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Glossary

Acronym	Definition
2hPG	Two-hour fasting glucose level
ADL	Activities of Daily Living
ATC	Anatomical Therapeutic Chemical Classification
AUDIT	Alcohol Use Disorders Identification
BCT	Behaviour Change Techniques
BCW	Behaviour Change Wheel
CACE	Cut down, Annoyed, Guilty, Eye-opener
COPD	Chronic Obstructive Pulmonary Disease
CVD	Cardio Vascular Disease
DDD	Defined Daily Dose
eHEALS	e-Health Literacy Scale
eHLQ	eHealth Literacy Questionnaire
EPR	Electronic Patient Record
FEV1	Forced Expiratory Volume
FPG	Fasting glucose level
FVC	Forced Vital C
GP	General Practitioner
HbA1c	Hemoglobin A1c
HDL	High Density Lipids
HHIE	Hearing Handicap Inventory for the Elderly
IADL	Instrumental Activities of Daily Living
IADLS	Instrumental Activities of Daily Living Scale
ICD	International Classification of Diseases



ICF	International Classification of Functioning
ICHI	International Classification of Health Interventions
ICPC	International Classification of Primary Care
IPAQ	International Physical Activity Questionnaire
IPH	Institute of Positive Health
ISCO	International Standard Classification of Occupations
ISCE	International classification of Status in Employment
ISCED	International Standard Classification of Education
LDL	Low-Density Lipids
MDI	Major Depression Inventory
MMSE	Mini-Mental State Examination
PAM	Patient Activation Measure
PASE	Physical Activity Scale for the Elderly
PHCS	Perception of Health Competence Scale
PHQ-4	Patient Health Questionnaire
PROM	Patient Reported Outcome Measures
PROMIS	Patient Reported Outcome Measurement Information System
PSS-4	Perceived Stress Scale
QoL	Quality of Life
SDH	Social Determinants of Health
SES	Socio Economic Status
SOC	Sense Of Coherence
SSS	Subjective Social Status
SWEMWS	Short Warwick-Edinburgh Mental Wellbeing Scale
VAS	Visual Analog Scale
WAI	Work Ability Index



WHO	World Health Organisation
MHLC	Multidimensional Health Locus of Control scale
REALM	Rapid Estimate of Adult Literacy in Medicine
TOFHLA	Test of Functional Health Literacy in Adults
HLQ	Health Literacy Questionnaire
GDPR	General Data Protection Regulation

Executive Summary

The aim of this report is to describe and motivate an evidence-based, holistic user state model based on health as the ability to adapt and self-manage, as adopted in the WellCo project. The user state assessment model is developed as part of WP4 that aim to develop personalised services for physical, cognitive and mental user assessment that can acquire data on individual's lifestyle, behaviour and surrounding environment based on advanced sensors.

The user state assessment model presented in this document supports this aim by providing a **static model of health** that include all determinants of health and aging as described **from a conception of individual health as the ability to adapt and self-manage** and inherent to a larger framework of health **that take social and environmental determinants**, as well as biological properties **into consideration**. By a static model we mean a theoretical user model that will translate into the data models for the data acquired from users, in turn feeding the data into the risk assessment tool and the recommender system with basic facts about the users health state and determinants of staying healthy. Beyond providing a theoretical user state model, the user state model provide the necessary patient reported metrics for the risk awareness tool, validated metrics applicable in all three trial sites and point to metrics that may be used for the ex-ante evaluation with a follow-up period of 6 months to measure the success of the WellCo trials.

We elicit a user state model for WellCo that basically comprises five components, of which four stand out as determinants of health, and the fifth is the outcome as the ability to adapt and self-manage. The four groups of determinants are (1) biological properties, (2) socio-economic status (SES), (3) dimensions of health as the ability to adapt and self-manage, and (4) social, political, physical and economic environment. Finally, the outcome is the concept of health as the ability to adapt and self-manage. In this way we suggest that this previous concept is extended with the biological properties, SES of the individual, and the surrounding social, political, physical and economic environment.

The user state assessment may benefit from the following recommendations:

- It is recommended not to assess more than necessary, both from an evaluative and user point of view. WellCo should **not provide information that may cause unnecessary concerns to the user**.
- It is recommended that **WellCo states how it views the relation between quality of life (QoL) and health as the ability to adapt and self-manage**, and whether measures of QoL may be used as proxies for the user health state.
- It is recommended **to be clear** on **what data** input that **is needed from** the user state assessment model to feed into **user engagement and** what data is needed in terms of **research**. Not all information from the user state assessment model may be suitable for user engagement.
- It is recommended to have a **core set of basic indicators** for the **assessment of personal properties, socio-economic status and bodily function**.
- It is recommended to use a step-wise approach to an **extended assessment** of the user comprising an initial assessment **of the overall health state and** an extended assessment of **the dimensions of health** in which the overall assessment show shortcomings.
- It is recommended to **build an assessment model that uses the International Classification of Functioning (ICF) conceptualization** to describe the functioning of the user (see Section 1). That is, to describe the user's problems in doing daily activities that considers the medical conditions, the bodily functions, the consequences for social participation, the environmental barriers and facilitators together with the available



personal factors. This way of constructing the assessment of the user will be of use for both the dynamic user model, the recommender system and the formal care personnel.

- If available, it is **recommended to use questionnaires from the PROMIS programme**. The use of Patient reported Outcome Measures (PROMs) is increasing, but is inconsistent across languages and national borders. Both when it comes to what PROMs that are used and for what purposes. Looking to the PROMs described in the PROMIS programme may serve to improve the use of PROMs.



1 Introduction

This report concerns task 4.1 in the EU funded Well-Co project. WellCo is financed by the call for personalised coaching for wellbeing and care of people as they age (Call number/title: SC1-PM-15-2017).

The aim of Well-Co is to **deliver a radical new solution in the provision of personalised advice, guidance and follow-up of users for the adoption of healthier behaviour choices** that help them **to maintain or improve their health and wellbeing status**. This will be **achieved by** developing **an affective aware virtual coach** that will help empower the user to change health behaviour.

WellCo takes the concept of health as *the ability to adapt and to self-manage, in the face of social, physical and emotional challenges* as the starting point for developing a solution for wellbeing and care (see the proposal page 2) [1]. In the wake of the rising prevalence of chronic diseases that is due to a combination of an ageing population and health risk behaviours such as smoking, sedentary behaviour and unhealthy diet the World Health Organisation (WHO) conception of health as a state of complete physical, mental and social well being and not merely the absence of disease or infirmity have recently been met with wide criticism for being utopian and from here giving rise to an overly focus on medicalization [2–4]. The concept of health as the ability to adapt and self-manage has been proposed by Huber et al. as a reaction to this criticism and a consequence of the before mentioned changes in the distribution of the burden of disease and increasing medicalization in populations worldwide [1,5].

Health as the ability to adapt and self-manage sees health as a subjective potential of the individual, whereas WHO sees health as an objective state that for most is unachievable due to chronic medical conditions. Moreover health is seen as dynamic, in the sense of a more process-oriented conception, contrary to a (utopian) static state. Lastly health is seen as a positive concept in the tradition of health promotion stemming from the Ottawa charters statement of health promotion. In the Ottawa Charter health promotion is defined as the process of enabling people to increase control over, and to improve, their health. This definition is in line with the salutogenic approach to health put forward by Antonovsky who describe health as a sense of coherence and resilience to stressors [6,7].

Health as the ability to adapt and self-manage fits well with the aim of developing a digital solution that provide personalised advice, guidance and follow-up of users for them to adopt healthier behaviour and hereby improve health and wellbeing.

First, the solution focuses on self-management. Second, the solution focuses on the individual and the behaviour that the person can actually change. However, it also has its limitations. It focuses overly on the individual potential as argued by Bircher and Kurruvilla, who define health as an emergent property that results from different interactions among components of a complex, adaptive system [8]. Bircher and Kurruvilla argue, that for a person to meet the demands of life, the person's biologically given potential, personally acquired potential as well as the social and environmental determinants need to be taken into consideration (**¡Error! No se encuentra el origen de la referencia.**). Yet, even though the model proposed by Bircher and Kurruvilla explains health as a complex adaptive system, and as such from a certain theoretical point of view, the particularities of the model is widely recognized [9]. Health as the ability to adapt and self-manage provides a concept of health that can help people improve their potential, but does not take the social environmental determinants, as well as the biological properties (genes, prenatal exposures) into consideration. Not taking the contextual factors into consideration can, moreover, infer that the individual merely have to adapt to her present, but poor, living conditions.

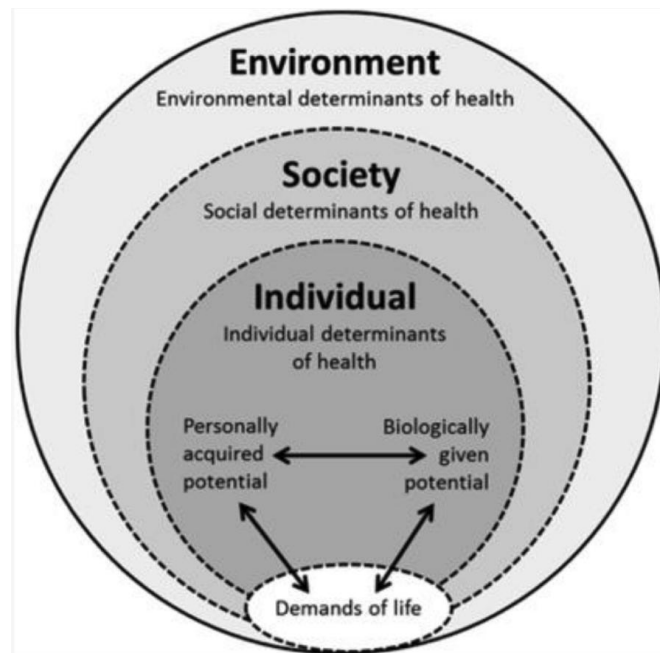


Figure 1. The Meikirch Model of Health

Beyond wellbeing and care the EU call also focused on solutions for people as the age, or aging, which is a debated field expressed in the number of definitions and approaches currently being put forward, including active aging (World Health Organisation), successful aging (American context), and healthy aging (EU). Despite the differences in semantics, agreement seems to be high when it comes to the determinants of a successful third age in good health (a merging of the above approaches to aging). Broadly, the determinants fall within the biological/physiological, mental/cognitive and psychological/spiritual domains, and the social and environmental domains [10,11].

