

# Requirements elicitation for a health monitoring mobile application: a participatory design approach with clinicians and researchers

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## Abstract

Participatory methods have been introduced in healthcare to increase the adoption and acceptance of digital solutions for disease management and health promotion. However, there is not much evidence-based knowledge on how to integrate participatory methods into cohort studies effectively and efficiently. This study reports the results of a health monitoring application requirements elicitation by using a participatory design approach with clinicians and researchers.

An electronic survey containing open-ended questions was developed ad hoc in the research group to address requirements and use(r) purposes of the application. Minor amendments were made after piloting the survey with two researchers. A link to the survey was distributed to clinicians and researchers affiliated with the Faculty of Medicine at University of Oulu. All in all, 28 responses were received between April and June 2024. The responses have been analysed with deductive content analysis.

The analysis identified 25 themes under the four major themes relating to functional, content and ethical requirements of the application and the use(r) purposes of the application. The contents of the application should consider the physical, mental, social and environmental aspects to address the monitoring of holistic wellbeing. The application was preferred to contain diverse functionalities to track and monitor the user's health in an automated manner and through user self-reporting. Extensive measures should be made prior and during the application usage to consider ethical requirements of the application. Purposes of use have been identified to include research, health promotion, personalised health management, diagnostics and policy and decision-making aid.

The mobile application should be developed to entail a comprehensive outlook on the individual's current health status by focusing on automated functions, straightforward interface and ease of use to induce attraction. In the future, participatory design activities will be broadened by involving patient and public

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representatives to the next steps of mobile application development and implementation to further increase the inclusivity and relevance of the application.

**Keywords:** health personnel, mobile applications, participatory design, research personnel, surveys and questionnaires

## Introduction

Participatory design is a co-design approach and an umbrella term for partnered research aiming to involve and engage community and patients in the design and conduct of health research [1]. Research co-design also includes the mindset of designing systems together with the users, not for the users by acknowledging the users' characteristics and needs to generate new knowledge [2,3]. The common factor in co-design is that something is being designed together with people who have different experiences or knowledge than the person who is doing the designing [4,5]. Attaining public views through co-design has been evaluated to hold a vital position in guiding how to design and implement digital solutions into healthcare to ensure the meaningfulness of the service and user needs [6,7]. Involving different stakeholders in the research planning effectively reduces unnecessary research, i.e. research waste [8,9]. By involving diverse types of expertise, researchers can better address the needs of various stakeholders and enhance the relevance of their work [2].

The Stay Healthy Through Ageing (STAGE) project aims to understand ageing with multi-morbidity with a life-course approach by implementing transferable person-centred and artificial intelligence (AI)-enabled solutions for early diagnosis, screening, treatment and long-term management to enhance healthy ageing [10]. One of the tasks in the project is to deliver a co-designed mobile application (STAGE app) which allows passive and active monitoring of an older adult's lifestyle to extract suitable features for risk prediction. Previous

literature has indicated that the use of mobile health (mHealth) apps can advance the patient's active role and contribute to patient empowerment and sense of autonomy in managing own health related issues [11]. Apps to deliver health have also changed the relationship between the clinician and the patient by improving care, yet the importance and significance of data protection is accentuated [12].

Several studies have explored the use of co-design in the development mHealth technologies to deliver health care and monitor health. A review by Eyles et al [13] conclude that in most studies mHealth apps were developed for disease management as compared with behaviour change. Another review by Noorbergen et al. [3] identified that most studies utilising co-design methods focus on mHealth system development in the context of disease management or health promotion, focusing mainly on physical activity, mental health and nutrition. Among the studies included in the review, healthcare professionals were the second most involved group after users, yet other researchers were clearly a minority as a group involved in co-creation. Another study reported findings from focus group sessions where clinicians and users designed together a prototype for a mobile app targeted for the use of mental health service users [14]. The results of the study highlight the importance of co-design in product design and development.

