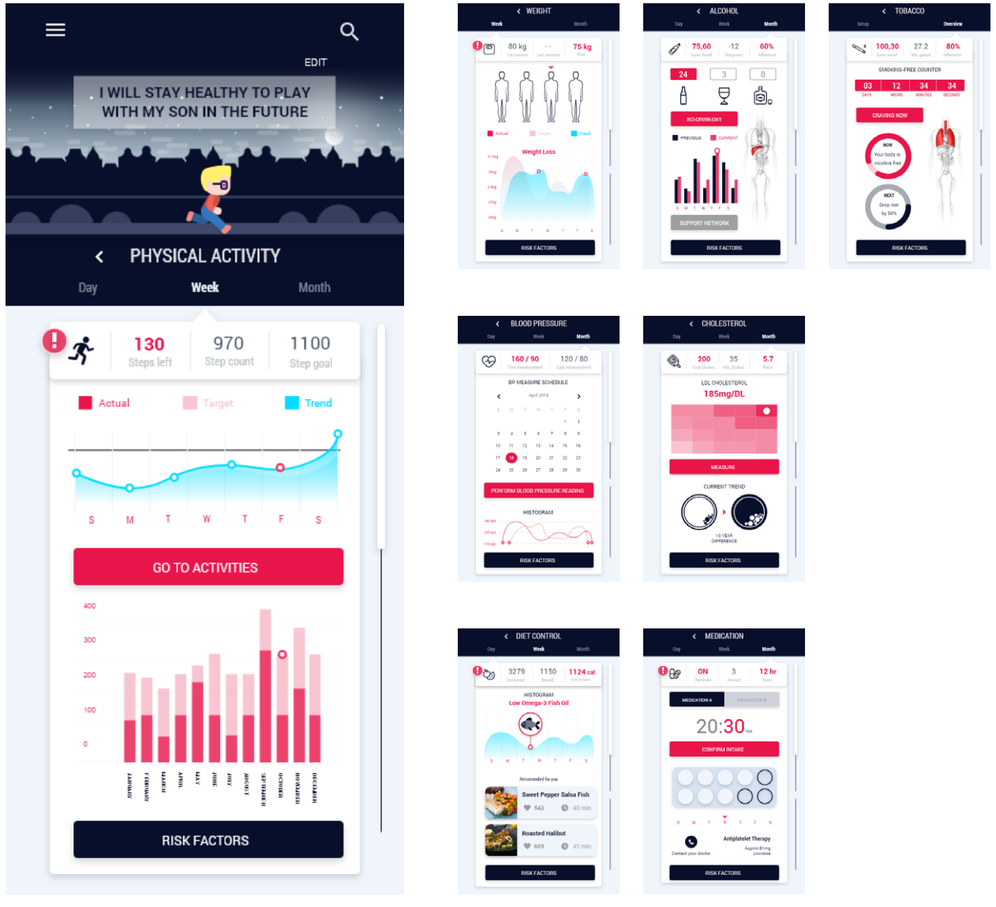


Figure 48 Context related section: Users manage their program with highlights on abstract progress and possible gains. The immediate link is to the “action sections”.

Figure 49 Health-related section. Users manage their program with highlights on medical information and possible consequences. The immediate link is to the “risk factor” section.



ACTIVITY MENU

Both context and health-related sections connect to a sub-menu to input physical activity. The user can select from different triggers to the same amount of activity. The categories are derived from the user typology, having individual and group activities with both controlled and open variables. All of the activities are based on the same system measurement; the different options are meant to determine the user typology. Once a type is selected the measurement works similarly to all options, counting activity amount and calories burned through the wearable.

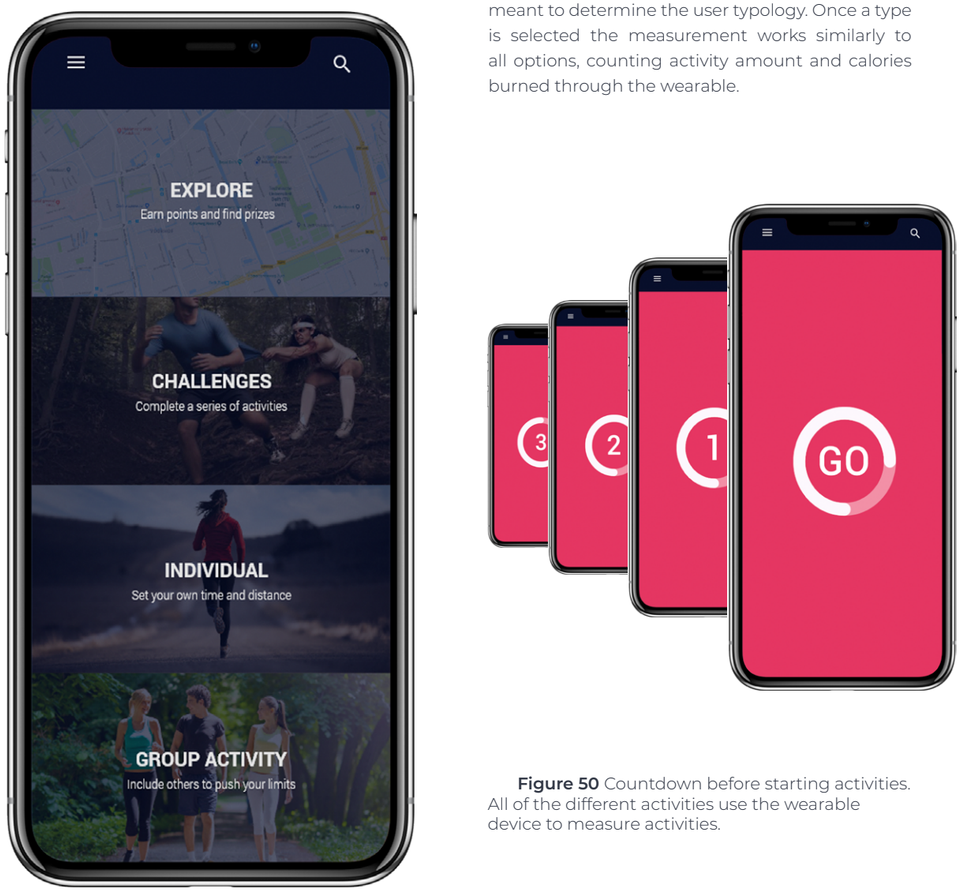
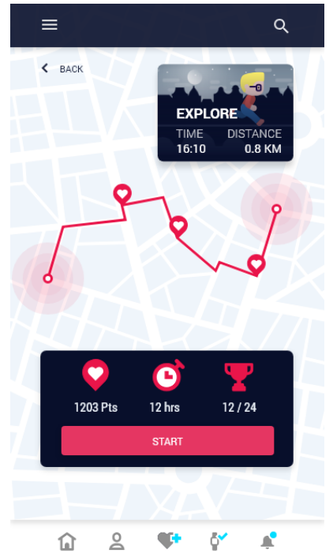
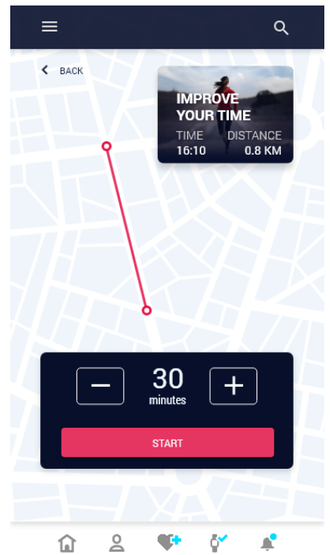


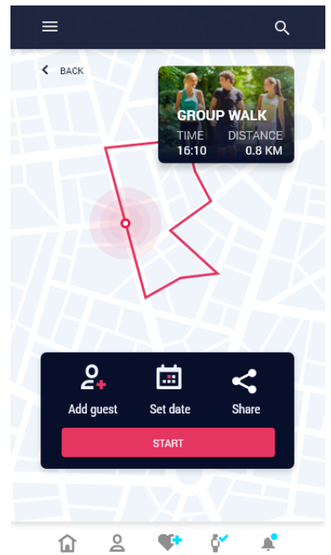
Figure 50 Countdown before starting activities. All of the different activities use the wearable device to measure activities.



