CITIZEN SCIENCE:
THEORY AND PRACTICE

Involving Members of the Public to Develop a Data Collection App for a Citizen Science Project on Housing Accessibility Targeting Older Adults

RESEARCH PAPER

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ABSTRACT

Background: While citizen science approaches are emerging within both social and health sciences, projects aimed at improving the living conditions of older adults remain rare. To enable forward-looking housing provision for the ageing population, valid and detailed information is needed on environmental barriers in the housing stock. Moreover, to promote active ageing and avoid involuntary moves to residential care facilities, there is a need for both increased public knowledge and raised awareness about accessible housing among older adults. Thus, Swedish senior citizens were engaged in a citizen science project—the Housing Experiment 2021—using a smartphone application to report environmental barriers in dwellings.

Aim: This paper describes in detail the process by which varied members of the public participated to develop an application that assured reliable data collection of environmental barriers by older adults.

Methods and Results: The scientific foundation for the app was the Housing Enabler. The development process comprised six iterative phases including participatory activities, namely, developing a citizen science version of the Housing Enabler; developing a print mock-up; developing an app prototype; testing and improving usability; beta version testing for reliability; final tests; and finishing touches.

Discussion: Through an iterative development process involving researchers, professionals, and members of the public, a reliable app suitable for senior citizens was created. The results can serve as an inspiration for development protocols increasing the involvement of older adults in app development as well as for citizen science projects targeting older adults.

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INTRODUCTION

Personal data, such as age of volunteers in citizen science projects, are seldom collected (Moczek, Hecker, and Voigt-Heucke 2021). However, in one review, 45% of volunteers engaged in a citizen science project monitoring water quality were retired (Donnelly et al. 2014), and the proportion of older adults among citizen science volunteers is considered to be large. However, designing citizen science projects aimed at improving living conditions for older adults is still rare. Even if citizen science projects related to biomedical science are increasing (Guerrini et al. 2022) citizen science approaches within social sciences and health sciences are rare (Barrie et al. 2019). The few examples found focused on older adults involved in evaluating and improving neighbourhood environments and promoting age-friendliness (King et al. 2020; Barrie et al. 2019; Tuckett et al. 2018). For example, in the Our Voice program, older adults used a smartphone application (app) to document their neighbourhoods. The collected data were used for community discussions, aimed to empower older adults to make suggestions to local authorities and politicians on improving the age-friendliness of the community. (King et al. 2020; Tuckett et al. 2018). The authors concluded that older adults, as experts in their lived neighbourhoods, were extremely suitable to collect and analyse data on age-friendly neighbourhoods. The use of an app was found to be an adequate way of collecting data despite "the participants' varying tech literacy" (King et al. 2020). Supported by the National Institute of Health in the United States, the Our Voice app is used in more than 20 countries (Mintz and Couch 2022). However, it should be noted that participation among older adults in trials on digital health technology was dependent on digital skills (Poli et al. 2020), and demands for high levels of tech literacy is possibly why some older adults avoid participating in citizen science initiatives.

An area where older adults would be suitable to collect data and act as citizen scientists is their own home environments. Thus, the Housing Experiment (Bostadsförsöket in Swedish), was launched as a citizen science project to investigate the character and occurrence of physical environmental barriers and accessibility problems in different types of dwellings and residential areas across Sweden. However, protocols describing development of citizen science projects with older adults as the main target group, and detailed description on how older adults with varying digital skills can participate in development of data collection apps are scarce. Here, we aim to describe in detail the process by which varied members of the public participated to develop an application that assured reliable data collection of environmental barriers by older adults.