In this study clinicians and researchers were invited to take part in co-design through the requirements elicitation process of the STAGE app [15]. The

STAGE app will be used as an additional data collection tool in the next Northern Finland Birth Cohort 1966 (NFBC1966) follow-up study in 2026-2028 when the cohort population is 60 years of age. Currently the protocol for the follow-up study is under development. In previous follow-up studies the protocol has included extensive questionnaires and clinical examinations [16]. In the next follow-up study, the app will be introduced to the cohort members during the clinical examination day and the participants can voluntarily choose whether they want to start using the app in monitoring their health, according to a separate agreement. As this is the first time the cohort data collection is accompanied by a mobile app data collection, a need for integrating participatory design in the mobile app development process has been proposed to ensure different users' (cohort members, healthcare professionals, researchers) acceptance and adoption.

The purpose of the study was to utilise the method of participatory design with clinicians and researchers to outline the requirements for and use(r) purposes of the STAGE app developed to monitor the older adult's lifestyle, health and well-being. The research questions were: 1) What are the requirements for a data collection application to support a cohort study? 2) For what purposes should the application be used?

## Material and methods

To involve clinicians and researchers in the requirement elicitation phase of the mobile app, an exploratory survey containing five open-ended questions was developed in the research group. This approach was chosen to discover spontaneous and diverse answers and avoid guiding the respondents in their responses [17] by using a method easily and quickly accessible for the respondents [18]. In research co-design, users contribute for example to

the study design through methods such as surveys [1,13] which can be complemented with additional methods. The survey was piloted with two researchers within the project group resulting in minor amendments to the wording of the questions. The open-ended questions were as follows; 'What kind of information about the person do you think is important to collect through the app?', 'How and for what purposes do you think the information could be used for the parties?', 'What functionalities/features do you think the app should have?', 'What kind of ethical issues do you see related to the collection of data with the app?' and 'If there were no constraints, the app would include...'.

For data collection, the online survey was distributed by using the Webropol Survey&Reporting application via an email list to the staff of the Faculty of Medicine at University of Oulu. The survey was accompanied by another survey aiming to invite researchers and clinicians to contribute to the planning of the next NFBC1966 follow-up study. All researchers and clinicians who received the survey were eligible to participate to gather as broadly as possible different perspectives of app requirements and use purposes. Data collection started in April 2024 and finished in June 2024. Two reminder emails were sent to the potential respondents. A total of 28 clinicians and researchers submitted their response to the survey. The respondents identified themselves as researchers/academics (n=10), clinicians and researchers/academics (n=9) and healthcare professionals (n=8). One respondent did not leave a response in the professional background question.

The collected data was analysed with deductive content analysis [19]. The theoretical structure where the unstructured analysis matrix was built on was based on the work of the co-creation working group in the STAGE project and the overall project

plan to identify functional, content and ethical requirements as well as use purposes of the digital tools developed in the project. The collected data was first transferred to a word-file and read several times. Next, the data (meanings responding to the research questions) was inserted into different

sections of the analysis matrix and similar concepts were combined. The concepts (n=179) were further developed into subthemes (n=74) and themes (n=25). Example of how the analysis process proceeded is shown in Table 1.

**Table 1.** Example of the analysis process (theme *physical activity* in major theme *content requirements*).

Direct quotes	Concepts	Sub-theme	Theme	Major theme
'Accelerometer data (most phones have it). This gives a good idea of the amount and intensity of movement.'	Intensity of movement Amount of movement	Amount and intensity of physical activity or exercise	Physical activity	Content requirements
'The amount of exercise' 'Daily exercise'	Amount of exercise			
'Own physical health' 'Physical activity' 'Heart rate variability data and amount of physical activity'	Physical health status Amount of physical activity			
'Daily activity' 'Distance walked' '24-hour activity cycle' 'Impact of physical activity on well-being' 'Information on physical activity throughout the day'	Daily activity	Daily activity and sedentary behavior		
'The amount of standing still' 'Sedentary behavior'	Sedentary behavior			
'Functional capacity, whether there are activity limitations, assistive devices, falls'	Functional capacity Assistive aids Falls	Functional capacity in relation to assistive aid use and falls		

## Results

The analysis resulted in 25 themes under the four major themes representing content (n=7), functional (n=7) and ethical (n=6) requirements for the app and the use(r) purposes (n=5) of the app. The themes are presented in Figure 1.