In the *EXPLORE* option, the user can increase his or her personal activity motivated with a digital hunt using GPS location. In the *INDIVIDUAL* section, the users set time and distance and compete again themselves.

CHALLENGES provide different topics to try, such as virtual zombie runs where environmental sounds are used to motivate activity. The *GROUP* activities give the possibility to contact other people and set dates to exercise together.

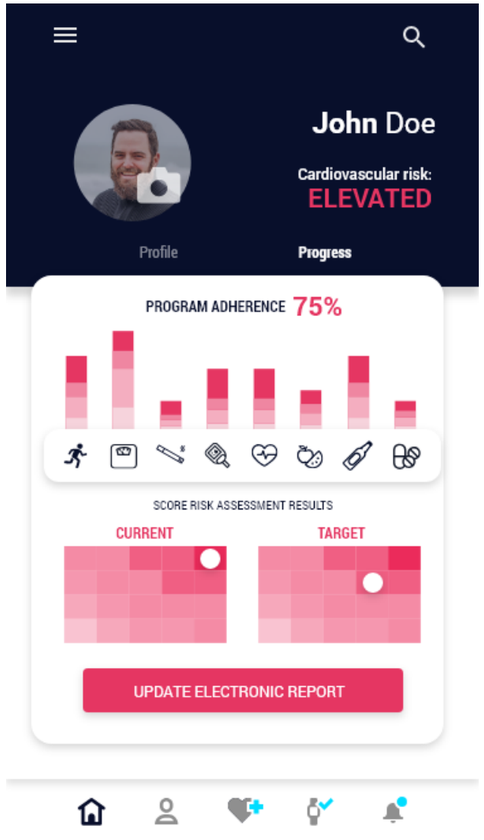


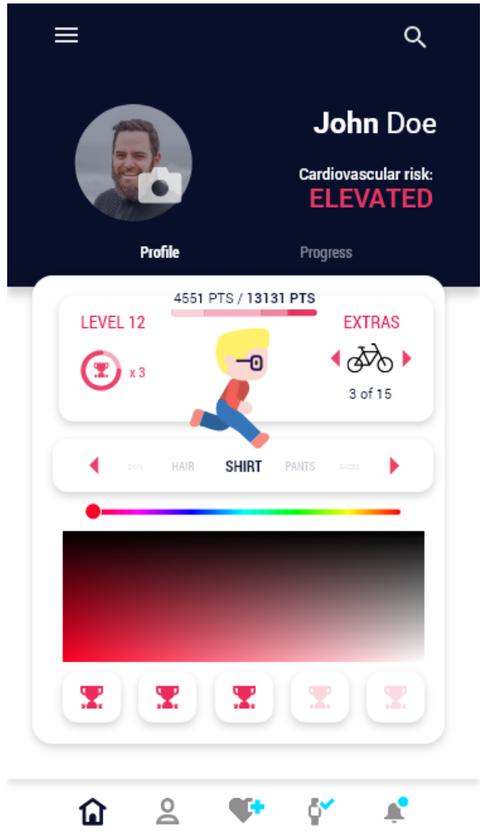


PROFILE

Similar to the dashboard page, the profile is divided into 2 sections. In the *PROFILE* the user can personalize the avatar, picture and elements in the context-related section.

In the *PROGRESS* section, the user gets a visual report of the program and an adherence percentage. In here the user can select to update his electronic record or send a report to the care professionals. If this is not done periodically the physician can send a notification or reminder.





LONGITUDINAL USE

PROGRAM MANAGEMENT

Daily activities, contextual factors and intrinsic motivators are expected to change in the time lapse between appointments of the prevention program. By having a responsive platform these changes can be addressed and the program can be adapted. In the first months, the system will learn from the interactions of the user and response to the input. It is expected that after several interactions the system reaches an adaptation “plateau” and detects major changes in mood or stress and determines the best time to show assessment questionnaires to detect comorbidities or intention. In any case, the user will input his preferences only at the beginning of the program and later one will only focus on managing his or her progress(Figure 51). For the user, only the system surface will be accessible, avoiding a saturation of data.

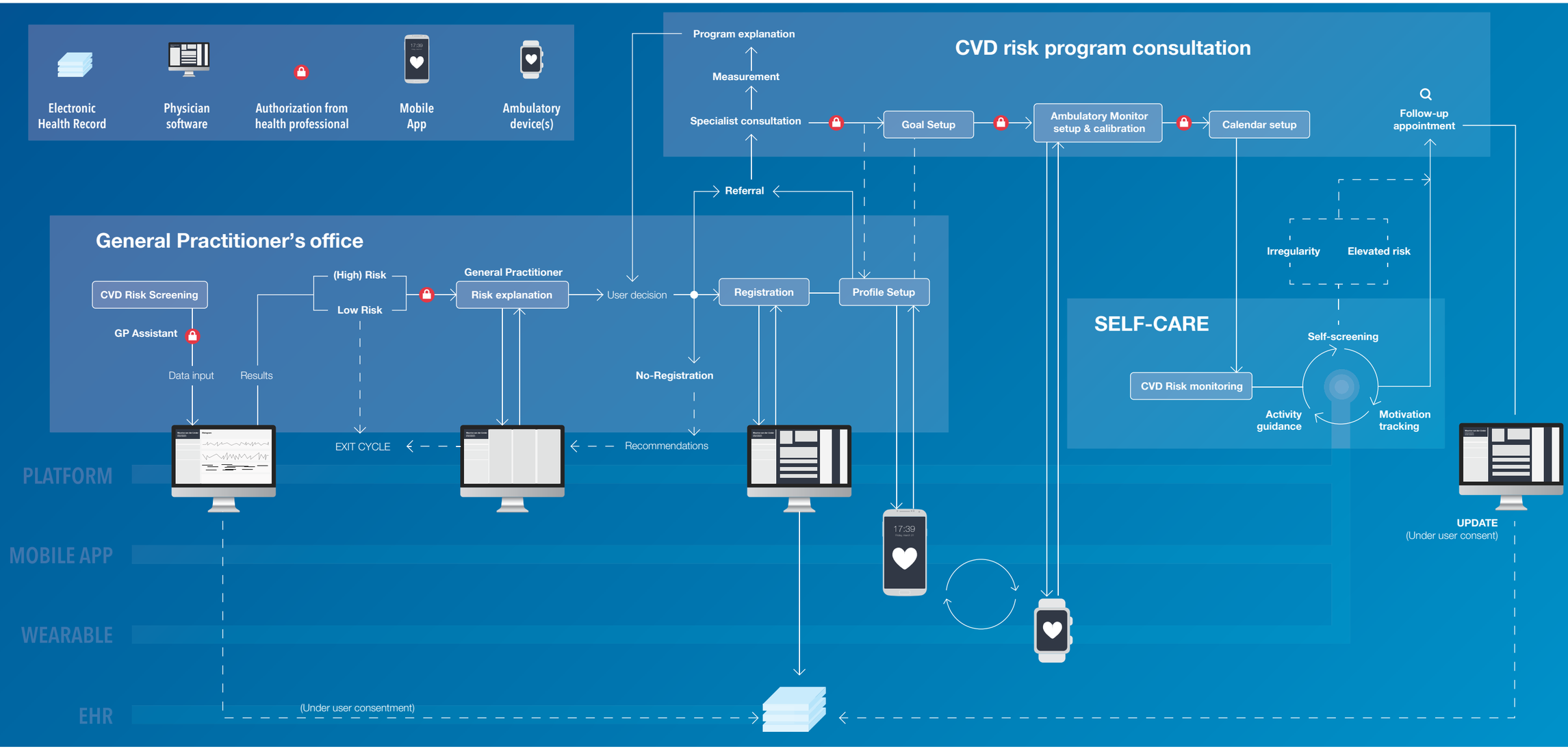
INCREASING ADHERENCE

The most important goal of the system is to increase adherence to the program and, as a consequence, reduce CVD risk overall. Since individuals have not been diagnosed with a CVD yet, there is the possibility to try different strategies. An incremented adherence level is accepted as a positive outcome of the system, even if it is not of a 100% since, currently, people can leave a program completely once they have a set-back.

