A Co-Design Approach to Explore Health Data Representation for Older Adults in Chile and Ecuador

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ABSTRACT

Displaying the information collected by mobile health technologies remains a challenge, especially when considering representation of health data for older adults - i.e., where and how to display data captured by health devices. We focus on an underrepresented group in HCI research: older adults in the global south, specifically in Chile and Ecuador. We studied the opinions of a group of 18 older adults on health data representation through interviews and remote co-design practices, encouraging them to imagine representations of health data through a presentation of personal objects. They imagined representations of health data in analog formats, where contextual information would be included. Visualization designs can be integrated into objects that older adults use frequently or are close to them. This study contributes design ideas on representations of health data for older adults in the global south and reflections on how to engage this population in remote co-design activities.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in HCI**.

KEYWORDS

co-design, visualization, older adults, health data

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1 INTRODUCTION

The *quantified self* - also called *personal informatics* - is a movement in which users use digital technologies to monitor their data, with the goal of remembering, finding patterns, or improving their health [66]. The rapid advent of mobile technologies has made this type of self monitoring ubiquitous through smartphones and activity trackers, which automatically record health data that users can then analyze. Older adults are able to use wristband activity trackers [77], but several usability issues remain, e.g. screen size, interaction techniques, and typography [50]. Past research has generally found that older users of activity trackers are on the younger end and interested in technologies [92], with more education and able to use more functions of the trackers [58]. However, extended education and technical abilities are less common in certain areas of the world for older adults, e.g. many older users in developing countries such as Chile and Ecuador have no computer experience (57.9% of older adults in Chile, compared to 31.8% in OECD countries) [82], and cultural factors may affect preferred wearable designs [50].

Data that is captured through activity trackers is most often explored by *quantified selfers* through simple statistics and visualized as line and bar charts [13]. Meaningful representation is essential for users, since they have to interpret the data themselves [83], and simple visualizations may provide little value to people who are interested in knowing more about themselves [49, 84]. In this search for better representations, a variety of visualizations have been proposed, e.g. through infographics, physical lights, timelines [13], storytelling [40], a spiral to represent periodic characteristics of the data [55], and physical representations [46] - e.g. 3D printed artifacts [52] and data sculptures [72]. Some approaches to representing health data collected from older adults' smart homes are described in the literature [6, 11, 96]. However, these are generally designed for researchers, clinicians, or caregivers, and not for the older adults themselves.

As with any user group, it is important to include older adults in the design of technologies intended for them, and there have been positive experiences in this regard (e.g. [97]), although there is little work involving older adults in the creation of health monitoring technologies and the accompanying data visualizations [91]. User-centered, participatory, and co-design approaches have been used to create technologies for older adults [4, 86]. Co-design workshops generally offer the possibility to think about meanings not yet experienced and technologies not yet developed [89]. However, the workshops themselves should consider their participants when deciding which activities to use. For example, older adults in one study reported feeling alienated from the material used in the design workshop, so they felt pressured to "accept" the technology rather than feeling empowered to create the new technology [86]. A related challenge is the lack of time to develop trust with older adult participants [104].

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Previous HCI research has often focused on negative aspects of aging [100], while other fields of research, e.g. critical gerontology, aim to expand our view about aging, promoting positive identities [48] and focusing on the capabilities and skills of older adults. The challenges in the design of health data representations - i.e., devices and visualizations of data - for older adults, especially when considering older adults from the global south, which is underrepresented in HCI research, led us to ask the following research questions: *1) What representations of health data can older adults from the global south imagine from personal, familiar objects?*, and, stemming from the COVID-19 pandemic which led to long quarantine periods in the region, *2) What considerations should we take into account when co-designing online with older adults?*. As a result of the COVID-19 pandemic may continue to isolate people, especially older adults, for longer, there is a compelling need to support the human-computer interaction community through new knowledge on how to co-design remotely with this population. In this work, we propose a co-design approach where older adults are allowed to explore, imagine, and create representations of health data through the presentation of personal objects. Using everyday objects can allows us not to alter the environmental system of these users, in such a way that we can maintain a normative behavior with a low probability of rejection [8]. Also, the presentation of objects allows us to work from an emotion, an experience, or a story related to the objects to evoke the future of artifacts (technologies) and their use [88]. In particular, our approach focuses on providing a set of materials (paper, pencils, modeling clay) to encourage creative thinking, something that is often overlooked as we get older [61]. The results of this work allowed us to successfully engage older adults in a remote co-design process to create health data representations. This paper adds to a limited range of literature that examines the process of designing health data representations for older adults. The contribution of this work is twofold. First, we share ideas on designs of health data representations for older adults in the global south, providing insights into how health data can be acquired and visualized for this underrepresented population. Second, we reflect on remote co-design with older adults and how such an approach can enable these users to imagine new technologies and representations of data.