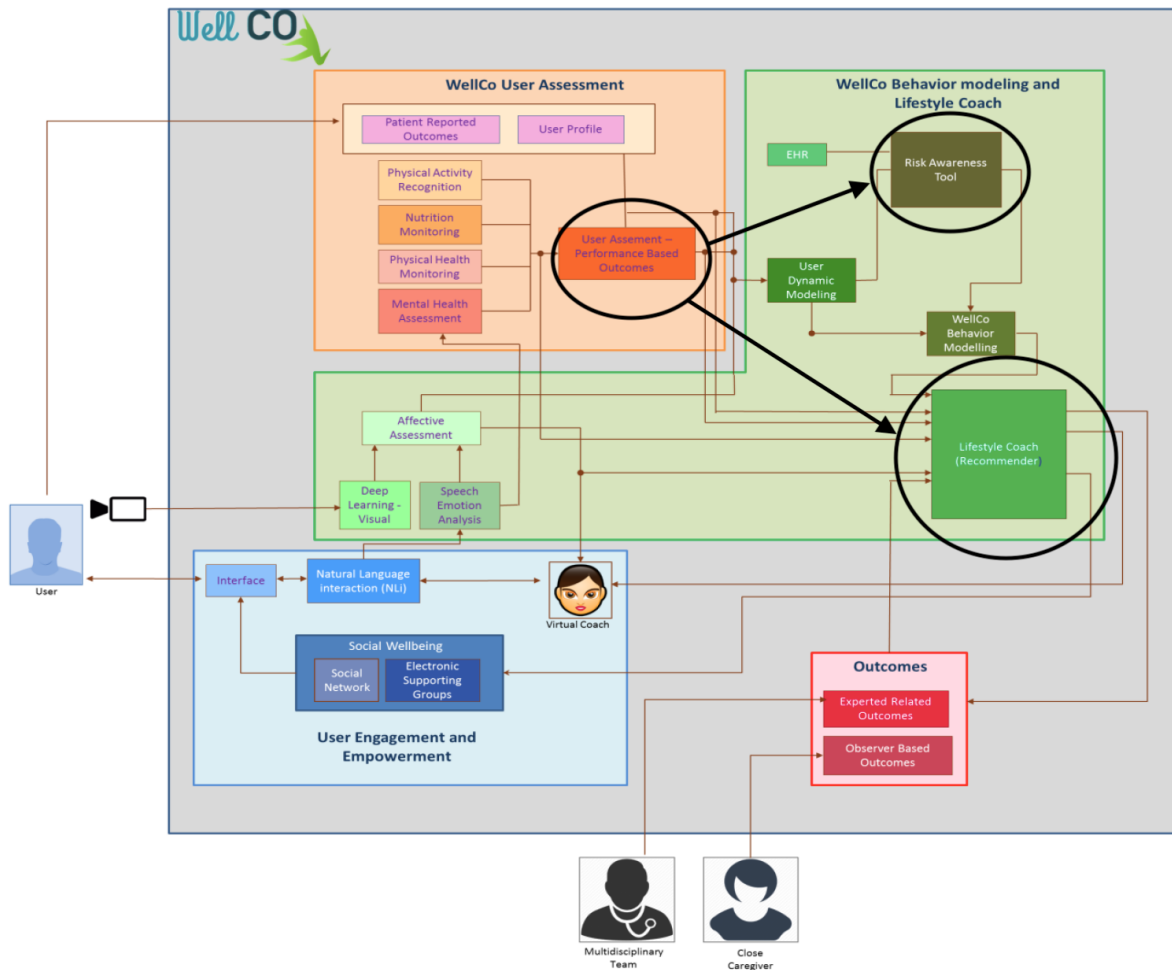


Figure 2. WellCo architecture overview (From the proposal)

The aim of this report is to **describe and motivate an evidence-based, holistic user state model based on health as the ability to adapt and self-manage**, as adopted in the WellCo project. The user state assessment model is developed as part of WP4. This work package aims to develop personalised services for physical, cognitive and mental user assessment that can acquire data on lifestyle, behaviour and surrounding environment based on advanced sensors. The user state assessment model presented in this document supports this aim by providing a **static model of health that include all determinants of health and aging** as described from a conception of individual **health as the ability to adapt and self-manage** and inherent to a larger **framework of health that takes social and environmental determinants, as well as biological properties** into consideration. By a static model we mean a theoretical user model that will translate into the data models for the data acquired from users, in turn feeding the data into the risk assessment tool and the recommender system with basic facts about the users' health state and determinants of staying healthy (**Error! No se encuentra el origen de la referencia.**). Beyond providing a theoretical user state model, the user state model provides the necessary patient reported metrics for the risk awareness tool, validated metrics applicable in all three trial sites and point to metrics that may be used for the ex-ante evaluation with a follow-up period of 6 months to measure the success of the WellCo trials. However, a wide variety of metrics have been developed to assess constructs such as those included in the user state assessment model described below. **We are in no way presenting an exhaustive list of scales, questionnaires and data collection methods, but merely an outline of useful scales,**



questionnaires and data collection methods available with references in how to find more information.

The report is structured as follows.

First, in **section 3** we **describe the operationalization of the concept of health** as the ability to adapt and self-manage as presented in the paper *Towards a 'patient – centred' operationalization of the new dynamic concept of health: a mixed methods study* by Huber et al. [12]. Moreover, we discuss how the operationalization of health as the ability to adapt and self-manage fits with operationalisations of other conceptions of health and with reviews of perceptions of health as described in the scientific literature.

Second, in **section 4** we **combine the concept of health** as the ability to adapt and to self-manage, in the face of social, physical and emotional challenges, **with the biological properties, and the social, political, physical and economic environment** into a full user state assessment model for WellCo.

Third, in **appendix 1** we suggest **metrics to assess the user state**. We both recommend metrics for the overall concept of health, the dimensions and, where appropriate and applicable, also the underlying aspects. We include **quantitative information only, and** strive for metrics that are **validated in at least all trial countries**. Finally, we consider the source of the metrics, both in terms of who will provide the information, and the available questions/scales and standardized codes.

2 Operationalization of health as the ability to adapt and self-manage

Health as the ability to adapt and self-manage was operationalized in a mixed methods study by Huber et al. [12]. A qualitative analysis aimed to elicit and judge the scope of the included a total of 140 people, whereas a questionnaire (N=1938) aimed to examine the importance attached to the proposed elements. The study took place in The Netherlands and included multiple stakeholders from policy makers, health professional to citizens.

The strength of the study was that it included a large number of multiple stakeholders and took a bottom-up approach to the operationalization of the concept of health that was put forward. The limitations are that it was only done in The Netherlands and that it did not follow any known/tested method such as a Delphi method, or at least discuss the chosen process.

The qualitative study resulted in six dimensions comprising 32 aspects of health (**¡Error! No se encuentra el origen de la referencia.**). The quantitative study showed that these dimensions were seen as evenly important. However, breaking down of the results revealed a number of interesting findings.

Dimensions of health as the ability to adapt and self-manage					
Bodily functions	Mental functions and perceptions	Spiritual/existential	Quality of life (QoL)	Social and societal participation	Daily functioning
Medical facts	Cognitive functioning	Meaning/ Meaningfulness	Quality of life/ Wellbeing	Social and communicative skills	Basic active daily living (ADL)
Medical observations	Emotional state	Striving for aims/ideals	Experiencing happiness	Meaningful relationships	Instrumental ADL
Physical functioning	Esteem/self-respect	Future prospects	Enjoyment	Social contacts	Ability to work
Complaints and pain	Experiencing to be in charge	Acceptance	Perceived health	Experiencing to be accepted	Health literacy
Energy	Self-management		Flourishing	Community involvement	
	Resilience/ sense of coherence		Zest for life	Meaningful work	
Balance					

Table 1. Operationalization of health as the ability to adapt and self-manage

Among patients (N=575), **quality of life** was the **most important dimension** followed by **mental function and perception**. **Social and societal participation** and **spiritual/existential** were the **least important**. The **importance of all six dimensions increased with age**. The importance of mental functions and perceptions, spiritual/existential and social and societal participation increased most with age, bodily functions the least. Except from activities of daily functioning, **men found the dimensions to be more important than women**. This is in contrast to the evidence, as women usually value health more than men. Except from bodily

functions, **people with a completed university degree found the other dimensions to be more important than people who had not completed a university degree.** This is in line with a prior study that found that people of lower SES favour a concept of health as the absence of disease, functioning over engagement, and have a more accepting attitude towards life [13]. **People with a chronic disease value bodily functions less and the spiritual/existential more than people with no chronic disease.** This is in accordance with the evidence and is described as a response shift [12].

The paper by Huber et al. is to our knowledge the only paper that operationalizes health as the ability to adapt and self-manage and the results from this study has yet to be reproduced in other settings and in studies that use other approaches than the mixed method approach used by Huber et al. To examine the validity of the operationalization of health as the ability to adapt and self-manage, we report on operationalisations of other concepts of health and reviews of the perception of health among people of older age (age above 60).

2.1 Concepts of health

In a now seminal paper, Christopher **Boorse** argued for a value-free negative conception of **health as absence from disease that took biological functioning and statistical normality as the main elements** [14]. Health could, as such, be understood and objectively measured as the absence of diseases and age-normal functioning. Though radical, the viewpoint however gained widespread support in the medical and population health sciences as it provided a measurable and objective notion of health.

WHO perceive health as a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity. **WHO** perceive health more broadly than the one suggested by Boorse. Based on the above statement on health, WHO developed the concept of **quality of life as a patient-oriented conception of the health state of the individual as both the wellbeing and absence of disease or infirmity dimensions of health** [15]. In a cross-cultural and cross-national process comparable to the one used by Huber et al., quality of life was operationalized in 6 domains; physical health, psychological, level of independence, social relations, environment, and spirituality.

2.2 Reviews of the perception of health in older people

Several reviews have been carried out **to define and operationalize health in people of old age**, that is, people above age 60 [16–18]. The below account of the literature is by no means a systematic review of reviews but a description of some of the most recent reviews.

A scoping review on health and self-care among people above age 65 elicited **four headings: frame of mind, having relationships and social activities, physical abilities and concerns, and maintaining self-care** [16]. Frame of mind is essentially mental health and was described as the most important dimension of health. Being satisfied and content with life, having willpower and internal control all increased the perception of health. Contrary, depression reduced the perception of health. Social activities, social usefulness, social support and having relationships, especially with the family, all increased the perception of health. Having functional ability and remaining independent increased the perception of health. Pain and sleeping difficulties reduced the perception of health. Maintaining self-care captures what is important to sustain daily activities; being able to adapt to changes in lifestyle and health over the course of life and have a positive attitude to changes. Religious beliefs, life experiences and the ability to seek information were moreover perceived as resources.

A meta-synthesis of qualitative studies of older adult's (people above age 65) definition of health **gave rise to five themes** [17]. 1) **Ability to do something independently**, or activities

of daily living, was described as **the most important dimension of health**. 2) Absence and treatment or control of diseases is a frequently used definition of health by the elderly, with **absence from pain** as the most frequently mentioned symptom. 3) **Acceptance** and adjustment to **changing health conditions with a positive attitude**, or realistic optimism. 4) **Connectedness with other people and god**. The relation with other people was described as reciprocal. 5) Having energy and stamina, **being vital and in good fitness** was also mentioned.

A systematic review of quantitative studies of perceptions of ageing (attitudes and expectations) on health and functioning among people above age 60 showed that **ageing was related to health and functioning across seven health domains: memory and cognitive performance, physical and physiological performance, medical conditions and outcomes, disability, care-seeking, self-rated health, quality of life and death** [18]. Positive ageing perceptions were associated with better self-rated health, psychological wellbeing, QoL, and health status. Positive ageing was also associated with good cognitive and physical functioning, including good memory, vision and hearing. In contrast, **low activities of daily living (ADL)**, the presence of **multiple chronic diseases** and **health risk behaviours** were associated with a **negative attitude to ageing**.

2.3 Strengths and limitations

The main strength of the definition of “health as the ability to adapt and self-manage” lies in the conceptualisation of health as dynamic, process-oriented and positive and not so much in the specific operationalization in six dimensions that needs validation and a more thorough theoretical underpinning. The overlap to current operationalisation of concepts of health such as the WHOQOL is evident; likewise, reviews have defined and operationalized health slightly different, though encompassing the same themes or domains.

Another strength of the concept of health as the ability to adapt and self-manage for a solution like WellCo is that **health is a property of the individual person**. Contrary to the WHOQOL, all dimensions and underlying aspects of **health as the ability to adapt and self-manage are changeable by the individual**. As much as being a strength, it is also an obvious limitation for a full understanding of health. Health as the ability to adapt and self-manage is extended by the notion *in the face of social, physical and emotional challenges*; an extension that is yet to be operationalized in the same way as *health as the ability to adapt and self-manage*.