CAREGIVER INVOLVEMENT

The final concept supports the actions that the user needs to follow in order to increase adherence without the health network being present. Nevertheless, it gives a possibility to reach the professional in charge of the prevention program when needed, but it is not the main feature since the system should not increase workloads for the health providers. As a final nudging element, the caregivers can send a notification and ask for an appointment when there is not enough input or behavioural change strategies fail.

Figure 51 Complete system interaction flow. While the user only interacts with the mobile application and wearable, the system gives information to the physician and updates the electronic health record of the user.



DESIGN OVERVIEW

KEY FEATURES

Personalization based on initial self-assessment

- Personal intention and intrinsic concerns are included in the system

Adaptive feedback based on user's activity

- Nudging strategies are based on interaction trends.

- Showing death-related data when adherence decreases.

Individual risk tracking

- The system tracks losses individually. This way a single set-back has fewer chances of ending in complete treatment abandonment.

- By tracking small signs of progress, the positive feelings can be extended to longer periods.

KEY BENEFITS

Support of different literacy levels.

- Individuals get familiar with health-related data gradually.

- The system can detect if the user has a high literacy level or needs more concrete information when a certain section is clicked more than others.

Scalability for other smart digital devices

- The system is planned to be synchronized with wearables and smart devices such as scales, blood monitors and pill containers.

- In case no smart technology is available, the system can still be used with just the wearable device to count steps and heart monitoring.

DETECTION OF COMORBIDITIES (DEPRESSION)

- By tracking adherence levels and comparing it with activity and responses in the application, the system can deliver validated self-assessment tests to evaluate if the individual suffers from depression or mental distress.

EVALUATE

CONCEPT EVALUATION

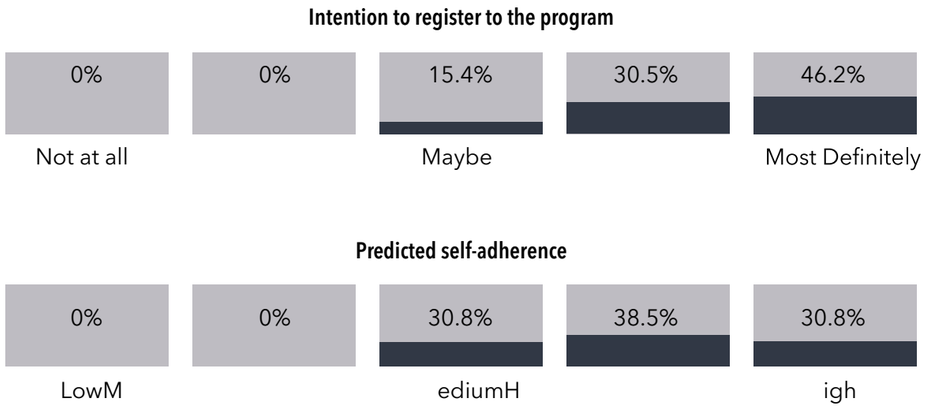
OBJECTIVE

A second user test was conducted to evaluate the effect of the changes made to the first concept. The mock-up prototype had more in-depth qualities and was planned to let participants explore different areas of the app without a script. The main objective was to understand how the users perceive these different areas and measure if all of them were needed and if they were understandable overall.

DESIGN BRIEF

HOW THE PROJECT ALIGNS WITH THE DESIGN BRIEF AND CONTEXT.

When the design direction was defined, there were certain aspects that were still not in the research plan, such as a detailed analysis of the interaction in the labelling consultation and a bigger scope of public institutions involved. Adding these factors to the conceptualization phase ensured a complex and feasible design.



ONLINE PROTOTYPE AND QUESTIONNAIRE

Using a cloud-based prototype and an online questionnaire, people were asked to rate the expected efficacy and adherence of the system after explaining the context. Similarly to previous tests, individuals were primed with a set of questions meant for self-reflection and to place themselves in the desired context. People were asked to picture themselves as being 40 years old and think about what would be their desired context regarding family, workplace and living place.

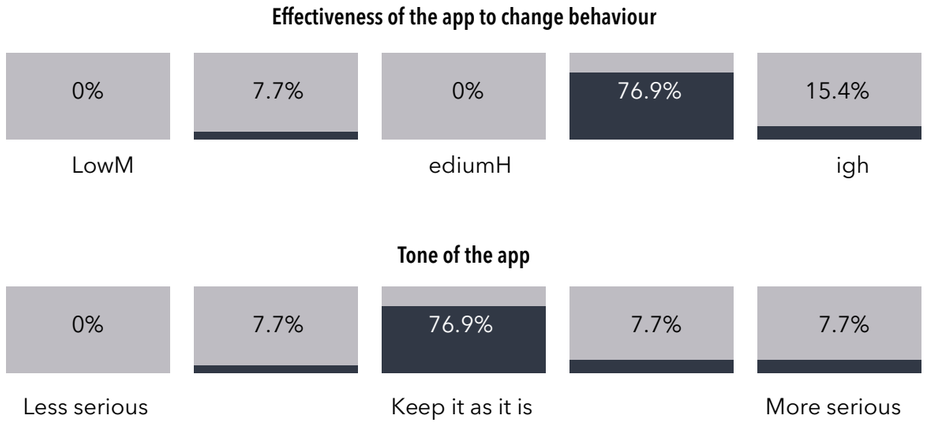
Later on, the prevention program strategy was explained to them, ending up in the invitation to participate in the program and receive the wearable tracking device. Their intention to participate was measured, resulted in a majority interested in the program but not with the same level of motivation.

The next step directed participants to the interactive application. In the first stage, they were given the individual assessment to then arrive at the main dashboard. Participants could interact with all of the displayed menus, making it possible to follow the planned flow until the more complex levels.

After interacting with the prototype participants were asked to measure their intention to use the application, how likely it would help them to change behaviours and if the general style of the app should be less or more serious. The results showed that most of the people preferred the current style, having a small tendency towards a more serious tone. About the efficiency and effect on risk behaviours, individuals were inclined towards a positive outcome, but 30% marked it as uncertain.

Finally, individuals were given a set of features and asked to specify which were more and least important for them. Of 6 given options, the possibility to adapt to personal interests and tracking progress were the highest rated, and having rewards was the least important. However, all of the options were pointed as the most important factor for at least one person, showing that there are very different preferences in strategies among individuals.

Figure 52 Results from digital survey with 15 participants.



"... an App is not enough for me to change my behavior, I need real-life pushers"

- Participant No. 4

In order to rely on the app, I'd definitely need a professional human opinion to ensure any diagnosis.

- Participant No. 9

"I see a scale connected in the app and I think it would be nice to have it like that. It could give me more motivation to use the app."

- Participant No. 13

LIMITATIONS OF FINAL EVALUATION

The concept iteration test was performed digitally only (Figure 52). This meant that micro-emotions were not included, and answers were limited to scales in specific areas such as intention to use and self-predicted effects. In addition, some of the users were expecting a more responsive application. Some of the elements were places with only a visual intention but a few users thought they were fully responsive and ended up giving a negative impression at the end. The introduction to the test also explained that the application would be tailored to their individual characteristics, but the mock-up included risks that might not apply to them, such as smoking or drinking.

DISCUSSION & RECOMMENDATIONS

DISCUSSION

Being CVD a global burden, several studies have worked with treatment adherence in different stages of the disease. The use of different strategies to increase adherence is not something new; digital reminders and electronic devices have been unsuccessful when trying to significantly increase adherence to a medical treatment after a CVD condition or other diseases[148, 149, 150].

Most of these studies focused on a single variant, such as wearable technology or physician messages. However, a study that integrated wireless pill bottles, lottery-based incentives, and social support did not significantly improve medication adherence either[151]. The authors discussed that the selection process of participants focused mainly on disease stage and demographic characteristics.

In their discussion researchers point out that the results could have been influenced by the moment individuals were reached and that results could have changed if participants would be given information immediately after their discharge.

PATIENT TYPOLOGY

Although the categorization of patient's personality was convenient to determine the interactions with a CVD condition, when used in a prevention scope, it seemed that the presence of a certain type was less constant than others. This might be the result of the lack of symptoms or illness.

The discussion of the validity of personality tests was considered but no clear definition was reached. Nevertheless, it was not the goal to determine a unique personality categorization, but more to become aware of the transitional aspects of personality and the complexity of behaviour and triggers in the medical context.