**Content requirements** include *physical activity, sleep, mental and holistic wellbeing, diet and substance use, environmental factors, social interactions* and *health metrics*. To monitor aspects relating to *physical activity* (Table 1.), the app should track physical activity intensity and amount, daily activity and sedentary behaviour. In addition, functional capabilities, the use of assistive aids and previous falls should be recognised. The app should also entail monitoring *sleep* functions, focusing on duration and quality, heart rate variability and recovery and brain functions during sleep. Monitoring sleep also accounts for monitoring smart phone use to collect information on the user's daily rhythm and sleep disturbances. *Mental and holistic wellbeing* contributes to assessing various psychological aspects of health, such as mood, stress levels, loneliness, psychological resources, motivation, (religious) beliefs, fears, life satisfaction, self-efficacy and self-compassion. For example, one participant described; "*Important to also collect data on factors related to psychological well-being such as stress and self-efficacy, and to include direct measures of well-being such as positive and negative affect*" (researcher). Moreover, holistic wellbeing includes current life situation, meaningful activities, hobbies and conditions or illnesses.

*Diet and substance use* theme entails different aspects relating to eating habits (regularity, variability, shopping information, food consistency) and aspects of eating control (associations to potential eating disorders). Substance use refers to habits of alcohol and tobacco use. The respondents also

perceived that the app could monitor *environmental factors* such as home surroundings, emotions related to certain places, the effect of neighbourhood's characteristics and time of day on activity behaviour and leisure and work time separation based on movement tracking. Moreover, *social interactions* could be monitored to follow social activity and behaviour (active times of the day, how often the person meets friends and family), use of culture services and how social relations affect health behaviour. Social interactions can also be considered to include the experience of social fulfilment and feelings of loneliness. *Health metrics* entails different measurements, i.e. blood pressure, glucose levels and heart rate. This theme also contains various laboratory results, diagnoses, fever, pain, menopause symptoms, medications, infections and anthropometric parameters such as weight development.

Several **functional requirements** were identified to be hoped to be considered when the app is developed, relating to *activity tracking and remote monitoring, gamification, user self-reporting, automated data collection and assessment, personalized recommendations and guidance, data integration* and *user-friendly interface*. The app should entail *activity tracking and remote monitoring* to allow GPS-based movement tracking. More specifically, the functionality would enable real-time monitoring of brain pulse and sun exposure and use different sensors such as nano band-aid. Elements of *gamification* could make the app more intriguing to use by integrating nudging and other gamified elements, memory games or rewards after specific activities or goals have been reached (such as weight loss). *User self-reporting* would allow the user to decide what kind of input or data they want to include in the app; the user could evaluate different activities or sleep, send voice mails, fill diaries on sleep, diet, symptoms or pain or write

free text, as expressed by one participant; “... *the possibility to make simple surveys and mark places on a map and describe their quality in a simple way, including free text*” (researcher). The app could also have options for user-generated feedback on locations and activities and the possibility to use camera functionalities.

Simultaneously, the respondents perceived that the app should require minimal user input and focus on *automated data collection and assessment*. The app should automatically register and record everything it measures, entailing a large variety of different variables in the individual. For example, the app could entail an integrated calculator for overall wellbeing linking to health risk assessments, use facial expression recognition, molecular recognition from the skin and evaluation of different scores (family, nature and relativity). To provide *personalized recommendations and guidance*, the app was hoped to include simple feedback mechanisms and recommendations according to previously asked questions, push notifications and nutritional advice according to previous or chronic conditions. The app could give suggestions for local sports activities, art exhibitions and tailored exercise plans, as well as relaxation and nutrition guidance and how to seek care or conversational advice. In terms of operability, *data integration* refers to the possibility of an open application programming interface (API) allowing linkage to other health monitoring devices and utilization of the data across platforms. There should be the possibility to link 24h activity cycle summaries from the user's own equipment to the app and store the data in cloud services. The respondents also viewed that the app should have a *user-friendly interface* with wireless or unnoticeable sensors and a straightforward yet interesting user interface. A favorable functionality would be the possibility to consult a

healthcare professional directly through the app but most importantly the app should be easy to use.