3 WellCo user state assessment model of health

In the following we elicit a **user state model for WellCo** that basically comprises **five components**, of which **four stand out as determinants of health**, and the **fifth is the outcome as the ability to adapt and self-manage**. The four groups of determinants are (1) **biological properties**, (2) **SES**, (3) **dimensions of health as the ability to adapt and self-manage**, and (4) **social, political, physical and economic environment**. Finally, the **outcome is health as the ability to adapt and self-manage**. In this way we suggest that the concept of health as the ability to adapt and self-manage is extended with the biological properties, SES of the individual, and the surrounding social, political, physical and economic environment. In the user state model, the dimensions of health as the ability to adapt and self-manage stand out as what is modifiable by the user. The biological properties, SES and the social, political, physical and economic environment are largely un-modifiable from the point of view of a digital solution for self-management, and stand out as either barriers or facilitators to changes in the users' health state. In the following the user state assessment is presented from right to left starting with health as the ability to adapt and self-manage.

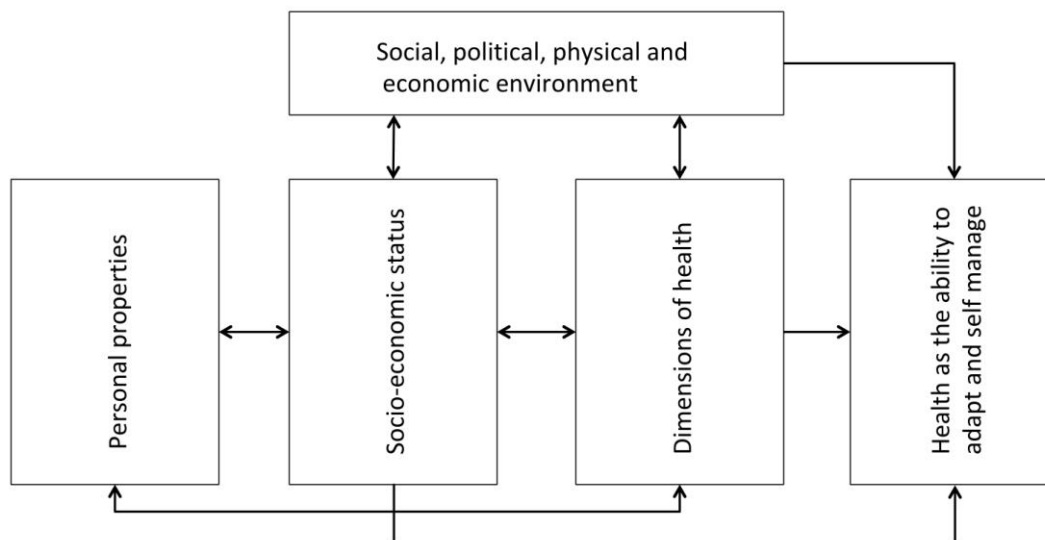


Figure 3. User State Assessment Model

We propose a stepwise approach to the user state assessment with a basic assessment applied to all users and a targeted assessment applied only if shortcomings are identified. The basic assessment comprises a core set of basic indicators of the personal properties, SES, bodily functions, few psychological constructs to assess the capability of change, and overall health state. The targeted assessment takes 1) the scores from the assessment of the overall health state, and provide an extended assessment if shortcomings are identified in one or more of the dimensions of health, and 2) the assessment of the bodily function and provides deeper insight into modifiable variables if shortcomings are identified and the user expresses an interest in behaviour change.

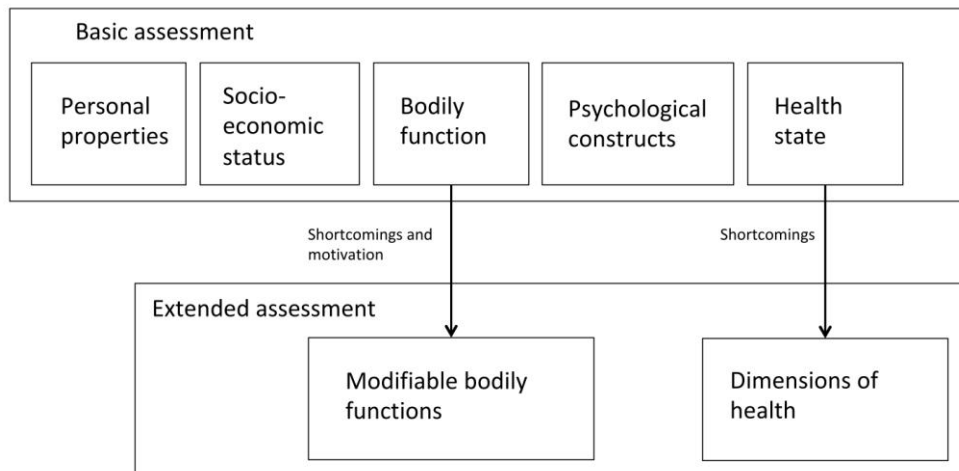


Figure 4. Stepwise user state assessment model

We also elicit **metrics to be used for the risk awareness tool** and suggest outcome measures to be used in the evaluation of the trials.

Metrics are described in terms of source and evaluation properties. Source is how the metric comes about, and by whom. Evaluation property is how and when the metric may come into use.

In WellCo, we make use of **six different sources to quantify the determinants of health**, mentioned above (1-4); (a) **questionnaires and surveys, implying self-reporting**, (b) **smartphone and other personal wearable sensors**, (c) non-wearable, **environmental sensors**, (d) **individual's electronic patient records (EPR)**, (e) **national health registers** and (f) **lab tests** and other medical technology-reported measures. These can be imputed by the patient, a clinician (physician, nurse or other formal caregiver), an observer (informal care giver or a partner), and other users of the system (crowd).

The user state model for WellCo is employed along four different health state evaluation approaches: (A) at the study baseline, (B) along the study implying continuous user's monitoring, (C) for an interval-based user's assessment, (D) at the study end. **Baseline information includes all necessary information about the user to elicit a first suggestion of the risk for to be used in the risk awareness tool and the information that is needed for the recommender system to e.g., rule out recommendations.** Monitoring is the on-going assessment of the user state that may feed into the risk awareness tool and the recommender system as well as feed into the user dynamic model and the user behaviour model. Interval may be used for proxy outcomes, both patient-reported and clinic-based, suggesting short-term changes that may lead to longer-term outcomes. End evaluation focuses on the longer-term outcomes that relate to health-state and functioning.

Appendix 1 presents all information on the user assessment model and the metrics.

3.1 Health as the ability to adapt and self-manage

The Institute of Positive Health (IPH) has developed a tool to specifically assess health as the ability to adapt and self-manage. However, the tool has yet to undergo scientific validation. The tool includes 32 questions related to the aspects of health and answered on a visual analogue scale (VAS) scale ranging from 0 to 10. The questions are short and easily understood, and may be translated to other languages than Dutch using forward and backward translation.

The **WHOQOL-100** and the short version **WHOQOL-BREF** is probably the scale that comes closest to the one developed by the Institute of Positive Health [15,19]. WHOQOL-BREF can be extended with WHOQOL-OLD for people above age 60 [20]. WHOQOL-OLD include six domains; intimacy, sensory abilities, autonomy, past, present and future activities, social participation, death and dying. WHOQOL is open source.

SF-36 is another measure of health. SF-36 is a validated and widely used tool to measure health. SF-36 comprises of eight domains of health: vitality, physical functioning, bodily pain, general health perceptions, physical role functioning, emotional role functioning, social role functioning, mental health. SF-36 comes in a shorter version (SF-12). SF-36 and SF-12 are licensed by RAND health; although free for research use, fees apply for commercial use.

Two shorter measures of health and quality of life is the **EuroQoL (EQ-5D)** and the **COOL/WONCA scale** [21,22]. Both scales are known to **make use of visuals when imputing data**.

The EQ-5D comprises five dimensions: mobility, self-care, usual activities, pain/discomfort and anxiety/depression that can be answered on a 5-point or 3-point scale combined with a VAS scale for self-rated health [21]. EQ-5D is under license from the EuroQoL group.

COOL/WONCA is a visual and user-friendly tool that measure functional status in 6 domains [22]. Functional status is defined as: 'the ability of a person to perform and adapt to the individual's given environment, measured both objectively and subjectively over a stated period of time'. The domains cover Physical Fitness, Feelings, Daily Activities, Social Activities, Change in Health and Overall Health. COOL/WONCA is free to use for research.

Finally, the **PROMIS Global Health measure** is a 10-item scale that measures overall health state. The PROMIS Global Health score may be mapped to EQ-5D scores.

All scales are patient-reported and may be used at baseline and end evaluation. Furthermore, **except from the IPH construct, all scales are multilingual**.

3.2 Dimensions of health

3.2.1 Bodily functions

"A person's level of functioning is the dynamic interaction between her or his health conditions, environmental factors, and personal factors. It is a biopsychosocial model of disability, based on an integration of the social and medical models of disability." ICF, WHO 2001

Medical facts, medical observations, physical functioning, complaints and pain, and energy describe the dimension bodily functions. It comprises objective aspects such as behaviour, the physical functioning of the organs, body composition and disabilities, manifest diseases and management hereof, and more subjective aspects such as pain and energy. Modifiable bodily functions comprise health risk behaviours, biomarkers, muscle strength, pain, disabilities such visual and hearing disabilities, and some few non-communicable diseases such as type-2 diabetes mellitus. Moreover, the impact of bodily functions may be influenced by lack of health interventions such as the availability of certain medicine or surgical procedures, technical aids such as hearing aids or environmental barriers such as physical structures, social norms or economic incentives.

Medical facts, medical observations, physical functioning, complaints and pain, and energy are somewhat overlapping terms that may be difficult to separate completely. Medical facts may include health risk behaviour, biomarkers and diseases, yet physical functioning may be described under the heading of biomarkers, as blood pressure is a marker of vascular functioning. Furthermore, pain may be described as a physical functioning, a medical fact and a medical observation. As such, affiliation is in the eyes of the beholder.

We use internationally recognized classification systems that have been endorsed by The United Nations (UN) and promoted by WHO as the starting point for the assessment of bodily functions. These are

- **International Classification of Diseases (ICD);**
- **International Classification of Functioning, disability and health (ICF);**
- **International Classification of Primary Care (ICPC);**
- **International Classification of Health Interventions (ICHI) (draft version);**
- **Anatomical Therapeutic Classification (ATC).**
- ICD was developed by the WHO and comprises five levels that **describe diseases originating from each organ system**, and in different stages of life, down to the single medical condition. It is available in version 11 (ICD-11) that also include codes referring to functioning. ICD-11 codes are searchable from <https://icd.who.int/>
- ICPC was developed by the World Organisation of Family Doctors (WONCA) for use in the primary care sector and is not as comprehensive as ICD-11. ICPC is **described according to the body systems** and comes in a second version ICPC-2. A main feature of primary care is to coordinate treatment and assess the patients. Beyond codes for specific diseases related to the body systems, ICPC-2 includes process-codes and symptoms-codes that describes the patient flow. ICPC-2 codes may be mapped to ICD-11 codes. ICPC-2 codes can be found on <https://ehelse.no/icpc-2e-english-version#icpc-2e-download->
- ICF was too developed by the WHO [23]. It consists of two parts. One part **describes the bodily functions and disabilities** and comprises two components. One component describes the bodily functions and disabilities from the perspective of physiological functioning and anatomical structures. The other component from the **activities and participation that is restricted due to the malfunctioning of the body**. Capacity and Performance can be used to describe the activities and participation. Capacity relates to what an individual can do in a ‘standardised’ environment. Performance relates to what the person actually does in his or her current (usual) environment. The gap between capacity and performance reflects the difference between the impacts of current and uniform environments, and thus provides a useful guide as to what can be done to the environment of the individual to improve performance. The second part also comprise of two components. One describes the environmental factors that may act as facilitator or barrier to activities, the other the personal factors such as biological properties and SES. ICD and ICF are complementary. ICF codes can be found on <http://www.who.int/classifications/icf/en/>
- ATC codes are used to **describe substances (the content, not the trademarks) from their effects on body systems**. Beyond information on the substance, ATC provides information on defined daily doses (DDD), units and route of administration. ATC codes can be found on https://www.whocc.no/atc_ddd_index/
- **ICHI relates to health interventions**. A health intervention is an act performed for, with or on behalf of a person or population whose purpose is to assess, improve, maintain, promote or modify health, functioning or health conditions. ICHI is currently in a draft version.
- Other classification systems are **SNOMED-CT for health care terminology and an alternative to ICHI**, and the ISO9999 for the classification of technical aids for persons with disabilities. However, only some countries have a license to SNOMED-CT. Spain and Denmark are members, Italy is not. SNOMED-CT codes may be mapped to ICF.