PROJECT LIMITATIONS

NO PATIENT CO-CREATION

Being risk labelling a single event, it was hard to reach individuals during the specific moment of risk labelling. The persons reached for interviews were already labelled or had a CV condition. The same applies to the online stories used for the creation of personas.

This meant that there were no vivid experiences but rather a narration of their personal stories. The behaviour analysis was focused on a wider spectrum of the target group. This aligned with the literature review and insights about the prevention paradox and the diversity of factors involved when going "upstream" in the CVD progression.

In the case of online questionnaires, availability was a key factor and no selection process was followed. Therefore participants may not represent the true population. This method was selected to have a broader perspective and bigger input in a fast-paced developing method, considering the scope of including a bigger population section.

A more empirical research with real patients could have given a richer psychological analysis with subtle emotions. However, this would have been more time consuming and, most likely, less representative for the broad target group. For ethical reasons, it was decided not to include people with a potential risk in co-creation sessions since this could have produced cognitive bias or affect their perception of medical indications. As a result of these variables, it is possible that the proposed solution does not meet all of the user needs when implemented in the real context.

LIMITATIONS OF AN APP BASED DESIGN

In the first stage of the research, it was observed that individuals tend to find it easy to avoid a digital application in their mobile phones. Giving full control of an app was not desirable, but it is expected that by making it available only for users that are labelled by a physician, the commitment and adherence increase.

It was planned to have similar triggers with different graphics for the types of users, however, research showed that individuals do not maintain the same typology over a long period of time. This is addressed by having different levels types of interactions but also means that the digital application would consume more resources of a device. It is expected that technological developments allow more complex software in the future, but currently, it is hard to determine if the performance of the application would be affected by limitations of the device.

AI AND MACHINE LEARNING

The system uses an A/B testing to determine the feature that fits the user better and that can give better longitudinal results. By iterating and refining this process the system can provide better outputs. Buzzwords such as machine learning and artificial intelligence are commonly used to give solutions to an untested area. This project considers that data from interaction input is quantifiable, can be categorized and fine-tuned based on the categorization to do a second A/B test. However, this would need to be tested further.

MEDICAL EXPERTS INVOLVED

Literature review helped to understand the state of the healthcare system and the input of three physicians gave a perspective on an individual level. However, these perspectives may not represent the overall healthcare view and knowledge. Literature validated the insights from the interviews, but other factors may be overlooked.

LONGITUDINAL TESTING

An important part of behavioural change is the adoption of new routines. To test if a behaviour has clearly changed, researchers need to conduct experiments for a longer period of time. In the case of CVD prevention programs, a follow-up appointment can be scheduled after one year if the risk is considered low. The timeframe of this project did not allow a longitudinal approach; however, other factors such as intensity of triggers and intrinsic motivators were studied to ensure feasibility and impact.

RECOMMENDATIONS

NEED OF A JOINT EFFORT

One observation during the research was that most people tend to reach physician advice only when they have a symptom. For a CV condition, this probably would mean that primary prevention is no longer an option. Public policies and strategies from the private sector are needed to call the attention of individuals at risk outside the health network.

The government, private industry, non-profit and patients need to work together to achieve a sustainable healthcare model. The focus of this project is on the interaction with a self-management platform; however, it is conceptualized as part of a bigger endeavour to deliver primary prevention assessments to a wider population.

A final storyboard shows a user journey from the general population sector to the prevention program follow-up. This concept benefits from the current infrastructure of the Netherlands: the national citizen database and the healthcare prevention flow but in order to realize it there is a need to include government and private stakeholders.

FULL HEALTHCARE SYSTEM CYCLE

Including performance information of a prevention program in the EHR of the users can help future condition treatment and recommendations outside primary stages of care. By knowing which strategies work for certain individuals might help care providers to deliver a meaningful message to patients and increase adherence to other medical treatments. To achieve this, a bigger scope would be needed, following a hierarchical flow to meet the requirements of hospitals, insurance, and caregivers.

ETHICAL CONSIDERATIONS

Incentives and strategies to change behaviour and increase adherence to a program take as granted that the prevention guidelines are designed with the wellbeing of individuals in mind. Medication prescription in primary prevention can raise questions about the real need for them and possible side-effects. This project follows established institutional recommendations, but medication intake should always provide information and give an opt-out option.

EXPANSION OF SCOPE

The healthcare system could benefit greatly from a self-management system that includes personal preferences and that is used in different health stages. This would need the involvement of more health professionals and institutions. This project was limited to the usability in primary prevention, but the principle of individuality and adaptability can benefit different care systems, having the wellbeing of the patients in mind.

CONCLUSIONS

INTEGRATION OF E-HEALTH TECHNOLOGIES IN EARLY PREVENTION STAGES

The current trend of including patients in their care give major possibilities for immediate feedback and increasing availability of data, but it doesn't come without critical elements. When receiving a bad prognosis, individuals react differently depending on intrinsic and extrinsic factors. In the current model, the health network is both a source of information and support. Human interactions play a major role in the communication of health-related information. When developing mHealth concepts there is a need to consider not only the medical information but the psychological implication of removing the care provider when giving information, positive or negative.

A big setback of addressing prevention programs is that individuals find it hard to adhere when there is no constant reminder or clear results. The lack of pain, symptoms or progression makes it hard to consciously think about a disease. Immediate triggers and priorities make the initial motivation and shock fade away. Constant reminders aim to balance this but need to be in line with the individual capabilities and desires. Terror-management strategies have not been successful in reducing modifiable risks since individuals manage unsettling implications very differently. Addressing these factors can have major benefits but the measuring system should both facilitate input and adapt its output, generating a cycle for constant interaction.

ADDING GRANULARITY TO PATIENT INFORMATION

The shift from health-related data to one controlled by the patient has the possibility to include individual perception to the readings in the EHR. By adding the patient typology to the data, the person in charge of the prevention program can deliver a more tailored care and advice during a follow-up consultation. Addressing the individual characteristics and adding more data means more complex databases and resources, but it is expected that by categorizing and measuring this data, a simplified and understandable report can be delivered to the health professional network.

NEED FOR LONGITUDINAL ANALYSIS

IN DESIGN FOR HEALTHCARE

Several products in healthcare are not adopted by desire but for need and can involve negative reminders while still asking for attention. This level of complexity needs to be considered in the design process since it affects stakeholders, interactions and wellbeing. The products, therefore, are not limited to an initial adoption. Products meant for a longitudinal use need to consider that individuals change over time. This, however, it's not impossible to plan and manage. Technological developments are making adaptability and transformation possible. This project aims for a planned adaptation instead of a response to implementation issues.

SELF-REFLECTION

This project started with a general view of cardiovascular diseases. The complexity of the problem required an extensive research both from literature and interviews with stakeholders. In the beginning, the topic was researched horizontally, covering different stages, stakeholders and technology. This added understanding and filtered concepts that were not suitable for all the involved parts, but also prolonged the literature research stage. The initial goal was to follow a user-centred research at early stages and start an iterative process. However, the research stage and literature uncovered topics that had to be understood before. The literature review was part of the whole project, even at final stages, to support every idea generated and assure the implementation and usability possibilities.

This project gave me the opportunity to assess what I learned from my studies and actively decide which methods and practices were more suitable to obtain insights and knowledge while making a balance of my own resources, capabilities and interests. When I started the project I developed a detailed planned with a time consideration for adjustments; however, the stacking complexity of the topic required constant adaptation. This was something that I did not consider at the beginning of the project.

Apart from these lessons, I acquired knowledge about management of complex topics and feasibility within the medical field. I am confident that designers have the capability of addressing highly technical and complex problems, but they need to be aware of their own limitations, capabilities and desired outcome.