BACKGROUND

The globally increasing life expectancy is causing a demographic shift towards ageing societies. Population ageing and the predominant ageing-in-place policies across countries in the Western world have made the design and appropriateness of the home environment for older adults an important issue both in research and policy debates. Because only 4% of those aged 65 and older and 13% of those aged 80 and older live in residential care facilities or similar forms of needs-assessed accommodation, the Swedish housing stock has to accommodate older adults with functional limitations (National board of health and welfare, 2016). While Sweden has high housing standards (Eurostat 2015), previous research indicates that there are considerable housing accessibility problems in the housing stock (Granbom et al. 2016). Accessible and adequately designed dwellings support continued independence in later life (WHO 2015). Accordingly, inaccessible dwellings with environmental barriers and home hazards impact negatively on activities of daily living (ADL) (Iwarsson, Horstmann, and Slaug 2007), are related to increased fall risks (Iwarsson et al. 2009), and lead to relocation to residential care facilities (Granbom et al. 2014; Stineman et al. 2012). Increased life expectancy is a positive development, but the fact that the total number of years lived with disability has not decreased places high demands on society to provide a housing stock that meets the needs of senior citizens (Murray et al. 2015).

Forward-looking housing provision with potential to accommodate the ageing population demands valid and detailed information on environmental barriers in the housing stock. Unfortunately, in Sweden, such inventories have been carried out using diverse methods at the municipality level, which renders limited possibilities to aggregate data on the national level. Moreover, such inventories were limited to outdoor and entrance sections of multi-family housing. Standardised inventories based on the best available knowledge imply substantial resources because they require trained data collectors to make detailed observations of many dwellings, and for confidentiality reasons, there are limited possibilities to collect data indoors in private housing. So far, the largest detailed on-site inventory on environmental barriers in the Swedish housing stock (Granbom et al. 2016) was made with the Housing Enabler (HE) methodology (Iwarsson, Haak, and Slaug 2012) and included aggregated data on 1,021 dwellings from three research projects (Iwarsson et al. 2007; Kylén et al. 2014; Nilsson and Iwarsson 2013).

Adding to this picture, to promote active ageing and avoid involuntary moves to residential care facilities, there is a need for both increased public knowledge and raised awareness among older adults and their families about the importance of accessible and well-designed housing.

THE HOUSING EXPERIMENT—A NATIONAL CITIZEN SCIENCE PROJECT IN SWEDEN

Since 2009, as part of Swedish events at the annual European Researchers' Night festival, the nonprofit organisation VA (Public and Science) has arranged a citizen science initiative for schools nationally. The aim of this initiative is to stimulate scientific literacy and an interest in science by letting students take an active role as research assistants, while generating genuine scientific output for participating researchers (Kasperowski and Brounéus 2016).

In 2021, for the first time ever in Sweden, older adults were addressed as the primary target group of VA's annual citizen science initiative. The purpose of the Housing Experiment was to increase public knowledge and awareness on accessible housing as well as to collect large-scale detailed research-based data on environmental barriers in the Swedish housing stock (the Housing Experiment webpage). The Housing Experiment idea stemmed from discussions and workshops in previous participatory research projects on ageing, housing, and health (see e.g., Löfqvist et al. 2019). The project idea was operationalised during iterative discussions in a transdisciplinary Lund University Thematic Collaborative Initiative on housing and societal rights for the ageing population. This initiative engages researchers from the faculties of Medicine, Social Work, Law and Technology as well as Kristianstad University and 11 non-academic partners. Examples of partners are VA, the two largest senior citizen organisations in the country, several housing companies, and tech development companies. Using the typology of Shirk et al. (2012), the Housing Experiment was a collaborative project. That is, it was initiated and designed mainly by scientists, but members of the public were, via a User Board and the Thematic Collaboration Initiative, engaged in refining grant proposals, aim and objectives, and data collection tools. They also participated in data collection, data analysis, and dissemination of findings.

With the digital transformation and smartphones widely accessible, new and advanced opportunities for data collection and collaboration in citizen science projects have emerged (Lemmens et al. 2021). Many older adults own a smartphone. However, using the smartphone regularly is less common in old age. In Sweden, 80% of 65–70-year-olds use the smartphone daily but only 36% of adults 76 years and older do (Swedish Internet Foundation 2021). While King et al. (2020) found that the use of an app was an adequate way of collecting data despite varying tech literacy among their participants, the heterogeneity of the population of senior citizens as regards different capacities warrants specific attention in the context of citizen science. Developing a data collection app was a vital element of the Housing Experiment, and this paper focuses on that process and how members of the public participated in its development.