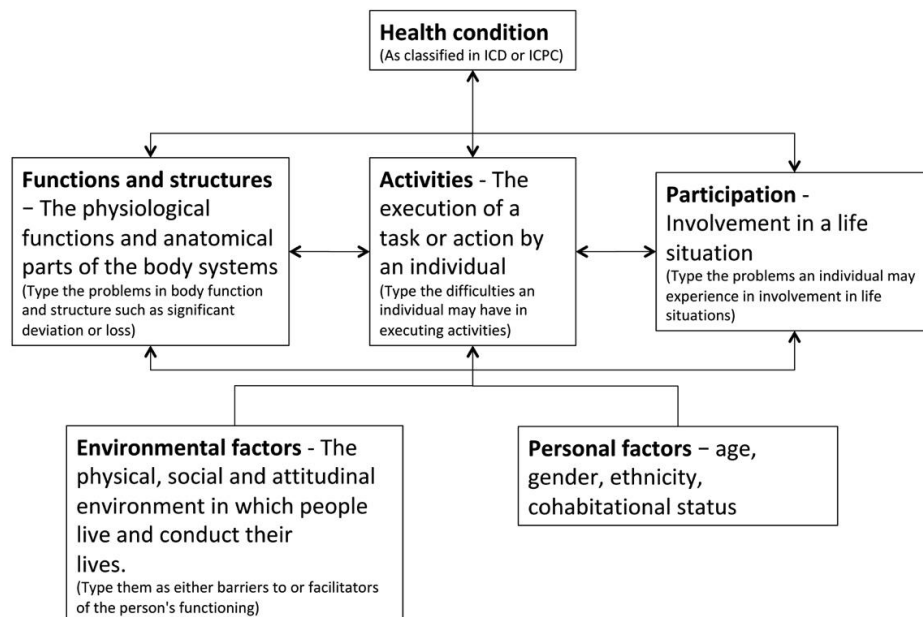


Figure 5. Conceptual model of ICF

Overall assessment of function may benefit from taking the conceptualization of functioning and disability from ICF as the starting point. This is both because it provides a structured assessment of the user, but also because this is a recognized approach in the assessment of functioning for health care professionals. The overall assessment of functioning may be done by the WHODAS 2.0 questionnaire, that can be self-reported or reported by the virtual coach, or a formal or informal caregiver, and supplied by information on diseases, biomarkers and health risk factors [24]. The WHODAS 2.0 is widely translated and quantifies the disability level (the gap between capacity and performance) in six domains of functioning; cognitive, mobility, self-care, participation, getting-along, life-activities. WHODAS 2.0 may be accessed from <http://www.who.int/classifications/icf/en/>

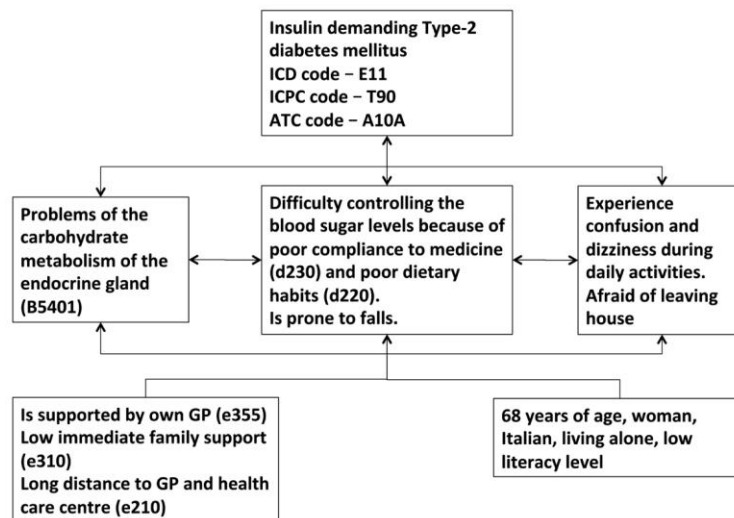


Figure 6. Example of an ICF conceptualization of a user

In the following, we **focus on the modifiable functions and how these may be assessed**. The section is divided into the following sub-sections; **Health risk behaviours, biomarkers and physiological markers that includes pain, diseases and health interventions**.

3.2.1.1 Health risk behaviours

Health risk behaviours are probably the most important determinants of morbidity, quality of life and mortality [25]. However, they are difficult to change on an individual basis, as they demand quite some agency. Interventions aimed at reducing health-risk behaviour are effective on an individual level, or a specific sub-group level, however population-level long-term effects of individual-oriented interventions are negligible, especially when applied to individuals at low-risk of e.g. cardio vascular disease (CVD) [26].

Health-risk behaviours mostly refer to physical activity, dietary intake, smoking, alcohol consumption and sleep. Health-risk behaviours are highly influenced by environmental factors; physical structures such as bike lanes and green areas, social norms and culture around e.g. dietary habits, political awareness and support to health such as age limits to sale of cigarettes and alcohol, and economic incentives such as taxes.

Clustering of health risk behaviours is common, especially among persons of low SES. Health risk behaviours seems mainly to be clustered into addictive behaviours such as alcohol and smoking, health promotion behaviours such as diet and physical activity, or all health risk behaviours together [27]. However, it is not evident if a single health risk behaviour approach, such as targeting diet but not physical activity, or a multiple health risk behaviour approach that target all health risk behaviours at a time, is the most effective [28]. Furthermore, it is not evident whether you should intervene sequential (one at a time) or concurrent (all at the same time). Yet, what is evident is that lower SES is linked to higher prevalence of health risk behaviours [27].

Overall **health risk behaviours may be assessed by self-report, from EPR systems or from devices**, however information on health risk behaviours is mostly absent from EPR systems. Self-report assessment may be performed in a step-wise manner with an initial assessment of the presence of health risk behaviours or not, that is, poor diet, sedentary behaviour, smoking, high-risk alcohol consumption or poor sleep. If the health risk behaviour is present a more

throughout assessment of the particular behaviour. In this way we may limit the width of the assessment and focus the attention on the relevant health-risk behaviours.

3.2.1.1.1 Physical activity and sedentary behaviour

Participation in regular physical activity reduces the risk of coronary heart disease and stroke, diabetes, hypertension, colon cancer, breast cancer and depression [29]. Additionally, physical activity is a key determinant of energy expenditure, and thus is fundamental to energy balance and weight control.

Physical activity increases muscle, cardio-vascular and lung functioning and can have a clinical effect either by directly affecting pathogens (e.g. in type 2 diabetes, claudicatio intermittent and ischemic heart disease), by improving the predominant symptoms of the basic disease (e.g., chronic obstructive pulmonary disease), or by to increase the condition, strength and hence the quality of life of patients who are weakened by disease (e.g. cancer). For some diseases, the disease may be a barrier to being physically active so that the patient does not achieve the positive effect on the prevention of other diseases.

Physical activity may be estimated from the frequency, duration, intensity and weight ending up in a measure of energy expenditure from taking part in physical activities [30].

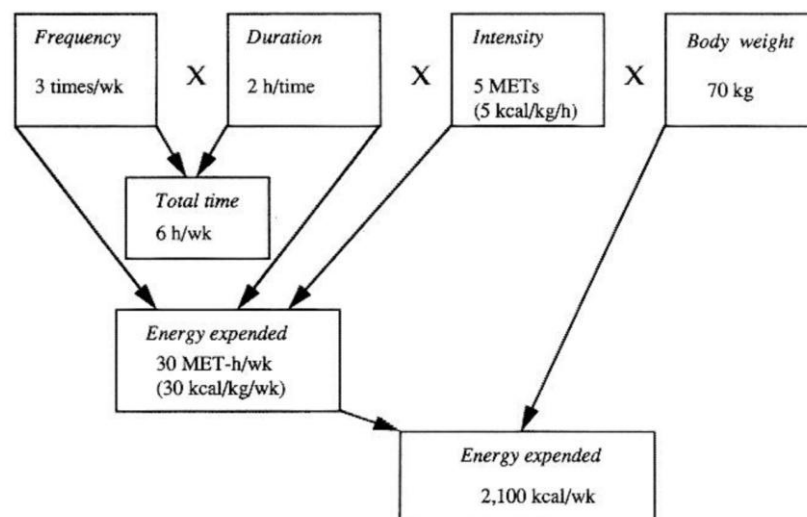


Figure 7. Estimates of physical activity

The **recommendations for physical activity among people of old age (above 65) is at least 150 minutes of moderate-intensity aerobic physical activity, or at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week, or an equivalent combination of moderate- and vigorous-intensity activity [31].** Aerobic activity (cardio) should be performed in bouts of at least 10 minute duration. **People with poor mobility** should perform **physical activity to enhance balance and prevent falls on 3 or more days per week.** Muscle-strengthening activities should be done involving major muscle groups, on 2 or more days a week. Evidence-based training schemes varies according to the medical condition. When the recommended amount of physical activity is not achievable due to medical conditions, the person should be as physically active as their abilities and conditions allow.

Physical activity can be assessed in a number of ways, either using self-report questionnaires, activity logs or diaries, observation, formal tests such as the VO₂-max test of level of fitness or monitoring of distance, steps or heart rate by some device [32]. However, self-report questionnaires have shown moderate validity and reliability in reviews

[33], with the evidence being especially poor when targeted elderly people [34]. Furthermore, due to the poor validity and reliability of self-administered questionnaires, it is recommended to **use both self-report questionnaires and accelerometers when assessing physical activity** [35].

The initial assessment may be performed by a four-category question on leisure time physical activity (sedentary/low/moderate/high) [36] or “*Do you usually daily have at least 30 minutes of physical activity at work or during leisure time (including normal daily activity)? (Yes/No)*” [37]. If the user answers sedentary/low leisure time physical activity or no to 30 minutes of daily activity these questions may be followed up by e.g. the International Physical Activity Questionnaire (IPAQ), Physical Activity Scale for the elderly (PASE) or a similar validated scale [38,39].

An even more in-depth assessment may come from monitoring physical activity using accelerometers during an interval of e.g. one or two weeks using a device.

Physical activity may be assessed at baseline and end with self-report questionnaires, and can be followed-up at certain intervals or continuously monitored using devices. Formal test results of diary/activity logs provided by formal caregivers may compliment the information gained from self-report questionnaires and devices.

3.2.1.1.2 Diet

Dietary behaviour is influenced by social, cultural or religious norms related to dietary habits, mainly in the family, but also at the level of the workplace, the cultural belonging, and national norms of healthy and balanced dietary habits. A healthy and balanced diet reduces the risk of obesity, type-2 diabetes, CVD and some cancers; it increases QoL and is associated with older age and higher SES [40,41].

A diet basically consists of sugar, fats, vitamins, proteins and minerals. Some sugars are protective to health, such as dietary fibres, other are not, such as refined sugar products and sugars with a high level of fructose. Some fats are protective such as omega 3 and 6 fatty acids from fish; others should be consumed in moderate amounts. Vitamins are mainly found in vegetables and fruit, whereas proteins are found in beans, lentils and meat. Minerals such as salt are found in all types of food products. All types of food products may be added sugars, fats, vitamins, proteins and minerals to e.g. increase its nutritional value in order to benefit the health, or lower the nutritional value to increase product attractiveness.