REFERENCES

1 *CardioLab Lab - Delft Design Labs*. Retrieved February 13, 2018, from https://delftdesignlabs.org/cardiolab/)

2 Sanchis-Gomar, F., Perez-Quilis, C., Leischik, R., & Lucia, A. (2016). *Epidemiology of coronary heart disease and acute coronary syndrome*. Annals of Translational Medicine, 4(13), 256. http://doi.org/10.21037/atm.2016.06.33

3 *Cardiovascular diseases (CVDs) key factors*. Retrieved August 19, 2018, from http://www.who.int/mediacentre/factsheets/fs317/en/

4 Laslett, L., Alagona, P., Clark, B., Drozda, J., Saldivar, S., Wilson, S., Poe, C., Hart, M. (2012). *The Worldwide Environment of Cardiovascular Disease: Prevalence, Diagnosis, Therapy, and Policy Issues: A Report From the American College of Cardiology*. Journal of the American College of Cardiology, 60(25), S1-S49. https://doi.org/10.1016/j.jacc.2012.11.002)

5 Wilkins, E., Wilson, L., Wickramasinghe, K., Bhatnagar, P., Leal, J., Luengo-Fernandez, R., Burns, R., Rayner, M., Townsend, N. (2017). *European Cardiovascular Disease Statistics 2017*. European Heart Network, Brussels. Retrieved May 19, 2018, from http://www.ehnheart.org/images/CVD-statistics-report-August-2017.pdf

6 Institute for Health Metrics and evaluation (2016). *Global burden disease - Risks by cause overview*. Retrieved 19 May, 2018, from https://vizhub.healthdata.org/gbd-compare/

7 Institute for Health Metrics and evaluation (2016). *Global burden disease - Risks by modifiable risks*. Retrieved 19 May, 2018, from https://vizhub.healthdata.org/gbd-compare/

8 WHO. *The challenge of cardiovascular disease – quick statistics (2016)*. Retrieved 10 June, 2018, from http://www.euro.who.int/en/health-topics/noncommunicable-diseases/cardiovascular-diseases/data-and-statistics

9 Gillman, M,W. (2015) *Primordial Prevention of Cardiovascular Disease*. American Heart Association Journal. 131(7). doi.org/10.1161/CIRCULATIONAHA.115.014849

10 Gillman, M,W., Ludwig, D,S. (2013) *How early should obesity prevention start?*. The New England Journal of Medicine, 369, 2173-2175. doi: 10.1056/NEJMp1310577

11 Hanson, M,A., Gluckman, P,D. (2014). *Early developmental conditioning of later health and disease: physiology or pathophysiology?*. Physiological Reviews. 94:1027–1076. doi: 10.1152/physrev.00029.2013

12 WHO. *The challenge of cardiovascular disease – quick statistics (2016)*. Retrieved 10 June, 2018, from http://www.euro.who.int/en/health-topics/noncommunicable-diseases/cardiovascular-diseases/data-and-statistics

13 Rose, G. (2001). *Sick individuals and sick populations*. International Journal of Epidemiology. 30 (3), 427–432. doi.org/10.1093/ije/30.3.427

14 Allebeck, P (2008). *The prevention paradox or the inequality paradox?*. European Journal of Public Health. 18 (3) 215. https://doi.org/10.1093/eurpub/ckn048

15 Rose, G. (1981). *Strategy of prevention: lessons from cardiovascular disease*. British Medical Journal (Clinical Research Ed.). 282(6279), 1847–1851.)

16 WHO. World Health Report, Chapter 6 – *Choosing priority strategies for risk prevention*. Retrieved 10 May, 2018, from http://www.who.int/whr/2002/chapter6/en/index1.html

17 OECD/European Observatory on Health Systems and Policies (2017). *Netherlands: Country Health Profile 2017*. State of Health in the EU. OECD Publishing. Paris/European Observatory on Health Systems and Policies, Brussels. http://dx.doi.org/10.1787/9789264283503-en)

18 Mensah, G. A., Wei, G. S., Sorlie, P. D., Fine, L. J., Rosenberg, Y., Kaufmann, P. G., ... & Gordon, D. (2017). *Decline in cardiovascular mortality: possible causes and implications*. Circulation research, 120(2), 366-380. doi.org/10.1161/CIRCRESAHA.116.309115

19 *Institute for Health Metrics and Evaluation - Netherlands*. Retrieved February 20, 2018, from http://www.healthdata.org/netherlands.

20 OECD/European Observatory on Health Systems and Policies (2017). *Netherlands: Country Health Profile 2017*. State of Health in the EU. OECD Publishing. Paris/European Observatory on Health Systems and Policies, Brussels. http://dx.doi.org/10.1787/9789264283503-en

21 National Institute for Public Health and the Environment. Ministry of Health, Welfare and Sport. *Trends in de volksgezondheid*. Retrieved February 15, 2018, from http://www.eengezondernederland.nl/Een_gezonder_Nederland/Highlights/Trends_in_de_volksgezondheid

22 National Institute for Public Health and the Environment. Ministry of Health, Welfare and Sport (2016). *RIVM forecasting study: a healthier Netherlands with more people living with a chronic disease*. Retrieved 15 February, 2018, from https://www.rivm.nl/en/Documents_and_publications/Common_and_Present/Newsmessages/2014/RIVM_forecasting_study_a_healthier_Netherlands_with_more_people_living_with_a_chronic_disease

23 WHO (2017) *Prevention of Cardiovascular Disease. Guidelines for assessment and management of cardiovascular risk*. Retrieved February 20, 2018, from http://www.who.int/cardiovascular_diseases/guidelines/Full%20text.pdf

24 D'agostino, R. B., Vasan, R. S., Pencina, M. J., Wolf, P. A., Cobain, M., Massaro, J. M., & Kannel, W. B. (2008). *General cardiovascular risk profile for use in primary care: the Framingham Heart Study*. Circulation, 117(6), 743-753.

25 Sans, S., Fitzgerald, A., Royo, D., Conroy, R, Graham, I., (2007). *Calibrating the SCORE Cardiovascular Risk Chart for Use in Spain*. Revista Española de Cardioogía, 60(05), 476-85. doi:10.1016/S1885-5857(07)60188-1

26 WHO/ISH *Cardiovascular Risk Prediction Charts. Strengths and Limitations*. Retrieved 20 February, 2018, from http://www.who.int/cardiovascular_diseases/publications/cvd_qa.pdf?ua=1.

27 European Association of Preventive Cardiology. *Heart Score Interactive tool*. Retrieved 5 May, 2018, from http://www.heartscore.org/en_GB/

28 Dzau, V. J., Antman, E. M., Black, H. R., Hayes, D. L., Manson, J. E., Plutzky, J., ... & Stevenson, W. (2006). *The cardiovascular disease continuum validated: clinical evidence of improved patient outcomes: part I: Pathophysiology and clinical trial evidence (risk factors through stable coronary artery disease)*. Circulation, 114(25), 2850-2870.

29 Giles, T., (2013). *Biomarkers, Cardiovascular Disease, and Hypertension*. The Journal of Clinical Hypertension, 15(1). doi: 10.1111/jch.12014

30 Balagopal, P. B., de Ferranti, S. D., Cook, S., Daniels, S. R., Gidding, S. S., Hayman, L. L., ... & Steinberger, J. (2011). Nontraditional risk factors and biomarkers for cardiovascular disease: mechanistic, research, and clinical considerations for youth: a scientific statement from the American Heart Association. Circulation, CIR-0b013e31821c7c64.

31 Vasan, R,S.,(2006). Biomarkers of Cardiovascular Disease. American Heart Association Journal. 113(19). doi.org/10.1161/CIR.0b013e31821c7c64

32 Vliegenthart, R., Oudkerk, M., Hofman, A., Oei, H,S., van Dijck, W., van Rooij, F., Witteman, J.,(2005). Coronary Calcification Improves Cardiovascular Risk Prediction in the Elderly. American Heart Association Journal, 112(4). doi.org/10.1161/CIRCULATIONAHA.104.488916

33 Liu, W., Zhang, Y., Yu, C, Ji, Q., Cai, M., Zhao, Y., Zhou, Y.,(2015). Current understanding of coronary artery calcification. Journal of Geriatric Cardiology, 12(6), 668–675. doi:10.11909/j.issn.1671-5411.2015.06.012

34 Starfield, B. (2006). *Threads and Yarns: Weaving the Tapestry of Comorbidity*. Annals of Family Medicine, 4(2), 101–103. http://doi.org/10.1370/afm.524

35 Valderas, J. M., Starfield, B., Sibbald, B., Salisbury, C., & Roland, M. (2009). *Defining Comorbidity: Implications for Understanding Health and Health Services*. Annals of Family Medicine, 7(4), 357–363. http://doi.org/10.1370/afm.983