2 RELATED WORK

Below, we discuss previous research related to two aspects of our work. First, we focus on health data representations, especially those used for older adults. Second, we discuss methods that have been used to elicit previous findings.

2.1 Health Data Representation for Older Adults

Some works on information design and visualization of health data for older adults has focused on the information's functionality, usability, and aesthetic appearance. For example, one study involved older adults with heart failure (HF) to create a health data dashboard. They identified that visualizations should show a positive data perspective; numbers can be more valuable than words alone; they also saw the need to include educational information to support the monitored data [3]. Likewise, a study conducted in 2019 on touchscreen design guidelines for older people recommended paying attention to interaction styles to address these users' declining vision and skill [76]. Another paper evaluated the usability problems of older adults using mHealth apps; they identified that the most severe problems were related to navigation through the app, which was affected by slower cognitive performance, technology anxiety, learning time, and execution speed [105]. A systematic review of the literature on mobile health technologies for older adults found that only 23.5% of studies evaluated visualization features, such as clarity of information organization, ease of understanding and interpretation of displayed images, or the "look and feel" of the visualizations [10].

Older adults have been found to prefer non-medicalized, discrete wearable technology, as medical-looking trackers may provoke anxiety or lead to early discouragement [99]. In terms of accessible computers, older adults prefer a friendly, conventional, non-technological, and non-stigmatizing design [31]. Visualizations of the collected data are often focused on functionality rather than experience and aesthetics, so they are usually represented as bar charts or line graphs. Although they allow users to understand, analyze, and search for details [25], they are not engaging, offer little context, and can be difficult to interpret by non-experts.

As a result, an increasing number of interactive visualizations have been developed that are specifically designed to allow non-expert users to achieve an open and reflective view of personally relevant data - sometimes trading interaction for aesthetics [41]. Haptic and tangible interfaces have been used to engage users with their data. For example, physical data visualizations with haptic interaction [43, 67] can encourage people to reflect on their meaning and provide a more enjoyable and engaging experience [98]. Living metaphors have also been found to be motivating and easy-to-interpret representations of data [60]. For example, the presentation of a virtual garden on a smartphone screen helped participants maintain their physical activity levels because they were interested in growing the virtual flowers [14].

Physical objects have been used as probes, to allow participants to think creatively, respond in comfortable ways, and respond either reflexively or instinctually [102].Personal, familiar physical objects have also been used to present visualizations. For example, a mobile phone case was modified with a 3D design, which contains heart rate information, so that the wearer can perceive the heart rate data while still having the unchanged functionality of the object [110]. This can make an everyday object more meaningful and affective [110]. Other studies have noted that in self-tracking practices, the physical artifact serves as a structured and constructive form of artistic expression giving rise to reflection and a way to capture their data more realistically [2]. The slow pace of interaction with physical materiality when tracking health data has been shown to allow users to reflect and explore the data, coupled with a digital disconnect [2, 8].

2.2 Involving Older Adults in Design

Technology is seldom designed from the perspective of older users [9], and since older adults are a heterogeneous group with a wide range of comfort and experience with technology [23, 54], involving

older adults from underrepresented groups in technology design is essential.

Researchers have increasingly involved target users in the design, development, and evaluation of assistive technologies by adopting co-design [22], participatory design [35], and user-centered design approaches [86]. These approaches allow users to create interventions that describe future objects, concerns, or opportunities [90]. For example, one study involved older adults in participatory activities to create their own imagined mobile phone system to support memory [70]. Other work has explored tangible participatory designs with older adults to create unconventional computers, resulting in well-evaluated, accessible devices [31]. Design probes, or craft objects, have been used to elicit from older adults meaningful information that can be used to design technologies that include participants' reflections [101].

Older adults may feel uncomfortable with technological devices that fail to take into account the heterogeneity of older adults, in terms of health conditions and social worlds [81]. For example, an alarm pendant can feel dehumanizing, and older adults often choose not to wear it, or to wear it selectively [81]. Ambient assistive technologies have also been implemented with input from caregivers, but not older adults themselves, which may lead to resistance [59].

Involving older people in the design of technology found that older people were better critics than designers. For example, older people's preference for technology is set by the design of the hardware rather than the design of the interface, as they could imagine the use of the phone and suggest improvements, but found it challenging to draw the interfaces [70]. Users often focus on what is possible [12, 42] rather than thinking about what they want to design. In a study conducted with older adults using the Makey Makey toolkit, although participants successfully interacted with the physical tools, they felt pressured to "accept" the technology rather than being the ones to create the new technology [86]. A successful strategy to face these issues was proposed by Harrington [38], who proposes generating prior engagement with the technology to receive highly informed insights and opinions at the time of the co-design sessions [38]. More evidence of the use of design methods with this population - such as remote co-design with simple materials - can help uncover how to help them be active co-designers and not just evaluators of technology.