**Ethical requirements** were identified to entail *user consent, voluntary participation, transparency and purposeful use of information, pseudonymization and anonymization, data security and protection throughout the data life course and truthfulness of the information*. Attainment of *user consent* was considered a vital aspect to enable ethical appropriate data collection and handling. The user of the app should be able to provide consent for data usage, choose what information they want to provide, know how to deny the use of their information and have the possibility to withdraw their consent at any time. The use of the mobile application should be based on *voluntary participation*, where the user voluntarily consents to data collection, usage and sharing which would prevent appearance of ethical dilemmas. The purpose and use of the data collected with the mobile app should be also based on *transparency and purposeful use of information*. The user should know what data is collected, who uses the data, how the data will be used and where the data will be stored. The information cannot be used against the user and tracking functionalities shouldn't be used without user awareness.

Another topic raised by the respondents concerns data *pseudonymization and anonymization*. Questions of data anonymization should be clarified prior to app usage and effective anonymization techniques should be implemented to protect individual identities. The collected data should be stored at minimum as pseudonymized into secured systems. *Data security and protection throughout the data life course* needs to be addressed by adhering to GDPR. Ethical evaluations and approvals should be well planned and conducted before initiating data collection, especially involving IT specialists into the evaluation process. Issues with data

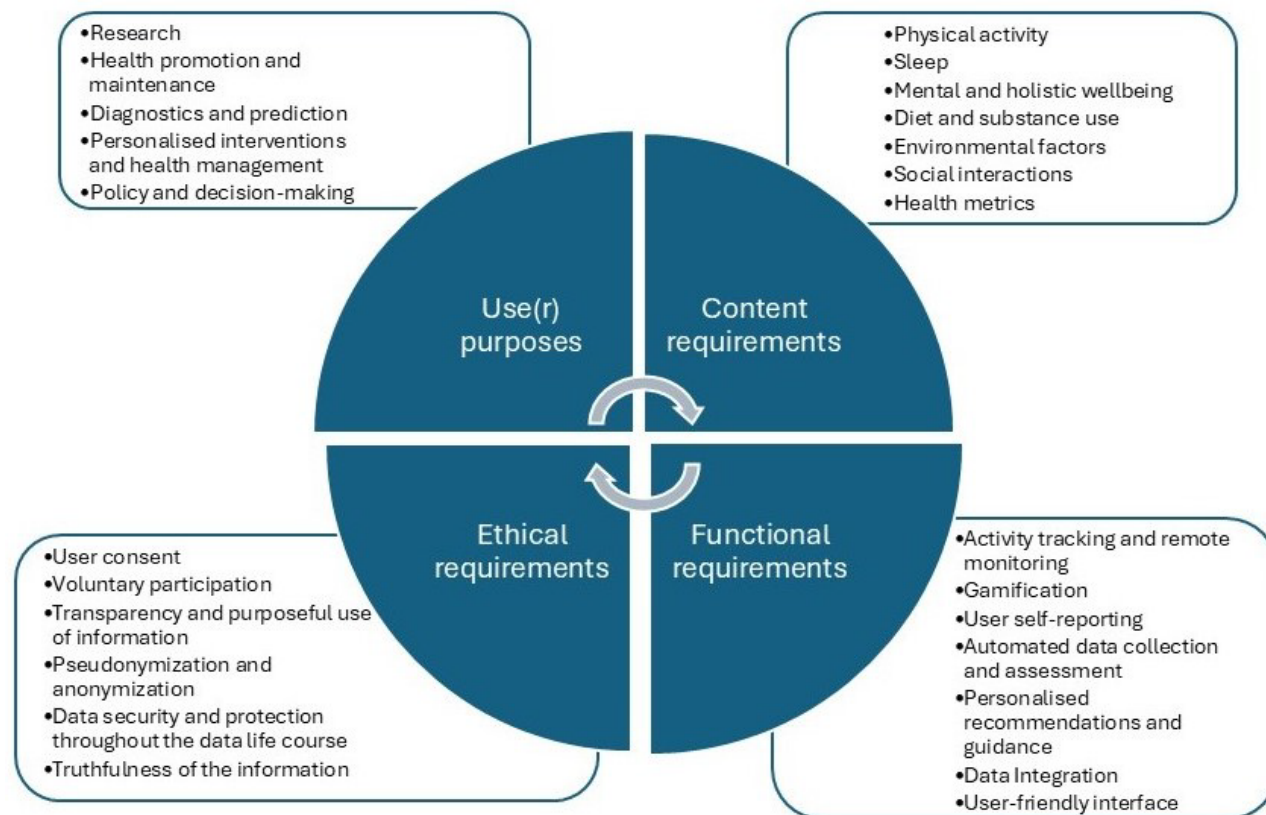


protection needs to be communicated clearly to the users and extensive strategies should be prepared to prevent data leaks and unauthorized access by ensuring robust security measures throughout data collection and transmission. Measures should also be considered to determine *truthfulness of the information*. App developers should evaluate how to ensure the identity of the person providing the information in the application, as noted by one participant; “*How to ensure who is actually recording the information?*” (clinician/researcher). The app should provide a safe space for users to give truthful answers on sensitive topics such as eating behaviour to avoid stigma and maintain trust. Moreover, in general the app should strive for inclusivity in data collection and include diverse user profiles, not limiting the use to those individuals already interested.

The fourth major theme of **use(r) purposes** include *research, health promotion and maintenance, diagnostics and prediction, personalised interventions and health management and policy and decision-making aid*. *Research* purposes include using the health-related data to study the health and economic impacts of physical activity, to understand how users perceive and interact with their environment and to conduct longitudinal studies to follow the development of certain diseases. The theme *health promotion and maintenance* focuses on encouraging users to monitor lifestyle habits and make better health decisions and enhance overall wellbeing. One participant described; “[the app] ... should aim to promote overall well-being and