Dietary recommendations vary from country to country. However, according to WHO a healthy diet is a diet where

- At least 400 g (5 portions) of fruits and vegetables a day (2). Starchy roots such as potatoes, sweet potatoes, and cassava are not classified as fruits or vegetables.
- Less than 10% of total energy intake should be from sugar equivalent to 50 g (or around 12 level teaspoons). Most sugars are added to foods or drinks but may also be found in sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates.
- Less than 30% of total energy intake from fats. Unsaturated fats (e.g. found in fish, avocado, nuts, sunflower, canola and olive oils) are preferable to saturated fats (e.g. found in fatty meat, butter, palm and coconut oil, cream, cheese, ghee and lard). Industrial trans fats (found in processed food, fast food, snack food, fried food, frozen pizza, pies, cookies, margarines and spreads) are not part of a healthy diet.
- Less than 5 g of salt (equivalent to approximately 1 teaspoon) per day (6) and use iodized salt.



Disease specific dietary recommendations, other than the ones described above, apply, as well as recommendations for vulnerable elderly people.

Dietary behaviour is likely the most difficult behaviour to assess [42]. Dietary behaviour may be assessed according to energy intake (quantity) or dietary pattern (quality). Both approaches inform the WHO recommendation and are usually assessed by dietary recall diaries and/or dietary quality scores. Basically, both approaches assess adherence to dietary recommendations. Analysis of dietary recall and dietary quality scores may hence change according to the current recommendations.

Initial assessment of dietary pattern may be done by a simple dietary quality score such as the WHO healthy diet index, the dietary quality score or a simple 4-item score put forward by the Swedish health and social authorities [43–45]. Other scores may also be used [46]. The guideline developed by the DIET@NET consortium may be used to choose the most suitable score [47].

Subsequently, a **more throughout assessment may be done by a dietary recall diary**, either by **imputing dietary information** such as in <http://www.myfood24.org> or by **photos of foods, bar codes or nutritional facts labels** [48]. Food databases can be found on <https://www.nutritools.org>.

Assessment of dietary behaviour may be done **at baseline and end**, but may **also be done as intervals throughout the study period**.

3.2.1.1.3 Smoking

Smoking is one of the most important causes of CVD and cancers and is influenced by the social, political and economic environment. Lower SES is associated with higher prevalence of smoking.

The recommendation for smoking is clear. Overall, individuals shall not smoke and avoid being exposed to second-hand smoke. Most people stop smoking on their own, usually after having tried to stop smoking several times. Smoking cessation initiatives such as smoking cessation services and medical treatment have shown to double the cessation rate, however from a low success rate of 3 to 6 % [49,50]. Web-based or online smoking cessation interventions show promising results [51].

Smoking is assessed by gram of tobacco smoked, or more pragmatic, number of cigarette equivalents smoked per day, when the user started smoking (age or year) or maybe eventually stopped smoking (age or year). One stop of pipe tobacco being equivalent to one cigarette. One regular cigar the equivalent of two cigarettes, and one Havana being the equivalent of four cigarettes. The output is package years as a measure of the total exposure.

Smoking behaviour may initially be assessed from asking whether the user is a daily smoker, occasional smoker, stopped smoking or never smoker. If smoker (daily/occasional), the behaviour may be assessed by asking how tobacco is consumed: cigarette, cigar or pipe.

Daily smokers may be asked about age or year started and number of (cigarettes/pipe stops or cigars) consumed a day. Occasional smokers may also be asked about age or year started, yet asked about number of (cigarettes/pipe stops or cigars) consumed per week. People who have stopped may be asked about age or year started and age or year stopped, and number of (cigarettes/pipe stops or cigars) smoked per day when they smoked.

Smoking cessation is mostly defined as six month without having smoked and **may be assessed by self-report or by measuring the level of carbon mono oxide (CO) in expiration air or cotinine in the saliva** [52].



Smoking is an addictive behaviour that is due to the content of nicotine in tobacco. It may also be useful to assess the dependency to nicotine with e.g. the Fagerstrom test of dependency to nicotine [53].

Assessment of smoking behaviour should be done **at baseline and end**.

3.2.1.1.4 Alcohol consumption

Alcohol is a cause of a wide range of diseases including some cancers, neurological diseases and injuries. The social, political and economic environment influences alcohol consumption, and lower SES is associated with higher prevalence of high-risk alcohol consumption.

Alcohol is assessed as units of alcohol measured in grams of pure alcohol, however there is no consensus on how many grams of alcohol is equivalent to one unit (standard drink) [54]. Recommendations for low-risk alcohol consumption hence also vary across countries.

Alcohol consumption **may initially be assessed by self-report by asking how many units the user has consumed during the past week or during a regular week**. Consumption may be assessed on overall number of units irrespective of type of drink or on the different types of drink. Both may benefit from visualizations of the number of standard units contained in a drink. Furthermore, the severity of the behaviour to the health of the user may be assessed by the **Alcohol Use Disorders Identification Test (AUDIT)** on alcohol disorders or the CACE (Cut down, Annoyed, Guilty, Eye-opener) test of alcoholism [55,56].

Assessment of alcohol consumption should be done **at baseline and end**.

3.2.1.1.5 Sleep

Poor sleep is most often comorbid with medical and psychiatric illness and complicated by the polypharmacy conventionally associated with them. Information on diseases and medical treatment is vital to an assessment of sleep. Good sleep may result in significant improvement in quality of life and daytime functioning. **Sleep behaviour may be assessed by self-report (questionnaires or diaries) or by objective measures** [57,58].

An initial assessment of the quality, quantity and timing of sleep may include questions such as; *Do you feel you get enough sleep? Do you feel refreshed after a night of sleep? Do you sleep at regular times that fit with your preferred daily schedule?* Further assessment may be performed according to the recommendations of Bloom et al., e.g. the **PSQI** or **monitored by a device**, however the validity of consumer devices seems questionable [57].

Assessment of sleep may be **done at baseline, interval, and end, and/or monitored**

3.2.1.2 Biomarkers and physiological markers

Biomarkers and physical functioning relates to the objective functioning of the body systems such as the muscular, lungs, heart, eyes, ears, liver, kidneys, digestive, neurological and vascular system. Some of these functionings relate to biomarkers, such as blood pressure and lipids for the vascular system, forced vital and expiration volume for the lungs, and a number of chemical markers for the kidneys and liver. Others relate to physiological markers such as muscle strength, body mass index (BMI), pain and visual and hearing impairments. Biomarkers and physical functioning are influenced by age, genetics and health risk behaviours and influence on the prevalence and seriousness of disease, ADL, QoL, social and societal participation. Biomarkers and physical functioning are usually used as proxy outcomes for either the effects of behaviour change or therapeutical intervention on health and disease.

Biomarkers and physical functioning is included in the ICF, ICPC-2, ICD-11 and SNOMED-CT classification systems and may be extracted from EPR systems or home-monitoring.

In the following we describe the most important biomarkers and physical functionings for the assessment of bodily functions in WellCo. These are based on reviews of determinants of healthy ageing and consist of bodily appearance and the muscle, cardio-vascular, lung, hearing and visual functioning.

3.2.1.2.1 Bodily appearance (weight maintenance function)

Bodily appearance is mainly influenced by the physical activity level, diet and genes/epigenetics. Smoking can reduce the BMI as smoking increases the metabolism and increases the weight to the normal weight level without increased metabolism. Some diseases and medications may also alter the bodily appearance such as metabolic and thyroid diseases, and anti-depressants, anti-psychotics, beta-blockers and anti-histamines. The risk of obesity and the prevalence of people who are obese is highly influenced by environmental factors such as availability of opportunities for exercise or sports, unhealthy diets, taxes, and social and cultural norms of certain diets and sedentary behaviour.

The appearance of the body can be described by the BMI, waist circumference, waist/height ratio, or waist/hip ratio with different cut-off point for different ethnic groups [59]. The measures may all predict morbidity and mortality, though waist circumference seems superior as BMI does not discriminate between muscle mass and fat [60–62]. BMI is calculated from the height and weight (weight in kg/(height in meter)²). A BMI above 27.5, a waist circumference above 102 for men and 88 for women, a waist/height of above 0.6 for people above age 50, and a waist/hip of above 0.90 for men and 0.85 for women seems to pose an increased risk of CVD or metabolic complications [59]. Hip circumference must be measured on the widest point around the buttocks. Waist circumference must be measured just between the top of the hipbone and the lower rib. All measured in centimetre.

	Body mass index	Obesity class	Disease risk (relative to normal weight and waist circumference)	
			Men < 102 cm Women < 88 cm	Men >102 cm Women >88 cm
Underweight	<18.5			
Normal	18.5–24.9			
Overweight	25.0–29.9		Increased	High
Obesity	30.0–34.9	I	High	Very high
	35.0–39.9	II	Very high	Very high
Extreme obesity	>40.0	III	Extremely high	Extremely high

Indicator	Cut-off points	Risk of metabolic complications
Waist circumference	>94 cm (M); >80 cm (W)	Increased
Waist circumference	>102 cm (M); >88 cm (W)	Substantially increased
Waist-hip ratio	≥0.90 cm (M); ≥0.85 cm (W)	Substantially increased

M, men; W, women

Figure 8. Cut-off points for different measures of bodily appearance

3.2.1.2.2 Muscle functioning

Muscle functioning refers to the strength and endurance of the muscles. Good muscle functioning is associated with better quality of life, better capability to perform activities of daily living (ADL) and take part in social activities. Muscle functioning is mainly influenced by physical activity and level of fitness.

Muscle functioning may be assessed from scales or tests such as the grip strength, sitting tests, stair test or walking speed [63].

3.2.1.2.3 Cardio-vascular functioning

The cardio-vascular system refers to both the heart functioning and the vascular functioning. It is assessed from the blood pressure and the levels of lipids in the blood. Blood pressure is divided into the systolic blood pressure during a heartbeat and the diastolic blood pressure during heart rest. Lipids are divided into cholesterol and triglycerides. Cholesterol is furthermore divided into total cholesterol, low-density lipids (LDL) and high-density lipids (HDL). LDL is harmful, whereas HDL is protective to health.

Cardio-vascular functioning **is assessed as the overall risk of cardio-vascular diseases using absolute risk scores that may include measures of blood pressure, lipids, age, gender, SES and co-morbidities**. Treatment is determined from the overall risk and from the level of LDL [64].

3.2.1.2.4 Metabolic functioning

The metabolic functioning influences on the risk of CVD and is influenced by health risk behaviours. Metabolic functioning is assessed from the level of sugar in the blood or from markers of blood sugars levels [65]. Type-2 diabetes is defined from an HbA1c of above 6.5% or 48 mmol/mol. Fasting glucose level (FPG) of above 7.0 mmol/L or 126 mg/dL. Two-hour fasting glucose level (2hPG) of above 11.1 mmol/L or 200 mg/dL.

3.2.1.2.5 Lung functioning

Lung functioning influences on the ADL, social participation and QoL and is influenced by smoking, exposure to environmental factors and genes. **Lung functioning is assessed from the volume of air that may be inhaled (Forced vital capacity (FVC)) and the air that may be exhaled during one second (Forced expiratory volume (FEV1))**. Diseases of the lungs are defined by different measures of the lung functioning. Chronic obstructive Pulmonary Disease (COPD) is defined as a FEV1/FVC rate of below 0.7 [66].

3.2.1.2.6 Hearing functioning

Hearing loss is the third most prevalent chronic condition in older adults and has important effects on their physical and mental health [67]. Hearing **may be assessed by an audioscope or by self-report using the Hearing Handicap Inventory for the Elderly (HHIE)**[67]. Hearing

loss is determined from the overall score of the HHIE. The HHIE is validated in Spanish and Italian [68,69].

3.2.1.2.7 Visual functioning

No known obvious or accessible assessment approach.

3.2.1.2.8 Neurological functioning

Chronic pain has a major impact on physical, emotional, and cognitive function, on social and family life, and on the ability to work. **Pain can be initially assessed from a simple VAS or numerical scale.** More throughout assessment by questionnaires may be performed in the presence of pain [70].