THE APP DEVELOPMENT PROCESS: METHODS AND RESULTS

The HE methodology (Iwarsson and Slaug 2010) and related research constituted the scientific base for the app and the Housing Experiment. The HE is based on a definition of accessibility grounded in the notion of person-environment fit and supported by robust research (Iwarsson, Haak, and Slaug 2012). The original instrument comprises two dichotomous checklists, for the personal (14 items) and the environmental component (161 items). The environmental component specifies 161 potential environmental barriers of an ordinary dwelling and is based on standards and guidelines for housing design as expressed in national legislation and guidelines. According to the original methodology, observation and recording of environmental barriers in authentic housing environments should be administered by health care professionals who have undergone specific training for use of the HE (Iwarsson and Slaug 2010). In 2008, the HE methodology was complemented with a screening version, which included a core set of environmental barrier items (HE Screening Tool) (Carlsson et al. 2009). A previous method study suggests that lay people can learn to administer reliable data collection using this 60-item list of environmental barriers (Iwarsson, Haak, and Slaug 2012). Accordingly, the HE Screening Tool was considered appropriate to use for the Housing Experiment.

DEVELOPMENT PHASES WITH PARTICIPATORY ACTIVITIES

The development process of the app comprised six iterative phases. The team involved included three researchers from Lund University, two citizen science specialists from VA, and two tech development company representatives. Two of the researchers (2nd and last author) are the original developers of the HE. The citizen science specialists from VA are experienced in developing and implementing citizen science projects and have research as well as communication expertise. The team members assumed different roles in the six phases (see Table 1). Members of the public were involved to give input, test, and give feedback throughout the development process. Older adults (65 years and older; n = 22) recruited via senior citizens' organisations that were part of the Lund University

CATEGORIES INVOLVED	PHASE 1	PHASE 2	PHASE 3	PHASE 4	PHASE 5	PHASE 6
Researchers (LU), scientific expertise	X	X	X	X	X	X
Citizen Science Specialists (VA), project manager, communications specialist, citizen science expertise	X	X	X	X		X
Graphic designer (VA)		X				
Digital accessibility and universal design expert		X				
App developers (miThings), technical expertise and know-how		X	X	X	X	X
Older adults, members of the public, primary target group	X			X	X	
University students, members of the public with housing accessibility knowledge				X		
Adults, members of the public					X	
Children (10–15 years), members of the public					X	

Table 1 Representation of researchers, specialists, developers and members of the public involved in the different phases of the development.

Thematic Collaboration Initiative were engaged in several phases. In addition, university students (n = 26) with housing accessibility knowledge were involved, as well as children (n = 5) and adults of working age (n = 3).

Phase 1: Developing a citizen science version of the Housing Enabler Screening Tool

The goal of the first phase was to develop a version of the HE Screening Tool (Carlsson et al. 2009) for implementation in the Housing Experiment app, which a member of the public with limited general knowledge about housing accessibility could administer in a valid and reliable way. Researchers and the VA specialist met frequently during this phase. The researchers ensured that high scientific quality was maintained, while the VA specialists used their experience from previous citizen science projects to make sure that the items were easily understood by members of the public with only limited knowledge of housing accessibility and research. An older adult (a User Board member) also gave input. The guiding principles were to a) use simple yet accurate language and terminology; b) keep sentences short; c) avoid double negatives; and d) reduce the number of items considerably without compromising the reliability and validity of the HE. The 60-item list from the HE screening tool was reduced and developed into a list of yes/no questions. As the Housing Experiment focused on entrances and indoor environments, the exterior surroundings section from the HE Screening Tool (20 items) was not included. Six items were excluded due to known negligible variance from previous research. That is, as those items had been present as environmental barriers in more than 95% of all dwellings in previous projects, it was not meaningful to collect further data on these barriers. To enhance readability and comprehension, five items that included two or more measurements were divided into two or three questions. Being particularly careful to avoid collecting any personal data of a sensitive nature, the team developed project-specific questions to include basic descriptive information in the app.

Phase 1 resulted in a set of 39 questions on the presence of environmental barriers at entrances and indoors. Overall, as exemplified in Figure 1, these questions ended up shorter than the HE Screening Tool items, and the language had less technical jargon. Seven descriptive questions addressed type of dwelling, zip code, building year, whether any resident in the dwelling used mobility devices (yes/no), and whether any resident was 65–79 years or 80 years or older (yes/no).