2.2.1 Remote co-design. Most co-design studies with older adults have been developed in face-to-face sessions [71, 79, 86]. Many studies also discuss asynchronous models [53]. Co-design in an asynchronous model has limitations, as they cannot evaluate the method as it develops [69]. Studies that have employed co-design have demonstrated the value of face-to-face [71]. However, several external and internal factors can disrupt co-design sessions in the synchronous remote format as sessions occur in real-time. For example, a study about distance design with and for children highlights unforeseen moments such as when a child joins a session from a moving car or that the online environment offered more autonomy for the child to disconnect or turn off the camera and perform a different activity [57]. Another study noted a reluctance of young people to engage in design activities via Zoom, given that they were still adjusting to the long periods of interaction with Zoom [37]. At the same time, other authors have been concerned with connecting and controlling accessible hardware (e.g., portable projectors, mini-printers, and overhead cameras) to support remote design activities for older people with dementia [68]. There is still a need for HCI researchers to successfully adapt the in-person design or co-design methods to an online environment. Nevertheless, our study examined remote co-design among older adults to devise health technology.

3 RESEARCH BACKGROUND

This section briefly describes our research background. Since populations in the global south have been underrepresented in HCI research, we discuss what it means to age in this region (specifically in this case, in Chile and Ecuador) and the characteristics these populations have.

3.1 Older Adults in Chile and Ecuador

This section will discuss the social, economic, and technological characteristics of the older adults population of Chile and Ecuador. We found some similarities and differences between these two countries.

3.1.1 Chile. Chile has 2.6 million people over the age of 60, equivalent to 16% of its population. Life expectancy for Chileans is 82 years for women and 77 years for men [93], and by 2050 the population over 60 is expected to constitute 30.6%, which will exceed the percentage of the population under 15 years of age [34]. According to a national survey, 73.2% of Chilean older adults report general satisfaction with life. Society in Chile, as in other Latin American countries, is collectivist, i.e., interactions between people within the community are determined by collective interest, which is above individual interest [33]. Most people over the age of 60 live in a family or with a close, supportive family, while around 15% live alone, and only around 3% have no close family relations [87]. However, 63% of older adults report being concerned about "having to depend on other people" [87]. The vast majority of adults say that they belong to the Catholic religion, with women, people over 75 years of age, and people with a lower level of education being those with the highest level of religiosity [87].

In terms of internet access, 74.9% of Chilean households have an internet connection; however, only 56.6%correspond to households headed by an older adult [16]. Among older adults with some higher education, 77% have internet access, and 64% own a smartphone, while among older adults with a primary education, 34% have access to the Internet, and 27% own a smartphone [39]. Between 2013 and 2019, Chilean older adults' possession of information and communication technologies increased. For example, smartphone possession increased by almost 40%, and those who have Internet at home increased by almost 20% [39]. Wearable devices have increased in popularity in Chile, with sales of wearable electronics climbing from 2.6 to 24.5 million dollars between 2014 and 2018 in Chile [19]. However, there is no available information about the use of wearables by older adults in Chile.

3.1.2 Ecuador. In Ecuador, the percentage of older adults is expected to increase from 9% to 13% by 2025 and double to 26% by 2050 [30]. This means that there will be more than three million

older adults by 2050 [103]. The life expectancy of older adults has steadily increased in Ecuador; men and women are expected to live an additional 21.4 and 23.6 years at age 60, respectively [24]. The increase in life expectancy does not mean that Ecuadorians will always live these additional years in good health. One study estimated that in 2010 approximately 23% of Ecuadorian older adults lived in good social conditions, 54% in fair or poor social conditions, and 23% in conditions of extreme poverty or destitution [30].

Like Chile, Ecuador is a country that has collective interests above individual interests. For example, care for the elderly by family members has traditionally been considered a central feature of national identity [20]. However, significant proportions of Ecuadorian seniors live alone and in poverty. Only 19% live with their spouse, and 5% live with their spouse and grandchildren. [27].

Religion plays an essential role in shaping the Ecuadorian people's political, cultural, social, and family life [74]. In fact, for many Ecuadorians, religion is the most important aspect of their lives. According to the last population census, 91.9% of the Ecuadorian population declared they were religious. Of these, 80.4% self-identified as Catholic, and 11.3% said they were evangelical [44].

Regarding internet accessibility, in 2019 the percentage of households with internet access in Ecuador was 59.2%, in urban areas 66.7%, and in rural areas, 42.9%. Among adults ages 55-64, 42% have a smartphone, and only 19% have a computer [45]. There is no available information about the use of wearables by older adults in Ecuador, nor are there reliable statistics about their use by the population in general.