*health*” (clinician/researcher). The app can motivate people to maintain a healthy lifestyle by sending activity reminders and nudging to make healthier choices. Other use purposes as part of health promotion and maintenance include analysing daily activities in relation to overall health, assisting in managing chronic pain and anxiety, assessing health related needs and support guidance. In addition, the app can store and analyse data to assist healthcare practice and function as a tool to rehearse hand-eye coordination, memory and learning.

*Diagnostics and prediction* refer to the utilisation of the app in contributing to the development of diagnostics and therapeutic advancements. The app can facilitate early detection of neurodegenerative diseases and stroke, evaluate overall health and identify and assess risk factors (specifically brain health related), aid in early diagnosis and monitor serious brain diseases. The app can also serve as a tool providing *personalised interventions and health management*. The user can receive help to address individual health challenges and personalised guidance and follow interventions to promote wellbeing. The app could provide alerts and feedback based on individual health data trends and user activity, identify user needs for tailored service provision and assess service needs. Lastly, *policy and decision-making aid* refers to the app functioning as a tool to provide data for decision makers and urban planners to enable data-driven decision-making in the development of healthcare practices and health and safety enhancing urban planning.



**Figure 1.** Major themes and themes relating to the content, functional and ethical requirements of the application and the use(r) purposes.

## Discussion

The requirement elicitation results indicate that mobile app should entail comprehensive functionalities to monitor health and lifestyle factors relating to overall health (physical, mental, social and environmental wellbeing). This information can be used to guide health behaviour at individual and societal levels and used for research, health promotion and aid in policy and decision-making. These aspects highlight the clinicians and researchers' wish for a comprehensive, user-centric health management app focused on automation, integration, and personalization. Previous research has addressed similar aspects by identifying that contents on physical and mental health have been widely included in mHealth apps to promote health or

support disease management [3,13]. However, this study has brought new information about the importance of including also social and environmental aspects of health, such as social behaviour and neighbourhood characteristics into data collection from the clinician and researcher perspective. These aspects are integral to promote active ageing and maintain holistic wellbeing by addressing the context of people's lives which determine their health [20,21].