Phase 2: Developing a print mock-up

The goal of Phase 2 was to decide on the format and design of the app and develop a print mock-up version. At this stage, the team was complemented with a design and communications specialist and an additional team member from VA, experienced in leading citizen science projects. They contributed with knowledge on user-friendly design and communication of citizen science projects, however, with limited experience in developing products for older adults. Two employees from a tech development company, which was commissioned for the technological solutions, were engaged to contribute with their knowledge on design, technical features, and solutions. The tech developers and researchers had previously collaborated on projects including HE methodology. An expert with a PhD in digital accessibility and universal design was consulted for feedback on for example colours, fonts, contrasts, and text size. Format and design suggestions were discussed and revised iteratively among researchers, VA specialists, and

EXAMPLE 1
HE Screening Tool
Insufficient manoeuvring space at doors (clearance less than 1.5 × 1.5 m, outside and inside, 70 cm on the opening side of the door at the main entrance, 50 cm at apartment door).
Citizen science version
Is the space outside or inside of the doors less than 150 × 150 cm?
Is the space at the opening side of the main entrance door less than 70 cm?
For any other doors at the entrance, is the space less than 50 cm at the opening side?
EXAMPLE 2
HE Screening Tool
Complex manoeuvres (more than one operation/movement) and good precision required.
Citizen science version
Do you need more than one grip/movement (e.g., twist and pull at the same time) to manage faucets, locks or handles?

Figure 1 Two examples of how the items from the Housing Enabler (HE) Screening Tool were optimized to improve readability and reduce complexity of the citizen science version for the Housing Experiment app.

tech developers. The ambition was to come up with a user-friendly design for both experienced and inexperienced smartphone users.

The results were visualised in a print mock-up version including all questions established in Phase 1. The mock-up included a front page and four sections. Each section had an introductory information page. The first and second sections included information and the seven descriptive questions about the dwelling and the residents. The third and main section included the 39 yes/no questions where the measurements of the dwelling were reported. When needed, pop-up windows were to be available with information or illustrations to help the user take the measurement correctly and to answer the question. In the fourth section, the data collected were to be uploaded to an online open access database. In addition, the person/s reporting the data were able to share their age, write a free text comment, and choose whether they wanted a summary of the data they had collected to be emailed to them. See Figure 2 for example on design.

Phase 3: Developing an app prototype

In Phase 3, the tech developers programmed a prototype of the app, based on the results of Phases 1 and 2, in both iOS and Android versions. Frequent online meetings were held with researchers, VA specialists, and tech developers to discuss challenges regarding content, user-friendliness, design, and technical solutions. At the end of Phase 3, the prototype was ready for a first round of testing. During Phase 3, no members of the public were involved, but when the prototype was ready, it needed to be thoroughly tested, which took place in Phase 4.

Phase 4: Testing and improving usability

The aim of the Phase 4 testing was to improve the usability of the prototype with the goal of arriving at the operational app's first version. Usability was tested by five older adults as well as all individuals hitherto involved in the development. The older adults were recruited via the Thematic Collaboration Initiative and the senior citizen organisations involved. The older adults who volunteered were fairly experienced in using digital technology and smartphones, they were 65 years or older, both men and women, had no previous experience of citizen science projects, and did not live in any type of age-restricted special housing. They received written instructions on how to use the prototype to measure and record data on environmental barriers in their own dwellings, and were asked to answer a study-specific questionnaire about the app, inspired by the System Usability Scale (Brooke 1996).