36 Wolff, JL., Starfield, B., Anderson, G., (2012). *Prevalence, Expenditures, and Complications of Multiple Chronic Conditions in the Elderly*. Arch Intern Med. 162(20):2269–2276. doi:10.1001/archinte.162.20.2269

37 Mosterman, S. (2018). *Self-monitoring for comorbidity*. TU Delft

38 Denollet, J., (1997).*Personality, Emotional Distress and Coronary Heart Disease*. European Journal of Personality, 11, 343-357

39 Chauvet-Gelinier J,C., Bonin, B., (2017). *Stress, anxiety and depression in heart disease patients: A major challenge for cardiac rehabilitation*. Annals of Physical and Rehabilitation Medicine, 60(1) 6-12. doi.org/10.1016/j.rehab.2016.09.002

40 Pourafkari, L., Ghaffari, S., Tajlil, A., Shahamfar, J., Hedayati, S., Nader, N., (2017). *The impact of cardiac rehabilitation program on anxiety and depression levels after coronary artery bypass graft surgery*. Cor et Vasa, 58(4) e384-e390. doi.org/10.1016/j.crvasa.2016.01.001

41 Pennix, B. (2017). *Depression and cardiovascular disease: Epidemiological evidence on their linking mechanisms*. Neuroscience & Biobehavioral Reviews, 74(B), 277-286. doi.org/10.1016/j.neubiorev.2016.07.003

42 Rustad, J,K., Stern, T,A., Hebert, K,A., Musselman, D,L.,(2013). *Diagnosis and Treatment of Depression in Patients With Congestive Heart Failure: A Review of the Literature*. The Primary Care Companion for CNS Disorders, 15(4). doi:10.4088/PCC.13r01511

43 Inoue, N., (2014). *Stress and Atherosclerotic Cardiovascular Disease*. Journal of atherosclerosis and thrombosis, 21(5). doi:10.5551/jat.21709

44 van Melle, J,P., de Jonge P., Spijkerman, T,A., Tijssen, J,G., Ormel, J., van Veldhuisen, D,J., van den Brink, R,H., van den Berg, M,P. (2004) *Prognostic association of depression following myocardial infarction with mortality and cardiovascular events: a meta-analysis*. Psychosomatic Medicine. 66(6):814-822. DOI: 10.1097/01.psy.0000146294.82810.9c

45 European Commission. *Health statistics – Atlas on mortality in the European Union*. Retrieved 10 June, 2018, from http://ec.europa.eu/eurostat/documents/3217494/5713707/KS-30-08-357-EN.PDF/40b6c473-cd05-45d6-9f66-8bf4260cd45f

46 European Commission. *Mental health and related issues statistics*. Retrieved 10 June, 2018, from http://ec.europa.eu/eurostat/statistics-explained/index.php/Mental_health_and_related_issues_statistics#Extent_of_depressive_disorders

47 OECD *Health Policy Overview-Netherlands (2016)*. Retrieved 10 June, 2018, from http://www.oecd.org/els/health-systems/Health-Policy-in-the-Netherlands-June-2016.pdf

48 Hole, B., & Salem, J. (2016). *How long do patients with chronic disease expect to live? A systematic review of the literature*. BMJ Open, 6(12), e012248. http://doi.org/10.1136/bmjopen-2016-012248

49 Kraai, I,H., Vermeulen, K,M., Luttik, M,L., Hoekstra, T., Jaarsma, T., Hillege, L., (2013). *Preferences of heart failure patients in daily clinical practice: quality of life or longevity?*. European Journal of Heart Failure, 15, 1113–1121. doi:10.1093/eurjhf/hft07

50 Pleasant, A., McKinney, J., (2011). *Coming to consensus on health literacy measurement: An online discussion and consensus-gauging process*. Nursing Outlook, 59(2), 95-106.e1. doi.org/10.1016/j.outlook.2010.12.006

51 Research 2 Guidance, mHealth App Economics (2017). *Current Status and Future Trends in Mobile Health*. Retrieved June 20, 2018, from http://www.uzelf.org/wp-content/uploads/2017/12/R2G-mHealth-Developer-Economics-2017-Status-And-Trends.pdf

52 Jaarsma, T., Strömberg, A., Gal, T. B., Cameron, J., Driscoll, A., Duengen, H. D., ... & Köberich, S. (2013). *Comparison of self-care behaviors of heart failure patients in 15 countries worldwide*. Patient education and counseling, 92(1), 114-120. doi:10.1016/j.pec.2013.02.017

53 ClinRisk-2. 2017 Web Risk Calculator. Retrieved 10 June, 2018, from https://qrisk.org/2017

54 The Commonwealth Fund. *International Profiles of Health Care Systems 2013*, Retrieved 20 June, 2018, from https://www.commonwealthfund.org/sites/default/files/documents/___media_files_publications_fund_report_2013_nov_1717_thomson_intl_profiles_hlt_care_sys_2013_v2.pdf

55 Boerma, W., (2003) *Profiles of General Practice in Europe. An international study of variation in the tasks of general practitioners*. NIVEL. Utrecht, Netherlands.

56 Oh, H., Rizo, C., Enkin, M., Jadad, A. (2005) *What Is eHealth: A Systematic Review of Published Definition*. Journal of Medical Internet Research, 7(1). DOI:10.2196/jmir.7.1.e1

57 Robert Wood Johnson Foundation. *The eHealth landscape: a terrain map of emerging information and communication technologies in health and healthcare*. Retrieved 3 March, 2018, from https://www.rwjf.org/app/rw_publications_and_links/publicationsPdfs/eHealth.pdf

58 WHO. *mHealth - New horizons for health through mobile technologies*. Retrieved 20 March, 2018. http://www.who.int/goe/publications/goe_mhealth_web.pdf

59 Ahern, D,K., Kreslake, J,M., Phalen, J,M. (2006). *What Is eHealth: Perspectives on the Evolution of eHealth Research*. Journal of Medical Internet Research, 8(1). DOI:10.2196/jmir.8.1.e4

60 Government of the Netherlands. *Government encouraging use of eHealth*. Retrieved 18 June, 2018, from https://www.government.nl/topics/ehealth/government-encouraging-use-of-ehealth

61 Madhok, R. (2002). *Crossing the quality chasm: lessons from health care quality improvement efforts in England*. Baylor University Medical Center Proceedings, 15(1), 77–83.

62 Gustafson, D. H., Hawkins, R. P., Boberg, E. W., McTavish, F., Owens, B., Wise, M., ... & Pingree, S. (2005). *CHESS: 10 years of research and development in consumer health informatics for broad populations, including the underserved*. In Consumer Health Informatics (pp. 239-247). Springer, New York, NY.

63 WHO. *Global Observatory for eHealth - Global diffusion of eHealth: Making universal health coverage achievable*. Report of the third global survey on eHealth. Retrieved 20 March, 2018, from http://www.who.int/goe/publications/global_diffusion/en/)(Universal Health Coverage Forum 2017. Tokyo Declaration on Universal Health Coverage. Retrieved 20 March, 2018, from http://www.who.int/universal_health_coverage/tokyo-decleration-uhc.pdf?ua=1

64 The Office of the National Coordinator for Health Information Technology (ONC)- *Electronic Health Records: The Basics*. Retrieved 23 March, 2018, from https://www.healthit.gov/faq/what-electronic-health-record-ehr

65 Faber, M,J., Burgers, J,S., Westert, G,P. (2012). *A Sustainable Primary Care System: Lessons From the Netherlands*. The Journal of Ambulatory Care Management, 35(3), 174–181. doi:10.1097/JAC.0b013e31823e83a4

66 Tang, P. C., Ash, J. S., Bates, D. W., Overhage, J. M., & Sands, D. Z. (2006). *Personal health records: definitions, benefits, and strategies for overcoming barriers to adoption*. Journal of the American Medical Informatics Association, 13(2), 121-126.