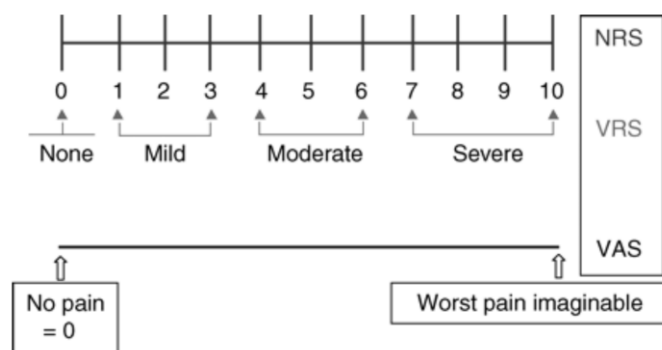


Figure 9. VAS pain scale

3.2.1.3 Diseases

Diseases relates to abnormalities in the body systems. Diseases are basically categorized into 1) traumas, 2) communicable diseases that are caused by microorganisms and may be transferred between people, 3) non-communicable diseases that cannot be transferred between people and are caused by genetic, environmental and/or behavioural factors, 4) congenital diseases that are caused by genetic factors or impacts to the foetus during pregnancy, 5) neoplastic diseases that are divided into benign and malign, where the malign versions are also labelled cancers. Cancers may be categorized as both non-communicable and communicable diseases and may be caused by microorganisms, genes, and environmental and behavioural factors. The importance of a single determinant of disease such as smoking for CVD, the BRCA gene for breast cancer or papilloma virus for cervix cancer is termed the aetiological fraction. For non-communicable chronic diseases behavioural factors may amount to up to 70 % of the aetiological fraction, for cancers in general behavioural factors amount to up to 40 % of the aetiological fraction [25].

Diseases may be assessed from the EPR using the ICD-11 and ICPC-2 classification systems and may be mapped between the two. However, as classifications are often used as part of a fee-for-service payment scheme ICD and ICPC-2 codes may be both incomplete and false. ATC therapeutic codes may complement ICD and ICPC diagnostic codes in order to assess diseases from the EPR.

Furthermore, in the absence of access to EPR information diseases may be assessed by self-reporting. A common question in surveys is *“Have you ever been told by a medical doctor that you have [disease]”*. **Clinical assessment from classification codes and self-reported assessment tend to differ and precautions should be taken when using either two [71]. The patient may validate the available clinical information, whereas a formal caregiver may validate self-reported information.**



3.2.1.4 Interventions

Health interventions basically include all follow-up of patients by the health care sector be it health promotion, disease prevention, treatment or rehabilitation. These are assessed according to which interventions are available, which intervention is received and whether it is followed as recommended. As such, compliance/adherence to, or self-management of, behaviour change and therapeutic treatment both comprises agency from the patient and may fail without the appropriate motivation, capability and opportunity. Beyond an assessment of compliance/adherence/self-management, assessment of possible side effects from therapeutics may be assessed, as these may be causes to shortcomings in other dimensions of health such as pain and ADL.

Health interventions are described in the International Classification of Health Interventions (ICHI) ([ICHI classification](#)) or the **SNOMED-CT classification system** ([SNOMED-CT](#)). ICHI is currently in a draft version and is as such yet to be implemented. SNOMED-CT is currently the most widely used classification system, yet it is not used in all European health care systems. **Behavioural interventions are moreover classified in the Behaviour Change Taxonomy** ([BCT](#)) system [72].

Furthermore, **therapeutic interventions may be identified using the Anatomical Therapeutic Classifications (ATC)** classifying all medicines according to the bodily system, active substance, and daily dose, and is as such generic across trademarks and national borders. Assessing what therapeutics people receive may be difficult in many health care systems, as this information is often imputed in parallel systems defined by the prescriber (pharmacy, general practitioner (GP), hospital, social care). Providing the name of the medicine, a photo of the barcode, or the pill, may identify what medicine the user is prescribed and consumed. However, such interventions depend on the existence of an appropriate reference database. This approach may also be used for supplements such as vitamins, minerals and the like.

Digital interventions in the form of Apps and the like have shown to improve compliance/adherence to health interventions [73]. Furthermore, availability of health interventions may be assessed using some form of crowd-sourced information.

Therapeutic treatments, and compliance, should be assessed at baseline and continuously updated. Availability may be assessed by a small and random selection of users on an on-going basis.

3.2.2 Mental functions and perceptions

“Mental health is defined as a state of well-being in which every individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community.” WHO

Mental functions and perceptions are described by cognitive functioning, emotional state, esteem/self-respect, experiencing to be in charge, self-management, and resilience or sense of coherence.

In the following, mental functions and perceptions are described as mental functioning, cognitive functioning and psychological constructs. This is because the aspects of health described in this dimension are somewhat overlapping concepts that may be either assessed in a concordant use of constructs or from one superior construct.

3.2.2.1 Mental functioning

Mental functioning is both influenced by and influences SES, health-risk behaviours and diseases. Poor mental functioning reduces QoL, social and societal participation and ADL, whereas spirituality seems to be protective to mental functioning.

Mental functioning may be assessed as a positive concept in the form of mental health or mental wellbeing. The SF-12/SF-36 mental health items, the WHO-5 wellbeing index or the Short Warwick-Edinburgh Mental Wellbeing Scale (SWEMWS) may be suitable scales [74,75]. Furthermore, mental wellbeing may be assessed as a negative concept in the form of stress, anxiety and depression. These negative concepts may be assessed by the short Perceived Stress Scale (PSS-4), the Short Patient Health Questionnaire (PHQ-4) or the Major Depression Inventory (MDI) [76–78]. A third approach may be an initial assessment with the PSS-4 combined with PHQ-4, or WHO-5 wellbeing index combined with MDI [76,77].

Mental functioning may be assessed by self-report at baseline and end.

3.2.2.2 Cognitive functioning

Cognitive functioning is ultimately about brain functioning: How the brain processes information into memory, language, speech, and movement. Cognitive functioning may be protected by high educational attainment and intellectual activities, healthy diet, physical activity, sleep, ADL, QoL, social participation, spirituality, and by the immune system and the gut flora [79–81]. Poor cognitive functioning is a trait in dementia diseases such as Alzheimer disease.

Cognitive functioning is assessed clinically using a number of different tests that assesses memory, language, speech, and movement. Cognitive functioning may be **assessed by constructs such as the Memory Failures of Everyday Life, Mini-mental state examination (MMSE), and the Everyday cognition scale [82–84].** None of these constructs may be used as diagnostic tools in themselves - only **in conjunction with a clinical assessment**. Digital cognitive assessment is an emerging field that is still in its infancy but with promising prospects [85]. **Cognitive functioning may be assessed at baseline and end.**

3.2.2.3 Psychological constructs

Psychological constructs have basically been developed to assess the capacity to cope with changes (self-evaluation) and to assess the knowledge, skills, intentions and ability to self-manage your life, lifestyle and disease(s) (self-management). Assessment of the capacity to cope is believed to include four constructs, namely neuroticism, locus of control, self-esteem and self-efficacy [86,87]. The processes that transfer the knowledge, skills, intentions and ability to self-manage and make changes for a healthier lifestyle or greater compliance to medical treatment have been described in a number of models such as the health belief model, theory of planned behaviour, theory of reasoned action, transtheoretical model of stages of change. However, all of these models have been compiled in the work that have lead to the theoretical domains framework and the behaviour change wheel (BCW) [88,89]. A large number of constructs have been developed to assess these processes. One or more of these may be valuable to include when evaluating WellCo.

3.2.2.3.1 Self-evaluation

Locus of control is a measure of the degree to which people believe that they have control over the outcome of events in their lives, as opposed to external forces beyond their control and may **assessed by the Multidimensional Health Locus of Control scale (MHLC) [90].**

Self-esteem is an individual's overall subjective emotional evaluation of his or her own worth and may be assessed by the Rosenberg self-esteem scale [91].

Self-efficacy is an individual's belief in his or her innate ability to achieve goals [92]. Individuals with high self-efficacy will exert sufficient effort that, if well executed, leads to successful outcomes, whereas those with low self-efficacy are likely to cease effort early and fail in their effort. Self-efficacy determine whether health behaviour change will be initiated,

how much effort will be expended, and how long it will be sustained in the face of obstacles and failures. With increased self-efficacy, individuals have greater confidence in their ability and thus are more likely to reduce health-risk behaviours. Self-efficacy is modifiable and may impact on adoption, initiation and maintenance of healthy behaviours and treatments. Self-efficacy may be assessed by the general self-efficacy scale or more specific scales on e.g. diabetes [93,94]. The general self-efficacy scale is available in Spanish, Italian and Danish [95].

Finally, yet not being a part of the core self-evaluations, **sense of Coherence (SOC)** was developed by Antonovsky as a main construct of the salutogenic model of health [96]. SOC seems to have an impact on the QoL; the stronger the SOC, the better the QoL, but not necessarily on health-risk behaviour change. SOC also seems to be a stable construct in older adults.

3.2.2.3.2 Self-management

Patient Activation Measure (PAM) is a construct that assesses patient knowledge, skill, and confidence for self-management that is translated into Danish, Italian and Spanish [97–100]. **PAM has shown to be related to changes in health-risk behaviour change and chronic disease self-management.**

Perceived Health Competence Scale (PHCS) assesses the degree to which an individual feels capable of effectively managing health outcomes and have shown good correlation with self-efficacy, QoL and changes in health-risk behaviour [101,102]. PHCS is not translated into Danish and Italian.

3.2.3 Spiritual/existential

The spiritual or existential dimension is described by meaning or meaningfulness, striving for aims or ideals, future prospects and acceptance.

Spirituality is somehow associated with health risk behaviour, however the direction of the association is not clear [103]. Furthermore, people tend to turn to spiritual traditions as they age and experience declining physical health and mental wellbeing [104]. Spirituality influences positively on QoL and has been described as a mechanism to cope with the age decline in health and wellbeing.

Spiritual wellbeing may be assessed by the FACIT-Sp scale that include items on meaning, peace and faith [105]. FACIT-Sp is available in Danish, Italian and Spanish (www.facit.org).

Spiritual wellbeing may be assessed at baseline and end.

3.2.4 Quality of life

“An individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns.”
WHO

QoL is described by wellbeing, experiencing happiness, enjoyment, perceived health, flourishing, zest for life and balance.

QoL is a broad ranging concept affected in a complex way by the person's physical health, psychological state, personal beliefs, social relationships and their relationship to salient features of their environment. QoL have been suggested as a way to operationalize the WHO definition of health as a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity. As such, QoL may both be seen as a dimension of health, as in the definition of positive health by Huber et al., and as an outcome with physical and mental health as core dimensions. In WellCo it **needs to be discussed further how QoL and positive**



health are related, and whether measures of QoL may be used as proxies for the user health state

The most used measures of QoL, such as **WHO-QoL** and **EQ-5D** have already been described in the subsection of section 2 titled “*Health as the ability to adapt and self-manage*”. A narrower concept of QoL is the **Health Related QoL (HRQOL)** that **include measures of healthy days, activity limitations and symptoms** [106]. Parts of the broad conception of QoL, or the HRQOL, may be used for this particular dimension.

Other concepts of QoL include that of QoL for persons with intellectual disabilities where QoL is described using the following domains; interpersonal relations, social inclusion, personal development, physical well-being, self-determination, material well-being, emotional well-being, rights, environment (home/residence/living situation), family, recreation and leisure, and safety/security [107]. However, this scale is only available in Spanish.

Furthermore, another approach is to highlight one aspect of QoL as the most relevant and valuable for WellCo. This aspect may be flourishing or general satisfaction with life. Scales have recently been developed but may not have been translated into Danish, Italian and Spanish [108–110].