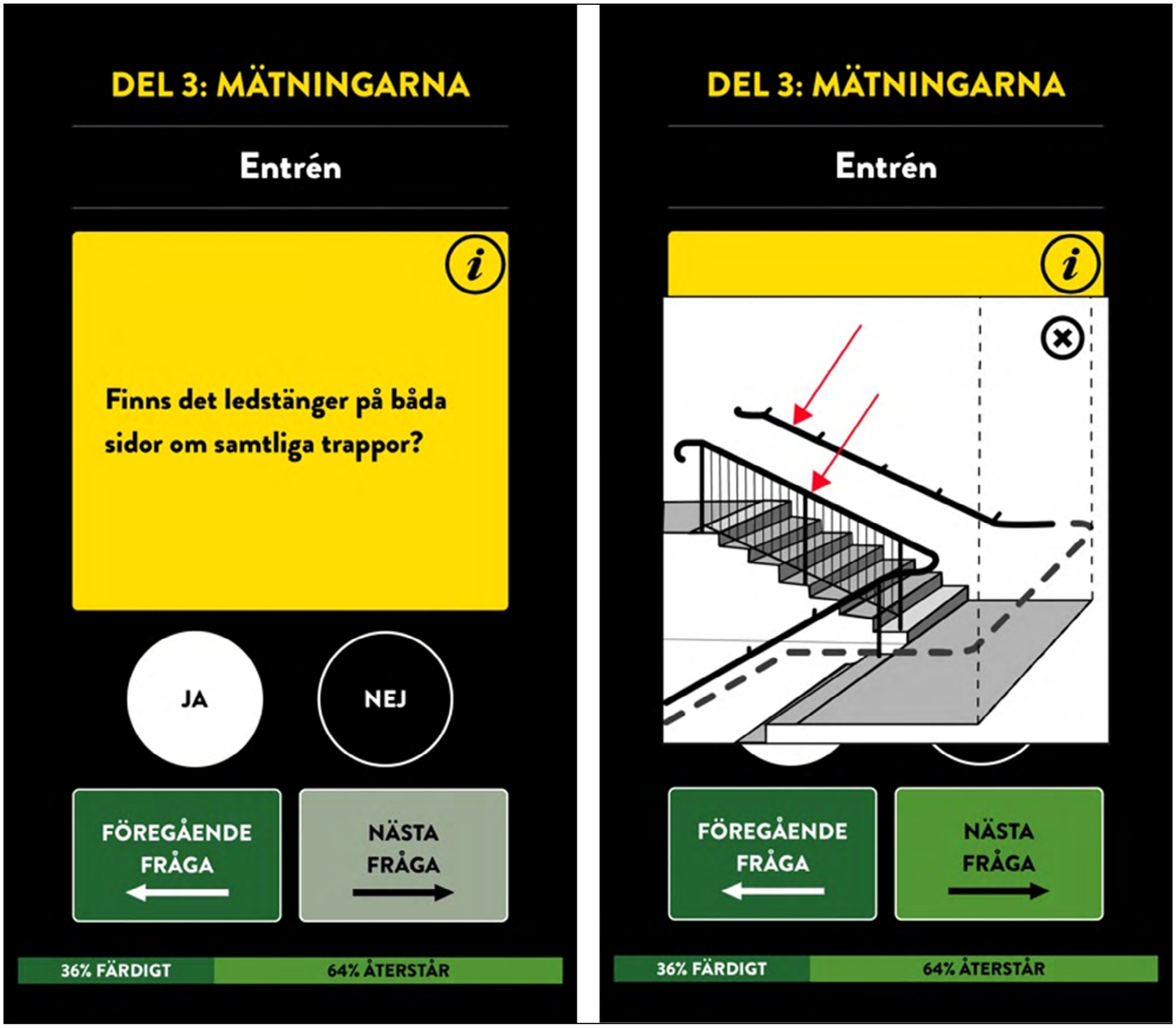

Figure 2 Illustration of items of the Housing Experiment app.

Instead of a purely quantitative survey approach, we chose a qualitative one to get a deeper understanding of the possible technical and handling issues with the app, to adjust the features in the best possible way. Hence, the original 5-point Likert scale was complemented with open-ended questions, together with a question on what kind of information they thought was needed in an online Housing Experiment instruction manual.