67 Roehrs, A., da Costa, C,A., da Rosa Righi, R., Farias de Oliveira, K,S. (2017). *Personal Health Records: A Systematic Literature Review*. Journal of Medical Internet Research, 19(1), e13. doi:10.2196/jmir.5876

68 WHO. *Package of essential NCD interventions for primary health care: cancer, diabetes, heart disease and stroke, chronic respiratory disease*. Retrieved 3 June, 2018, from http://www.who.int/cardiovascular_diseases/publications/pen2010/en/

69 Sans, S., Fitzgerald, A., Royo, D., Conroy, R, Graham, I., (2007). *Calibrating the SCORE Cardiovascular Risk Chart for Use in Spain*. Revista Española de Cardioogía, 60(05), 476-85. doi:10.1016/S1885-5857(07)60188-1

70 Chen, L., Tonkin, A,M., Moon, L., Mitchell, P., Dobson, A., Giles, G., Hobbs, M., Phillips, P,J., Shaw, J,E., Simmons, D., Simons, L,A., Fitzgerald, A,P., De Backer, G., De Bacquer, D. (2009). *Recalibration and validation of the SCORE risk chart in the Australian population: the AusSCORE chart*. The European Journal of Cardiovascular Prevention & Rehabilitation, 6(5), 562-70. doi:10.1097/HJR.0b013e32832cd9cb

71 Hense, H,W., Koesters, E., Wellmann, J., Meisinger, C., Völzke, H., Keil, U.(2008). *Evaluation of a recalibrated Systematic Coronary Risk Evaluation cardiovascular risk chart: results from Systematic Coronary Risk Evaluation Germany*. The European Journal of Cardiovascular Prevention & Rehabilitation, 15(4), 409-15. doi:10.1097/HJR.0b013e3282feec66

72 James McCormack/Pascal Pfiffner (2017). *The Absolute CVD Risk/Benefit Calculator*. Available from http://chd.bestsciencemedicine.com/calc2.html

73 American College of Cardiology. *ASCVD Risk Estimator Plus*. Available from http://tools.acc.org/ASCVD-Risk-Estimator-Plus/#!/calculate/estimate/)

74 Ahead Research Inc 2013-2018. *ASCVD algorithm*. Available from http://www.cvriskcalculator.com/

75 Mayo Foundation for Medical Education and Research (MFMER). *Heart Disease Risk Calculator*. Available from https://www.mayoclinic.org/diseases-conditions/heart-disease/in-depth/heart-disease-risk/itt-20084942

76 ClinRisk. *QRISK 2-2017 cardiovascular disease risk calculator*. Available from https://qrisk.org/2017/

77 National Vascular Disease Prevention Alliance (NVDPA). *Cardiovascular disease risk calculator*. Available from http://www.cvdcheck.org.au/

78 Medical Statistics Unit, London School of Hygiene and Tropical Medicine (2006). *A Risk Score for Cardiovascular Disease*. Available from http://www.riskscore.org.uk/

79 MDCalc - *Framingham Coronary Heart Disease Risk Score*. Available from https://www.mdcalc.com/framingham-coronary-heart-disease-risk-score

80 Government of Alberta. *Heart Disease Risk Calculator*. Available from https://myhealth.alberta.ca/Alberta/Pages/Heart-Disease-Risk-Calculator.aspx

81 Research 2 Guidance, mHealth App Economics (2017). *Current Status and Future Trends in Mobile Health*. Retrieved June 20, 2018, from http://www.uzelf.org/wp-content/uploads/2017/12/R2G-mHealth-Developer-Economics-2017-Status-And-Trends.pdf

82 Government of the Netherlands. *Risk adjustment under the Health Insurance Act in the Netherlands*. Retrieved 10 March, 2018, from https://www.government.nl/documents/leaflets/2012/08/10/risk-adjustment-under-the-health-insurance-act-in-the-netherlands

84 Rijksoverheid. *Health insurance in the Netherlands*. Retrieved 10 March, 2018, from https://www.rijksoverheid.nl/documenten

85 Kroneman, M., Boerma, W., van den Berg, M., Groenewegen, P., de Jong J, van Ginneken, E., (2016). *The Netherlands: health system review*. Health Systems in Transition, 18(2),1–239.

86 *EU General Data Protection Regulation (GDPR)*. Retrieved March 20, 2018, from https://www.eugdpr.org/

87 Patel, V., Hughes, P., Barker, W., Moon, L. (2016). *Trends in Individuals' Perceptions regarding Privacy and Security of Medical Records and Exchange of Health Information: 2012-2014*. ONC Data Brief, no.33. Office of the National Coordinator for Health Information Technology: Washington, DC.

88 Arndt, A., Goldenberg, J,L. (2017) *Where Health and Death Intersect - Insights From a Terror Management Health Model*. Association for Psychological Science, 26 (2), 126-131. doi:10.1177/0963721416689563

89 Taylor, J., Coates, E., Brewster, L., Mountain, G., Wessels, B., & Hawley, M. S. (2015). *Examining the use of telehealth in community nursing: identifying the factors affecting frontline staff acceptance and telehealth adoption*. Journal of advanced nursing, 71(2), 326-337

90 Government of the Netherlands. *The government makes rules and regulations to reduce tobacco use*. Retrieved July 3, 2018, from https://www.government.nl/topics/smoking/discouraging-smoking

91 *Gezondere levensstijl in basispakket*. Retrieved July 3, 2018, from https://nos.nl/artikel/2234580-gezondere-levensstijl-in-basispakket.html

92 *NZa stelt regels op voor vergoeding leefstijlcoaching*. Retrieved July 3, 2018, from https://www.nationalezorggids.nl/zorgverzekering/nieuws/43119-nza-stelt-regels-op-voor-vergoeding-leefstijlcoaching.html

93 Government of the Netherlands. *Meer ruimte voor preventie in basispakket zorgverzekering*. Retrieved July 3, 2018, from https://www.rijksoverheid.nl/actueel/nieuws/2018/06/01/meer-ruimte-voor-preventie-in-basispakket-zorgverzekering

94 *Hartstichting - Verhalen*. Retrieved February 1, 2018, from https://www.hartstichting.nl/verhalen

95 Harteraad. *Ervaringen & ontmoeten*. Retrieved February 1, 2018, from https://www.harteraad.nl/ervaringen-ontmoeten/

96 Keller, V. F., & Carroll, J. G. (1994). *A new model for physician-patient communication*. Patient Education and Counseling, 23(2), 131-140.

97 Roter, D. L., Hall, J. A., & Katz, N. R. (1988). *Patient-physician communication: a descriptive summary of the literature*. Patient Education and Counseling, 12(2), 99-119.

98 Rathert, C., Mittler, J. N., Banerjee, S., & McDaniel, J. (2017). *Patient-centered communication in the era of electronic health records: What does the evidence say?*. Patient education and counseling, 100(1), 50-64.

99 Ong, L. M., De Haes, J. C., Hoos, A. M., & Lammes, F. B. (1995). *Doctor-patient communication: a review of the literature*. Social science & medicine, 40(7), 903-918.

100 Roter, D. L., & Hall, J. A. (1989). *Studies of doctor-patient interaction*. Annual review of public health, 10(1), 163-180.

101 *The Myers & Briggs Foundation*. Retrieved March 1, 2018, from https://www.myersbriggs.org/

102 IPSOS. *An Rx for Emotional Research*. Retrieved March 1, 2018, from https://www.ipsos.com/en-us/knowledge/consumer-shopper/rx-emotional-research

103 Paul, A. M. (2010). *The cult of personality testing: How personality tests are leading us to miseducate our children, mismanage our companies, and misunderstand ourselves*. Simon and Schuster.

104 McCloud, S. (1993). *Understanding comics: The invisible art*. Northampton, Mass.

105 Collins, F. S., & Varmus, H. (2015). *A New Initiative on Precision Medicine*. The New England Journal of Medicine, 372(9), 793–795. http://doi.org/10.1056/NEJMp1500523

106 Bosworth, H. B., Granger, B. B., Mendys, P., Brindis, R., Burkholder, R., Czajkowski, S. M., ... & Kimmel, S. E. (2011). *Medication adherence: a call for action*. American heart journal, 162(3), 412-424.

107 *The precision medicine initiative*. Retrieved March 5, 2018, from https://obamawhitehouse.archives.gov/node/333101

108 U.S. Department of Health & Human Services - National Institutes of Health. *The precision medicine initiative*. Retrieved March 5, 2018, from https://syndication.nih.gov/multimedia/pmi/infographics/pmi-infographic.pdf

109 Tiessen, A. H. (2014). *Cardiovascular risk management in general practice Groningen: s.n.*

110 Hawkins, R. P., Kreuter, M., Resnicow, K., Fishbein, M., & Dijkstra, A. (2008). *Understanding tailoring in communicating about health*. Health Education Research, 23(3), 454–466. http://doi.org/10.1093/her/cyn004

111 Storni, C. (2010). *Multiple forms of appropriation in self-monitoring technology: reflections on the role of evaluation in future self-care*. Intl. Journal of Human–Computer Interaction, 26(5), 537-561.