QoL may be assessed at baseline and end.

3.2.5 Social and societal participation

Social and societal participation is described by social and communicative skills, meaningful relationships, social contacts, experiencing to be accepted and meaningful work.

The social dimension has been shown to be as strong a predictor of mortality as health risk behaviours such as smoking and sedentary living [111]. Better social relationships have been linked to better health risk behaviours, lower risk of CVD and better compliance to treatment. These effects of social relationships have been proposed to be either explained by greater behavioural and physical resources to adapt to stressors on health (internal), or that supportive social norms and networks influences on cognitive function, emotional health, and behaviours that may lead to a better health state (external) [111].

Social relations and participation comprise constructs such as the social networks, social interactions and the social support of a person from family, friends and significant others. It is **assessed in term of the perceived support (quality) and more objective measures of the magnitude and type of network, support or interaction (quantity)**. Several scales have been developed to assess social relations, including the questions mentioned in the section on personal properties (section 3.3) that apply to family relations (marital status, family relations and children) [111]. The scales on social relations and participation assess concepts such as network, support, loneliness, and participation and may benefit from an initial assessment of the perceived social support from family and friends and social participation followed by a more throughout assessment if low perceived support or low social participation is reported.

How much do you agree or disagree with the following statements?

(Definitely Agree, tend to agree, tend to disagree, definitely disagree)

- *If I needed help, there are people who would be there for me*
- *If I wanted company or to socialise, there are people I can call on*

Social and societal participation may be assessed at baseline and end.

3.2.6 Daily functioning

Basic active daily living (ADL), instrumental ADL (IADL), ability to work and health literacy describe daily functioning. ADL comprise the basic actions that involve caring for one's self and body, including personal care, mobility, and eating [112]. The ability to perform ADLs and IADLs is dependent upon cognitive (e.g., reasoning, planning), motor (e.g., balance, dexterity), and perceptual (including sensory) abilities. There is also the important distinction of the individual's ability to complete the task (physical and/or cognitive ability) versus the ability to recognize that the task needs to be done without prompting (cognitive ability). ADL and IADL are as such strongly related to bodily functions and mental functions and perceptions. **ADL may be assessed by the Physical Self-maintenance Scale**, whereas **IADL may be assessed by the Instrumental Activities of Daily Living Scale (IADLS)** [112,113].

Factors associated with poor work ability are lack of leisure-time vigorous physical activity, poor musculoskeletal capacity, older age, obesity, high mental work demands, lack of autonomy, poor physical work environment, and high physical work load. **Work-ability may be assessed with the Work Ability Index (WAI)**[114].

Health literacy concerns the knowledge and competences to meet the demands of health and may be defined as knowledge, motivation, and competences to access, understand, appraise, and apply health information. The role of health literacy is to make judgments and take decisions in everyday life concerning healthcare, disease prevention and health promotion to improve or maintain QoL during the course of life [115]. SES, mainly educational attainment, bodily functions, age, and social skills influence health literacy. Higher health literacy increases the capability to handle chronic disease and succeed with behaviour change. Health literacy may be seen as comprising three constructs; functional health literacy, interactional health literacy and critical health literacy [116]. Functional health literacy increases participation in health programmes, interactional health literacy enhances the capability to interact with e.g. health professionals, whereas critical health literacy improves empowerment and the capacity to influence wider environmental structures. Health literacy was first developed as a concept to assess the competences to understand and act upon written and verbal health information. These endeavours resulted in **a number of rather complex assessments such as the Rapid Estimate of Adult Literacy in Medicine (REALM) and the Test of Functional Health Literacy in Adults (TOFHLA), the TOFHLA-SF, and the Health Literacy Questionnaire (HLQ)** [115,117–119].

However, the number of digital interventions that we have seen during recent years has given rise to e-health literacy assessments. E-health literacy may be defined as the ability to seek, find, understand, and appraise health information from electronic sources and apply the knowledge gained to addressing or solving a health problem [120]. **E-health literacy may be assessed by the e-health literacy scale (eHEALS)** that is translated into Italian and Spanish, yet not in Danish [121–123]. The eHealth Literacy Questionnaire (eHLQ) was validated in Danish and English [124].

Health literacy is a central concept in the assessment of digital interventions such as WellCo. Nonetheless, health literacy scales are comprehensive. Furthermore, e-health literacy scales are not validated in all languages.

Daily functioning **may be assessed at baseline and end.**

3.3 Personal properties

The personal properties are what we are born with such as the genes, biological sex, ethnicity, epigenetics, prenatal influences, the impact of the course of life as we age through childhood,

adolescence, adulthood and old age and family situation, that is marital status and children. [125]

Age may be the strongest determinant of health, especially among the older ages as risk of disease and death increase markedly in old age. Biological sex set a certain scope of bodily functions, as some diseases are sex specific such as prostate and ovarian cancers. Genes and epigenetics, that is, inherited changes in how genes are expressed and hence how genes alter disease risk, vulnerability to behaviours and contextual factors, and personality, are both unchangeable fundamental biological properties [126]. Height is used to determine the bodily function in the form of BMI and is to some extent given by the genes, but may be impacted over the course of life by behaviour, disease, treatment, SES and environmental factors.

Personality evolve over the course of life and prenatal influences may impact the personality traits we are born with [127]. Personality may impact on the risk of disease and death [128,129]. Especially conscientiousness stands out as a singularly striking predictor of health across the decades of life [130]. Associations between conscientiousness and diverse aspects of health are unsurprising given that conscientiousness reflects constructs that are indicative of deliberative, self-controlled, and goal-directed behaviours, including impulse control, planning, the delay of gratification, orderliness, and the propensity to follow social norms and rules [128]. Contrary, neuroticism seems to be related to reduced self-rated health and mortality [128,129]. Personality may be treated as changeable in line with the dimensions of health as it may be subject to change over the course of life from conscious intervention [131]. Some of the aspects mentioned in e.g. the spiritual/existential dimension (meaning, prospect), QoL (happiness) and the social and societal dimension (social and communicative skills) may also be seen as personality traits.

Assessing the family situation is complex as it comes in more and more forms. Family situation is about partnership and children, the quality of the partnership, and mental stress or pressure put forward by childrearing, caretaking and disease [132]. A particularly strong correlation is found in people living alone and poorer health status with men being especially vulnerable [133]. Contrary, people with supportive partners fare better [132].

Weight may be viewed as a personal property, but also be as a bodily function and a medical fact. Weight is changeable over the course of life and should be treated as such.

3.3.1 Metrics

Age is measured in years at baseline.

Sex is imputed as male/female at baseline.

Ethnicity may be assessed as an objective measure of country of origin or a subjective measure of culture or race [134]. **Ethnicity may be imputed as baseline. Culture and race are sensitive information** and may be prone to special attention from Data Protection Authorities.

Height is measured in cm/in and imputed **at baseline**. Both measures are needed, together with a conversion table.

Weight is measured in kilogram (kg). May be supplied by the user **at baseline and at end**. If relevant, weight may be followed-up on an interval basis or continuously monitored as part of an intervention.

The **personality trait conscientiousness** may be assessed **at baseline** in order to feed into the recommender system, and hereby provide information on users with low conscientiousness who may need closer monitoring and more proximal goals [135]. Personality may be measured by a

number of very brief measures [136–139]. The measure by Gosling et al. is available in Italian, Spanish and Swedish (may be translated into Danish) and is free to use [136]¹.

Family inheritance (as a proxy for genetic and epigenetic influence) may be assessed by asking for diseases that occurred in the nearest family (grandparents, parents, siblings) before the age of 70. At least type-2 diabetes, hypertension, hyperlipidaemia, stroke, heart failure, atrial fibrillation, COPD, anxiety, depression, psychiatric disorders, and dementia should be included. It may also include severe obesity (BMI above 35), osteoarthritis, hearing impairment, and visual impairment. Family inheritance may be assessed by the user at baseline.

Family situation may be assessed in relation to both the quantity and quality. Quantitatively it may be assessed in term of the number of children and cohabitational status. It may be assessed by the following questions “Who do you live with? (you can tick more answers) (husband/ partner/ parent(s)/ child(ren)/ other relatives/ friend(s)/ other/ alone). Do you have children? (yes/no), if yes, how many? Quality may be initially assessed on a 10-point VAS from the questions “How happy is your relationship with your partner, all things considered?”, “How happy is your relationship with your child(ren), all things considered?”, “How happy is your relationship with your parent(s), all things considered?”. If the relationship with the partner is unhappy, then it may be assessed further by a more comprehensive scale such as the marital quality index or the like [140,141]. No validated scales for assessing intergenerational relationships have been found.

3.4 Socioeconomic status

“Socioeconomic status (SES) is a composite of an individual’s economic and sociological situation.” WHO

SES account for a person’s work experience, economic and social position and is primarily based on income, education, and occupation. SES is a powerful determinant of health. As a general rule the wealthy, employed and people of higher educational attainment tend to have a better health state and better health prospects than people of poorer SES [142]. Low SES may hence influence on the risk awareness tool as SES is related to the risk of chronic diseases.

Occupational status is related to health as unemployment may lead to chronic stress and reduced quality of life and may lead to lower income and delays in treatment and poor compliance. If employed, exposures to health risks are related to the industry of the employment. Exposures may be air or particle pollution causing chronic diseases such as COPD, CVD and certain cancers and reduced quality of life, activities of daily living and the opportunity for social participation. Hard physical work or assembly line work may lead to reduced bodily function and musculoskeletal diseases, reduced QoL and social participation. Likewise, sedentary work may lead to chronic diseases such as type-2 diabetes, CVD and reduced physical functioning and from here to lower quality of life, social participation and activities of daily living. Occupational status may influence on the recommender system in terms of when to provide the user with recommendations. E.g. recommendations should not be provided during working hours if the goal is to increase leisure time activity or nutrition. Contrary, if the goal is to reduce sedentary behaviour during working hours or healthier diet in the canteen, then the recommender system should provide recommendations during working hours.

Low income may lead to financial insecurity and chronic stress that increase the risk for chronic diseases such as type-2 diabetes and CVD. Income may also determine the housing situation posing a risk for assaults, air pollution and poor air quality due to e.g. mould. Finally, income is related to the ability to pay for basic amendments and social activities hereby reducing the

¹ <https://gosling.psy.utexas.edu/scales-weve-developed/ten-item-personality-measure-tipi/>

quality of life, and treatments that may create a delay in health seeking and reduced compliance to medical treatment. Low income may influence on the recommendations from the recommender system as it may prioritize free activities compared to commercial or paid activities.

Educational attainment is directly related to employment status and type of occupation, and income. Low educational attainment is also related to low health literacy and may lead to delays in health seeking and poor compliance to medical treatment or behaviour change. Educational attainment may be a proxy for health literacy if this information is not available. If information on health literacy is available this is a better measure of the complexity or the coaching, and of the recommendations that may be suggested to the user.

3.4.1 Metrics

We may rely on patient reports using questionnaires as the use of national social registries in multisite trials are extensive and resource demanding. We may also rely on both objective and subjective measures as well as singular and composite measures. Objective measures of SES are difficult to translate between countries due to differences in purchasing power and status, and have also been shown to have response bias as the wealthier report lower income [143]. SES is also seen by many people as sensitive information and is hence prone to non-response (although it is regarded as common information in the General Data Protection Regulation (GDPR)). Moreover, the evidence suggests that subjective measures may be a more precise measure of social status than objective measures [144]. On the other hand subjective and composite measures of SES may miss the value that each of the components of SES may bring to the model. SES may be assessed at baseline.

Educational attainment is assessed by the international standard classification of education (ISCED) as primary school/secondary school/high school/vocational attainment/bachelor level university degree/masters level university degree or above [145].