The results of Phase 4 showed that the five older adults were satisfied overall with the usability both in terms of handling the app and in understanding what should be measured and reported. Areas that we identified as needing improvement concerned information pages, opening and closing pop-up information and illustration windows, terminology used for some of the measurements regarding steps and stairs, and clarity of one pop-up illustration window indoors. For example, one older adult commented: *"In the questions about the entrance it was sometimes unclear whether they regarded the entrance to the apartment or the entrance to the building, or both."* Another thought the pop-up windows could be improved: *"Possibly be made larger and easier to click. And place the closing button in another corner of the screen."*

Revisions to improve the usability were made, and the usability test was repeated. This time, another group of members of the public were approached—students in the Occupational Therapy Bachelor´s program at Lund University (n = 26). The students were undergoing training to administer professional home environment assessments, to identify environmental barriers and fall hazards, and to suggest home modifications for clients with functional limitations, which was considered an adequate setting for additional usability testing. The first author instructed the students on how to use the app to measure and record

ITEM, n (%)	STRONGLY DISAGREE 1	2	3	4	STRONGLY AGREE 5
I thought the app was easy to use	0 (0)	0 (0)	3 (12)	6 (23)	17 (65)
I imagine that most people would learn to use this app very quickly.	0 (0)	0 (0)	2 (8)	11 (42)	13 (50)
I felt very confident using the app.	0 (0)	0 (0)	2 (8)	12 (46)	12 (46)

Table 2 Usability* ratings by university students (n = 26).

* System Usability Scale (Brooke 1996).

data on environmental barriers in their own dwellings and to answer the aforementioned usability survey.

Overall, the university students were satisfied with the usability of the app and considered it easy to use. They felt confident using it and thought most people would learn to use it very quickly (see Table 2). Most comments concerned the function of emailing a summary of the data they had collected to the user. Apparently, depending on what email client the participants had on their smartphones, some emails could not be sent, the response was delayed, or the layout of the email appeared as code. In addition, some measurements still needed refinement or clarifications, and additional pop-up illustration windows were wanted. Again, the results of the test were discussed by the involved researchers, VA specialists, and tech developers, followed by revisions into a beta version of the app.

Phase 5: Beta version testing for reliability

To test inter-rater reliability, 18 older adults (65 years and older; eight women, ten men) were recruited via the Thematic Collaboration Initiative, local senior citizen organisations, and patient organisations. They were invited to use the app to measure and record data on environmental barriers in a two-room apartment made available by one of the team members. To counteract any undue influence of the measurements and recording of data among the participants, monitored by one researcher (first and last authors), a maximum of two participants in each section/room of the apartment was allowed at the same time. The participants were instructed to use their own smartphones. However, in the few cases where the app (still in development mode) download failed, participants borrowed a smartphone for the test situation. The two researchers assisted during the testing, provided instructions, and monitored the test situations to ensure compliance. The visits lasted 30–45 minutes each, and the participants received a SEK 200 gift card when the test was completed. To produce data to be used as the gold standard for the evaluation of inter-rater reliability, the last author (developer of the HE methodology) used the app to measure and record data in the apartment. Percent agreement for each participant and each item was calculated by pairwise comparisons between the participant assessment and the gold standard. Using a standard level for accepted agreement (McHugh 2012), rates lower than 80% were considered to warrant further scrutiny and tracing of potential sources of error.

The results of phase 5 showed that of the 39 questions, 24 (61%) had an agreement of 80% or more. The causes of low agreement for the 15 items were varied. Some were caused by misunderstanding questions, forgetting to measure all areas of the dwelling section before answering the question (Are any of the thresholds higher than 1.5 cm?), and not being meticulous enough when using a ruler. Another reason was interpretations needed to answer questions that did not include measurements (Is there enough space for a shower chair in the shower area?). One question, on stairs at the entrance, was misunderstood by several participants. They incorrectly answered “no” and then the app by default filtered out the following four questions regarding bannisters, step height etcetera. We used the results of the inter-rater reliability test for additional app improvements This optimisation included dividing one more question into two questions, so from here on the app included 40 questions. We revised general information on how to measure, and we made further clarifications regarding certain measures in the app as well as in the online manual.

Phase 6: Final tests and finishing touches

While the development process this far had been focused on the main target group (i.e., older adults), a final testing step was made to include other potential members of the public who also might have had an interest in participating in the Housing Experiment. Accordingly, twelve participants including children (aged 10–15 years, n = 5), adults of working age (n = 3), and older adults (n = 4) carried out a final test. They were instructed to use the app in their own dwellings and then answer the usability survey (see Phase 4).