The functional features of the app highlight the need to develop a comprehensive, user-centric health management app focused on automation, integration, and personalization without forgetting the possibility for self-selected input. These aspects were perceived to enhance the attractiveness of the app which should also be designed with a



straightforward, user-friendly interface in mind. Previous studies have addressed similar functional requirements by evaluating the usability of developed mobile apps. Wang et al. [22] concluded that healthcare professionals involved in the development of an anticoagulation self-management mobile app evaluated the app as easier to use compared to other healthcare professionals, patients or their caregivers, indicating an accentuated need to include different stakeholders in different development phases to increase usability through functionalities. Loh et al [23] have also studied the usability of a mobile app by using the system usability scale (SUS) in their study involving geriatric patients with cancer. Their study identified that infrequent symptom surveys or mere reminders do not suffice in increasing physical activity, without feedback possibility. This highlights the importance to enable continuous, repeated measurements, needs-based tailoring of the app and interaction with the healthcare provider.

As part of ethical requirements, the participants highlighted the importance of transparency, consent, data protection, and ethical handling of sensitive information in the mobile app. Clinicians and researchers were also concerned about the truthfulness of the information provided in the app. Legal aspects and policy guidelines need to be addressed when considering the protection of mHealth users' data. Moreover, it has been recognised that rapid development of new forms of data and the ease of transferring and sharing data challenges privacy, security and data governance. [24.] As AI-enhanced solutions are becoming increasingly more in common also in the field of mHealth, guidelines and regulations, such as the new EU AI Act [25], need to be followed when designing, evaluating and piloting new health monitoring apps.

Clinicians and researchers were involved in the requirements elicitation through an exploratory survey to attain their expertise to gather the content, functional and ethical requirements for the mobile app. Moreover, use and user purposes were identified which is important considering the aim to utilise the collected data as broadly as possible to benefit not only patient outcomes and healthcare practices but also the day-to-day work of clinicians in clinical decision-support and patient interaction [11]. Yet, clinicians and researchers might lack expertise on certain aspects of mobile app requirements which can diminish their potential to recognise some relevant benefits and challenges in software development [15]. Therefore, inclusion of various stakeholders from different disciplines and users is important to gain wide understanding of different needs, requirements, possibilities and challenges.

The future steps in the STAGE project to develop co-designed, AI-enabled digital solutions to monitor health aims to include various other stakeholders by using patient and public involvement (PPI) which is another approach of co-design to further increase the inclusivity of healthcare research by defining and differentiating different levels of involvement according to engagement (consultation vs. publicly led research) [1,26]. Citizens in the same age group, informal caregivers, educators, policy makers and business-oriented actors will be involved to further increase the quality of the research and relevance of the mobile app [26,27]. Moreover, the perspectives relating to the use of AI as part of health monitoring should be further addressed together with different stakeholders, especially considering the benefits and harms connected with using AI in healthcare delivery [4].

### ***Strengths and limitations***

This study is part of a larger, international project which aims to develop AI-assisted, person-centred tools to enhance healthy ageing. This work describes only the preliminary actions of the project's co-design actions which will be supplemented in future with a variety of methods. As convenience and self-selecting sampling strategies were applied to reach respondents from the sample population, we might have dismissed clinicians and researchers with opposing viewpoints or opinions regarding the necessary requirements and use(r) purposes of the mobile app. Moreover, we only targeted those clinicians who are affiliated with University of Oulu and therefore, might have missed opinions of clinicians working in primary healthcare services or the private sector. The small number of participants must be considered as a limitation in this study. Yet, data saturation was evaluated to be achieved as the responses were repeating similar contents already mentioned indicating that the sample size was sufficient to answer our research questions [19]. Data analysis was conducted solely by the first author (author initials) which can reduce the validity of the results and introduce bias in interpretation. Inclusion of two or more researchers in the analysis process could have strengthened the dependability of the study [28].

### ***Conclusions***

The requirement elicitation results indicate that clinicians and researchers wish for a variety of different features in the app which allow active and passive data entry, linkage to other devices and a contact possibility to the user's healthcare provider. Attractiveness through ease of use and automation of functionalities was perceived important to ensure adherence to use as well as inclusion of various contents to address physical, mental and social wellbeing. Involving clinicians and researchers to mobile app requirement elicitation increases the relevance of the app from the users' perspective and it has the potential to increase their interest of using the app for clinical and research purposes and recommending the app during patient encounters. Future endeavours in the STAGE project deepen the co-design approach to PPI activities with different stakeholders to ensure the app entails the relevant components to study healthy ageing.

### ***Conflict of interest statement***

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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