Occupation may be assessed according to International classification of Status in Employment (ISCE) and the International Standard Classification of Occupations (ISCO). In ISCE occupational status may be overall assessed as self-employed/employed/unemployed/retired/Not on the labour market for other reasons. If self-employed we may ask for number of employees. If employed we may assess the occupations from ISCO, or assess the occupation very briefly as unskilled/skilled/clerical/professional/manager. If the user is unemployed we may ask for unemployment benefits/social welfare/none. If retired we may ask for age-related or disease-related retirement. We may also ask for shifting working hours e.g. night shift or changing shifts night/day/evening.

Income may be assessed in a variety of ways, including family income, assessments of wealth and subjective assessments of economic pressure [143]. Family income and wealth may be assessed as both a relative and absolute measure and as both net income, income after taxes and income after taxes and common expenses. Relative measures may be reported as family income or wealth in relation to national income or wealth percentiles, quartiles, median, or mean. Absolute measures may be in the form of yearly household net income, after taxes or after taxes and common expenses, or the wealth of the household in e.g. stocks, bonds, property, business, and loans. Economic pressure can be assessed by asking for household unmet material needs, not to be able to make ends meet, and financial cutbacks made by the household [146].

A composite very brief subjective measure of social status (SSS) is the SES ladder where the user is asked to place herself on a 10 rung ladder where the top rung is the highest social status compared to people of that specific country, and the lowest rung being the lowest social status. **The SES ladder has proven to assess social status very well in a simple and visual way**



[147,148]². The SES ladder can also be transformed into a community ladder where your social status in the local community is assessed or the social status of your community compared to the area/region or country as a whole.

3.5 Environmental factors

“The social determinants of health (SDH) are the conditions in which people are born, grow, work, live, and age, and the wider set of forces and systems shaping the conditions of daily life. These forces and systems include economic policies and systems, development agendas, social norms, social policies and political systems.” WHO

The influence of the wider social, political, physical and economic environment on health have been well documented in the so-called Marmot review [149].

The wider political system is impacting population health [149–151]. E.g. the ruling political party or political philosophy impacts population health where countries ruled by social democratic parties fare better than conservatives, liberals and fascist parties in that particular order [152].

The social environment relates to the cultural milieu, social coherence and trust, and the support and availability of social institutions

When it comes to the **physical environment** it is **about rural or urban location and availability of green areas and opportunities for physical activity**. A systematic review of environmental factors that potentially influence older adults' level of physical activity gave rise to five themes: pedestrian infrastructure, safety, access to amenities such as access to building and green areas, aesthetics, and environmental conditions [153].

Two themes stand out as economic determinants of health: economic equality and prices of amenities such as tobacco, alcohol, healthy diets and housing [149]. More equal countries have better population health status [154,155]. Furthermore, higher taxes on health risk behaviours such as smoking and unhealthy diets, and subsidies of healthy diets, is related to better health [156,157].

3.5.1 Metrics

Environmental factors may be assessed from domain 3 in the WHOQOL-BREV questionnaire or domain 5 from WHOQOL-100. May be assessed at baseline.

One alternative approach may be to **use crowd sourced information on the perceived influence of environmental factors**, such as the perceived trust in others and the state, the perceived attitude towards the governing party in terms of support to population health, the perceived availability of green spaces or bike-lanes, or facts about the prices on cigarettes, alcohol and healthy foods. This information may be collected from a random selection of users on an on-going basis.

Another alternative approach may be to tap into global indexes such as the **better life index** (www.oecdbetterlifeindex.org) that provides figures of environmental factors on a country-level.

² <http://www.macses.ucsf.edu/research/psychosocial/usladder.php>



4 Conclusion

The user state assessment model presented along this document has aimed to provide a **static model of health** that included all determinants of health and aging as described **from a conception of individual health as the ability to adapt and self-manage** and inherent to a larger framework of health **that take social and environmental determinants**, as well as biological properties **into consideration**.

The outcomes from this theoretical user model will be translated into the data models for the data acquired from users, in turn feeding the data into the risk assessment tool and the recommender system with basic facts about the users' health state and determinants of staying healthy. Beyond providing a theoretical user state model, the model defined in this document provides the necessary patient reported metrics for the risk awareness tool, validated metrics applicable in all three trial sites. It also points to metrics that may be used for the ex-ante evaluation with a follow-up period of 6 months to measure the success of the WellCo trials.



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6 Appendix 1- User state assessment model – metrics, sources, data collection and outcomes

Dimension	Aspect	Metric	Modifiable	Source	Data collection
Overall health	Health as the ability to adapt and self-manage (1)	IPH tool	Yes	Questionnaire	Baseline, End (1)
	Health state (1)	SF-36 or SF-12	Yes	Questionnaire	Baseline, End (1)
	Quality of life (1)	WHOQOL-BREV WHOQOL-OLD	Yes	Questionnaire	Baseline, End (1)
	Quality of life (1)	EQ-5D	Yes	Questionnaire	Baseline, End (1)
	Health functionings (1) Global Health measure	COOL/WONCA PROMIS	Yes Yes	Questionnaire Questionnaire	Baseline, End (1) Baseline, End (1)
Bodily functions	Smoking status (1)	Daily smoker/occasional/stopped/never Smoker: age started, cigarettes/day ⇒ package years, daily use Occasional: age started, cigarettes/week ⇒ package years, weekly use Stopped: age started, age stopped, cigarettes/day ⇒ package years, weekly use	Yes	Questionnaire	Baseline, End (1,3)
	Nutritional status	Dietary quality scores Dietary re-call diary	Yes	Questionnaire	Baseline, Interval, End (1)
	Alcohol consumption	Units per week AUDIT CACE	Yes	Question/ questionnaire	Baseline, End (1,3)



	Physical activity	Physical activity scores (leisure-time) Fitness scores (steps, distance)	Yes	Questionnaire Wearables	Baseline, Interval, End (1,2)
	Sleep	Do you feel you get enough sleep? Do you feel refreshed after a night of sleep? Do you sleep at regular times that fit with your preferred daily schedule? PSQI	Yes	Questions/ Questionnaire/ Wearables?	Baseline, End (1,2)
	Bodily appearance	Body Mass Index (BMI) (weight in kg/(height in meter) ²) Waist circumference Waist/hip ratio Waist/height ratio	Yes	Questionnaire EPR	Baseline, End (1,2,3)
	Muscle functioning	Grip strength Walking distance Sitting test Stairs test	Yes	Test	Baseline, Interval, End (1,2,3)
	Cardio-vascular functioning	Blood pressure (systolic/diastolic) (mmHg) Cholesterol (total, LDL/HDL) (mmol/L or mg/dL) Triglyceride (mmol/L or mg/dL)	Yes	EPR/self-report	Baseline, Interval, End (1,2,3)
	Metabolic functioning	HbA1c (mmol/L or mg/dL) 2hFG (mmol/L or mg/dL)	Yes	EPR/self-report	Baseline, Interval, End (1,2,3)
	Lung functioning	FVC (L) FEV1 (L) FEV1/FVC (%)	Yes	EPR/self-report	Baseline, Interval, End (1,2,3)



	Hearing functioning	HHIE	No	Questionnaire/ EPR	Baseline (1,3)
	Visual functioning	-	No	EPR	Baseline (3)
	Cardio-vascular disease	Have you ever been told by a medical doctor that you have had a stroke or ischaemic heart disease?	No	Questionnaire	Baseline, End (1)
		ICD code = E11, ICPC code = T90 Medication ATC = A10	No	EPR	Baseline, End (3)
	Lung disease	Have you ever been told by a medical doctor that you have asthma?	No	Questionnaire	Baseline, End (1)
		ICD code = E11, ICPC code = T90 Medication ATC = A10	No	EPR	Baseline, End (3)
Mental functions and perceptions	Type-2 diabetes	Have you ever been told by a medical doctor that you have Chronic Obstructive Pulmonary Disease (COPD)?	No	Questionnaire	Baseline, End (1)
		ICD code = E11, ICPC code = T90 Medication ATC = A10	No	EPR	Baseline, End (3)
	Type-2 diabetes	Have you ever been told by a medical doctor that you have type-2 diabetes?	No	Questionnaire	Baseline, End (1)
		<i>or</i> ICD code = E11, ICPC code = T90 Medication ATC = A10	No	EPR	Baseline, End (3)
Mental functions and perceptions	Mental functioning	Mental wellbeing (SWEMWS, SF-36 mental, WHO-5)	Yes	Questionnaire	Baseline, End (1,3)
		Mental conditions (Perceived stress, MDI)			



Spiritual/ existential Quality of life Social and societal participation Daily functioning	Cognitive functioning	Memory Failures of Everyday Life Mini-mental state examination Everyday cognition scale Other constructs may also be applied	Yes	Questionnaire/ ests	Baseline, End (1,3)
	Psychological perceptions	General Self-efficacy Scale Locus of control Sense of coherence scale (SOC) Patient activation measure (PAM) Perceived health competence scale (PHCS)	Yes	Questionnaire	Baseline, End (1,3)
	Spirituality	FACIT-Sp	Yes	Questionnaire	Baseline, End (1)
	QoL	HRQoL WHOQOL-BREV EQ-5D	Yes	Questionnaire	Baseline, End (1)
	Perceived social support	Two initial questions on perceived support Scales assessing social network, support, interaction	Yes	Questionnaire	Baseline, End (1)
	Magnitude and type of network, support or interaction	See family situation below (Personal properties)	(Yes)	Questionnaire	Baseline, End (1)
	ADL	Physical self-maintenance scale	Yes	Questionnaire	Baseline, End (1,3)
	IADL	Instrumental activities of daily living scale (IADLS)	Yes	Questionnaire	Baseline, End (1,3)
	Work ability	Work Ability Index (WAI)	Yes	Questionnaire	Baseline, End (1)



Personal properties	Health Literacy	ehealth literacy scale (eHEALS) eHealth Literacy Questionnaire (eHLQ)	Yes	Questionnaire	Baseline, End (1)
	Age	Years	No	Questionnaire	Baseline (1,3)
	Gender	Male/female	No	Questionnaire	Baseline (1,3)
	Height	cm / in	No	Questionnaire	Baseline (1,3)
	Ethnicity	Country of origin Cultural	No	Questionnaire	Baseline (1)
	Personality	Brief personality measures	(Yes)	Questionnaire	Baseline (1)
	Family heritage	“Have any first-line relatives (grandparents, parents, siblings, children) been diagnosed with one of the following medical conditions before the age of 70?” (Type-2 diabetes, Stroke, Ischaemic heart disease, Chronic obstructive Pulmonary Disease, Arthritis, Asthma) (Two or more/One/None/Don’t know)	No	Questionnaire	Baseline (1,3)
	Family situation	“Who do you live with? (you can tick more answers) (husband/partner/parent(s)/child(ren)/other relatives/friend(s)/other/alone). Do you have children? (yes/no), if yes, how many? “How happy is your relationship with your partner, all things considered?” (VAS scale from 0-10) “How happy is your relationship with your child(ren), all things considered?” (VAS scale from 0-10) “How happy is your relationship with your parent(s), all things considered?” (VAS scale from 0-10)	No Yes	Questionnaire	Baseline (1)



SES	Educational attainment	International standard classification of education (ISCED) [145]	No	Questionnaire	Baseline (1)
	Employment status	International Standard Classification of Occupations (ISCO) International classification of Status in Employment (ISCE)	No	Questionnaire	Baseline (1)
	Income	Family income Economic pressure	No	Questionnaire	Baseline (1)
	SES	SES ladder	No	Visual scale	Baseline (1)
Environmental	Social environment	WHOQOL100 – domain 5	No	Questionnaire	Baseline, End (1)
	Economic and political environment	Crowd-sourced Tapping into databases (e.g. OECD)	No	Questionnaire Dataset	Baseline, Interval, End (1)

Outcome measures (see Data collection)

- 1) Patient-reported outcome measure (PROM)
- 2) Performance-based outcome measure (PBOM)
- 3) Clinically-based outcome measure (CBOM)