The results of this final test showed that the language and terminology needed further improvement to be comprehended by children. For example, we had to replace the Swedish words for “passing through” and for “kitchen

LIX SCORE	ORIGINAL VERSION (n = 33)	APP VERSION (n = 40)
<30 (very easy to read, cf. children's books)	5 (15%)	13 (33%)
30–40 (easy to read, cf. fiction)	10 (30%)	17 (43%)
40–50 (average, cf. normal newspaper texts)	4 (12%)	6 (15%)
50–60 (difficult, cf. official texts)	6 (18%)	4 (10%)
>60 (very difficult, cf. bureaucratic)	8 (24%)	0

Table 3 Lix readability scores* of questions in the Housing Enabler Screening Tool as compared to the app version.

* (Björnsson 1968).

counter" with synonyms. In addition, further clarification and information about certain measurements were necessary. For example, we added a reminder to measure threshold height on both sides of the threshold. There was also a need of reminders to use the pop-up information and illustration windows. To maximise the size of the text despite limited space, we changed font style after the feedback provided. Some coding errors were detected and fixed. In addition, feedback from the children implied that completing all the measurements felt tiresome. Thus, on some information pages between sections we added encouraging feedback such as "The entrance section is complete! You are halfway through! Click "next" to move on to the kitchen." After the final language refinements, we used the Swedish Lix readability index (Björnsson, 1968) to compare the readability of the original HE Screening Tool questions with the app questions. We found that the average readability score decreased from 45 (average difficulty, cf. newspaper articles) in the original, to 34 (easy to read, cf. popular literature) in the app version (Björnsson 1968). As can be seen in Table 3, the proportion of texts with high (difficult) readability scores was drastically reduced. After these final adjustments we considered, the app ready to use in the Housing Experiment.

ETHICAL CONSIDERATIONS

It should be noted, according to current Swedish legislation on research on humans, formal ethical approval was not applicable for the Housing Experiment, including the development of the app for data collection. Still, in all project phases and activities, we adhered strictly to the principles of the Helsinki Declaration.

DISCUSSION

In this paper we describe a development process using participatory activities that resulted in a well-accepted and usable app for smartphones with sufficient inter-rater reliability for use in a citizen science initiative on accessibility in the ordinary housing stock in Sweden. Involving researchers and professionals with different but complementary expertise as well as members of the public including older adults in participatory activities was instrumental for the app development process. However, the development was not without challenges.

As it can be challenging to recruit volunteers to be involved in a process with multiple phases, having a well-established structure for involvement of different categories of users was highly beneficial. The User Board has been at our research centre for more than 10 years, which facilitates identifying members of the public for taking part in an endeavour like this. In addition, our ongoing Thematic Collaboration Initiative is a great asset, with confirmed partners for involvement in research collaboration firmly established. A potential downside with panels such as our User Board is that over time the members become "professional representatives" and are more like scientists than members of the public (Eriksson 2018). Becoming a professional representative has been acknowledged also among volunteers in citizen science projects where several participants take part in a multitude of projects and several have academic backgrounds (Allf et al 2022). For this project, we conclude that the advantages override those potential risks.