112 Barlow, J., Wright, C., Sheasby, J., Turner, A., & Hainsworth, J. (2002). *Self-management approaches for people with chronic conditions: a review*. Patient education and counselling, 48(2), 177-187. doi:10.1016/S0738-3991(02)00032-0

113 IDC, *Worldwide Wearables Market*. Retrieved 14 June, 2018, from https://www.idc.com/getdoc.jsp?containerId=prUS42818517

114 Giles, T. (2013). *Biomarkers, cardiovascular disease, and hypertension*. The Journal of Clinical Hypertension, 15(1), 1-1.

115 Casiglia, E., Tikhonoff, V., Albertini, F., & Palatini, P. (2016). *Poor reliability of wrist blood pressure self-measurement at home: a population-based study*. Hypertension, HYPERTENSIONAHA-116.

116 Komori, T., Eguchi, K., Hoshide, S., Williams, B., & Kario, K. (2013). *Comparison of wrist-type and arm-type 24-h blood pressure monitoring devices for ambulatory use*. Blood pressure monitoring, 18(1), 57-62.

117 Doshi, H., Weder, A. B., Bard, R. L., & Brook, R. D. (2010). *Does "hidden undercuffing" occur among obese patients? Effect of arm sizes and other predictors of the difference between wrist and upper arm blood pressures*. The Journal of Clinical Hypertension, 12(2), 82-88.

118 American Heart Association. *"What is High Blood Pressure?" Chart*. Retrieved 17 March, 2018, from http://www.heart.org/idc/groups/heart-public/@wcm/@hcm/documents/downloadable/ucm_300310.pdf

119 Ramli, A. S., Halmey, N., & Teng, C. L. (2008). W*hite coat effect and white coat hypertension: one and the same?*. Malaysian family physician: the official journal of the Academy of Family Physicians of Malaysia, 3(3), 158.

120 Glanz, K., & Bishop, D. B. (2010). *The role of behavioral science theory in development and implementation of public health interventions*. Annual review of public health, 31, 399-418.

121 Shah, A. K., & Oppenheimer, D. M. (2008). *Heuristics made easy: An effort-reduction framework*. Psychological Bulletin, 134(2), 207-222.

122 Hole, B., & Salem, J. (2016). *How long do patients with chronic disease expect to live? A systematic review of the literature*. BMJ open, 6(12), e012248.

123 Leonard, T. C. (2008). *Richard H. Thaler, Cass R. Sunstein, Nudge: Improving decisions about health, wealth, and happiness*.

124 Das, S., & O'Keefe, J. H. (2006). *Behavioral cardiology: recognizing and addressing the profound impact of psychosocial stress on cardiovascular health*. Current atherosclerosis reports, 8(2), 111-118.

125 Rozanski, A. (2014). *Behavioral cardiology: current advances and future directions*. Journal of the American College of Cardiology, 64(1), 100-110.

126 Katz, M., & Wajngarten, M. (2015). *Behavioral cardiology: cardiology's new frontier of action*. Arquivos brasileiros de cardiologia, 104(1), 3-4.

127 Operskalski, J. T., & Barbey, A. K. (2016). Risk literacy in medical decision-making. Science, 352(6284), 413-414.

128 Peretti-Watel, P., Constance, J., Guilbert, P., Gautier, A., Beck, F., & Moatti, J. P. (2007). *Smoking too few cigarettes to be at risk? Smokers' perceptions of risk and risk denial, a French survey*. Tobacco Control, 16(5), 351-356.

129 Chapman, S., Wong, W. L., & Smith, W. (1993). *Self-exempting beliefs about smoking and health: differences between smokers and ex-smokers*. American journal of public health, 83(2), 215-219.

130 Tiessen, A. H. (2014). *Cardiovascular risk management in general practice Groningen*: s.n.

131 Does Connectivity Help — or Hurt — the Doctor-Patient Relationship?. Retrieved 29 April, 2018, from http://knowledge.wharton.upenn.edu/article/does-connectivity-help-or-hurt-doctor-patient-relationship/

132 Kreuter, M. W., Farrell, D. W., Olevitch, L. R., & Brennan, L. K. (2013). Tailoring health messages: Customizing communication with computer technology. Routledge.

133 van Dooren, M., Visch, V., Spijkerman, R., Goossens, R., & Hendriks, V. (2016). Personalization in Game Design for Healthcare: a Literature Review on its Definitions and Effects. International Journal of Serious Games, 3(4). https://doi.org/10.17083/ijsg.v3i4.134

134 Quoidbach, J., Gilbert, D. T., & Wilson, T. D. (2013). The end of history illusion. Science, 339(6115), 96-98.

135 Reibling, N., & Wendt, C. (2012). Gatekeeping and provider choice in OECD healthcare systems. Current Sociology, 60(4), 489-505.

136 Yesavage, J. A., Brink, T. L., Rose, T. L., Lum, O., Huang, V., Adey, M., & Leirer, V. O. (1982). Development and validation of a geriatric depression screening scale: a preliminary report. Journal of psychiatric research, 17(1), 37-49.

137 Kurlowicz, L., & Greenberg, S. A. (2007). The geriatric depression scale (GDS). AJN The American Journal of Nursing, 107(10), 67-68.

138 Zung, W. W. (1965). A self-rating depression scale. Archives of general psychiatry, 12(1), 63-70.

139 Kroenke, K., Spitzer, R. L., & Williams, J. B. (2003). The Patient Health Questionnaire-2: validity of a two-item depression screener. Medical care, 1284-1292.

140 Beck, A. T., Steer, R. A., & Carbin, M. G. (1988). Psychometric properties of the Beck Depression Inventory: Twenty-five years of evaluation. Clinical psychology review, 8(1), 77-100.

141 Rozanski, A., Blumenthal, J. A., Davidson, K. W., Saab, P. G., & Kubzansky, L. (2005). The epidemiology, pathophysiology, and management of psychosocial risk factors in cardiac practice: the emerging field of behavioral cardiology. Journal of the american college of cardiology, 45(5), 637-651.

142 Medisafe app homepage. Retrieved 20 June, 2018, from https://medisafe.com/

143 Wellth app homepage. Retrieved 20 June, 2018, from https://wellthapp.com/home

144 Gratitude app homepage. Retrieved 20 June, 2018, from http://getgratitude.co/

145 ThinkUp app homepage. Retrieved 20 June, 2018, from http://thinkup.me/

146 The fabulous app homepage. Retrieved 20 June, 2018, from https://thefabulous.co

147 NERIS Analytics Limited. 16 personalities online test. Retrieved 5 June, 2018, from https://www.16personalities.com

148 Jakicic, J. M., Davis, K. K., Rogers, R. J., King, W. C., Marcus, M. D., Helsel, D., ... & Belle, S. H. (2016). Effect of wearable technology combined with a lifestyle intervention on long-term weight loss: the IDEA randomized clinical trial. Jama, 316(11), 1161-1171.

149 Finkelstein, E. A., Haaland, B. A., Bilger, M., Sahasranaman, A., Sloan, R. A., Nang, E. E. K., & Evenson, K. R. (2016). Effectiveness of activity trackers with and without incentives to increase physical activity (TRIPPA): a randomised controlled trial. The lancet Diabetes & endocrinology, 4(12), 983-995.

150 Choudhry, N. K., Krumme, A. A., Ercole, P. M., Girdish, C., Tong, A. Y., Khan, N. F., ... & Franklin, J. M. (2017). Effect of reminder devices on medication adherence: the REMIND randomized clinical trial. JAMA internal medicine, 177(5), 624-631.

151 Volpp, K. G., Troxel, A. B., Mehta, S. J., Norton, L., Zhu, J., Lim, R., ... & Levin, T. (2017). Effect of electronic reminders, financial incentives, and social support on outcomes after myocardial infarction: the HeartStrong Randomized Clinical Trial. JAMA internal medicine, 177(8), 1093-1101.

Delft, August 2018