Our ambition was to develop an app that was easy to use regardless of the level of digital skill of the individual user. As perceived usefulness and ease of use facilitate acceptance and are positively associated with older adults' attitudes towards technology (Hauk, Huffmeier, and Krumm 2018), making design efforts to meet the expectations and needs of older adults is a basic prerequisite for success in attracting interest for participation in a citizen science initiative. However, to identify and involve volunteers with limited digital skills was challenging. First of all, volunteers interested in testing an app are usually knowledgeable in digital solutions, and it proved virtually impossible to involve people with limited digital skills. Second, a certain level of digital skill was needed to be able to manage the different versions of the app. Overall, older adults are interested in and want to use technology (Hunsaker et al. 2020), and, particularly in Sweden, adults in this population segment are familiar with technology and technology development (Swedish Internet Foundation 2021). Still, we did observe challenges relating to digital technology literacy in the inter-rater reliability test, where some participants needed hands-on assistance to be able to download the app for use on their smartphones. This is an important observation for future citizen science initiatives targeting senior citizens, which requires careful consideration and preparedness to provide such support. Even if Sweden is a country with very high levels of internet use and digital technology literacy, it might be easier for some older adults to use a computer rather than a smartphone app. However, in this project as well as many other citizen science projects, it was necessary to have a portable device because the measurements took place in different areas of the dwelling. Differences in technical preferences and skillsets are fundamental to keep in mind in citizen science endeavours, since they will otherwise introduce bias when participants are systematically excluded due to this digital divide. To offer "open house" testing with support from tech developers rather than providing guidance only for individual testing at home could be one solution for the future, similar to our test situation in Phase 5. Even if open house testing and testing individually at home captures the whole user experience in accordance with ISO 9241-210 human-centred design for interactive systems (International Organization for Standardization 2010), during open house testing, the feedback reaches the development team immediately (Sturm and Tscholl 2019). To assure high data quality when data is collected by members of the public is a well-known challenge in citizen science, and sometimes different stakeholders define high quality in different ways (Balázs et al. 2021). In the Housing Experiment, data assurance and data-quality protocols were discussed and implemented throughout but were particularly considered during the app development. A fundamental condition for high data quality is that the questions and instructions are correctly understood. The HE methodology usually requires a five-day training course for data collectors to assure good reliability and validity. Therefore, we were meticulous in the challenging process of translating the original HE methodology into a version that members of the public could use, supported only by the software and written and video-based on-demand training material. In Phase 1, numerous iterations were made between the original HE items and the citizen science version among scientists, VA specialists, and one older adult. The process was facilitated by the scientists' longstanding experiences from research with user involvement and the VA specialists' research competence. In addition, the older adult involved early on had experience from involvement in research as a member of the User Board of the research centre. To test data quality, conventional reliability testing was made in Phase 5, and the observations of how the participants in this testing approached the task of using the app in an authentic housing environment gave additional knowledge about how the app was handled and what might be useful to highlight in training material.

Our initial plan was to frame the Housing Experiment as a collaborative cross-generational endeavour, where students could work together with older family members or friends. This would enable older adults without smartphones (or with limited experience/ability in using such technology) to work together with tech-savvy grandchildren or other children in using the app to report data. It would also provide a social incentive for older and younger generations to engage together in the project, which was welcomed by the senior citizen organisations involved. Unfortunately, these plans had to be cancelled due to the COVID-19 pandemic, where the Swedish strategy had a special emphasis on protecting older adults from exposure to the SARS-COV-2 virus. In addition, the fact that the development of the app took place during the pandemic resulted in delays and challenges in recruiting participants for the different phases.

CONCLUSIONS

This paper shows a successful approach to develop an app for use in a citizen science project addressing accessible housing for the ageing population and with senior citizens as the main target group. With careful planning and an iterative development and test process involving researchers, specialists, tech developers, senior citizens, and other members of the public, we showed how it is possible to arrive at a useful and reliable app. Using participatory activities particularly in the early (addressing content and readability) and later (addressing usability and reliability) development phases, insights and experiences from the target group can help to shape an app that meets specific needs and wishes of the intended users. From the challenges encountered, we conclude that content and readability are issues that require specific attention and efforts, not only early in the process but throughout; new issues may emerge late in the development process. Our example and detailed account of experiences can be useful for future citizen science projects involving app development by serving as inspiration for development protocols that increase the participation of older adults in such development as well as for citizen science projects with older adults as the main target group.

DATA ACCESSIBILITY STATEMENT

Data can be accessed by contacting Dr. M. Granbom via marianne.granbom@med.lu.se.

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COMPETING INTERESTS

The Housing Enabler is a commercial product sold by Veten & Skapen HB and Slaug Enabling Development with Drs. Iwarsson and Slaug as copyright holders and owners. The remaining authors have no conflict of interest.

AUTHOR CONTRIBUTIONS

All authors contributed to conception and design of the study. MG, MB, and SI collected data. MG, MB, FB, and BS did the analyses. MG drafted the manuscript, which all authors revised critically for important intellectual content. All authors approved the final version to be published.

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