3.2 The Covid-19 Pandemic in Chile and Ecuador

COVID-19 disease is an infectious disease caused by the SARS-CoV-2 virus [107], which was declared a pandemic in March 2020. At that point, the disease was already present in more than 100 countries, including Chile and Ecuador [21].

In Ecuador, like Chile, several measures were implemented to reduce the spread of the SARS-CoV-2 virus. These measures included closing land, air, and sea borders, and suspension of public services except for health, security, risk services, and food services. In Chile, extensive quarantines were implemented, along with a night-time curfew between 10 p.m. and 5 a.m, and these measures continue to be applied by region according to epidemiological indicators, health care network, active search, and traceability indicators, and vaccination progress [18]. For several months, in some areas of Santiago, Chile, people could only leave their homes twice a week, with a special permission that they had to request. On March 16 2020, Ecuador declared a state of national emergency, along with quarantine and a night-time curfew from 21:00 to 05:00 hours. From March 25, the curfew was increased from 14:00 to 5:00 the following day [36]. These measures were applied for about 60 days. The situation during 2020 and the first semester of 2021 in both countries made many services become

4 METHODS

To inform and extend our understanding of health data representation for older adults, we organized a remote co-design workshop in which we asked participants to imagine where and how to display health data. We used methods inspired by object presentation and followed an adaptation of methods from dialogue-labs [63] to achieve this.

The co-design workshop was carried out completely online complying with the health measures of the pandemic at that moment. It took place between April and May 2021. The sessions were previously coordinated with each participant. We explained the videoconferencing platform that would be used (Zoom), and asked them to have someone with them to help connect them to the session. Individual sessions were held, where each participant interacted with one researcher (the first 5 participants interacted with two researchers). The duration of each session was 1-hour maximum. All sessions were audio and video recorded and subsequently transcribed. The Ethics Committee of the Pontificia Universidad Católica de Chile approved the research protocol under code 190405002. Participation in the study was voluntary and informed consent was received digitally from the participants.

4.1 Materials

Before the co-design workshop, a box of materials was sent to each participant. The materials consisted of pencils, sheets of paper, an eraser, and modeling clay. In addition, a copy of the informed consent form and copies of the DIGCOMP and IADL questionnaires were placed in the box. Participants were asked to read the informed consent information and complete the questionnaires. The information from the questionnaires has been detailed in Section 4.3. Due to the global pandemic context [1], gloves and alcohol for disinfecting the materials before use were included in the materials box. Participants were told that pencils and paper could be used during the workshop to brainstorm, draw or write, as needed.

4.2 Participants

We recruited 18 older adults (7 women, 11 men) aged 60-77 years. To recruit participants, we used non-random sampling, specifically snowball sampling, in which the researcher establishes contact with specific participants, and then they invite new potential participants to the sample until the sample is complete. A message to recruit participants was sent through WhatsApp groups of family members and coworkers of two researchers; in the message, we explained the study's objective, the activities to be performed, and the time the study will take. Also, in the message, we requested to spread the information with their contacts who could be interested in the study. People interested in participating contacted the researchers through phone calls. The details and objectives of the research were explained during the phone call; given the COVID-19 restrictions (social distancing), we did not speak personally with the participants. One week before the session, participants received the box with materials and informative documents (see Section 4.1). Some interested parties were reluctant to participate in the study for fear of making mistakes in the control of Zoom and not having the technological support of someone.

Nine participants were Chilean (and currently living in Chile), and nine were Ecuadorian (and living in Ecuador). All participants spoke Spanish as their native language. Spanish is the native language of the researchers as well, so the study and analysis was

completely conducted in Spanish, and then translated to present in this article. The participants' demographic data are shown in Table 1, which includes the nationalities, ages, gender, marital status, education levels and occupation, and work status of the older adults. The mean age of our participants was 65.83 years. Twelve participants were married, four were widowed, and two were divorced. The majority of participants had completed their university education (13/18, 72.2%), one had a technical education (1/18, 5.5%), and four participants had a high school education (4/18, 22.2%). The area where the participants worked included teaching, engineering, architecture, and law. Of the 18 participants, thirteen were retired (13/18, 72.2%), and the rest were still working (5/18, 27.8%).

In terms of digital skills, the majority had an intermediate level (10/18, 55.6%), implying that participants were skilled in information seeking, communicating with technology, and problem-solving such as accessing the bank via the internet. The remaining participants had a basic level (8/18, 44.4%); they were skilled in searching for data, information, and content in digital environments, accessing and navigating them. Of the older adults, ten were autonomous; they could perform activities of daily living, including preparing food, using public transport, shopping, housekeeping. Seven had a light dependency, and only one participant reported moderate dependency. The predominant disease among the participants was hypertension (10/18, 55.5%), followed by diabetes (5/18, 27.8%) and hearing loss (3/18, 16.6%). There were also heart disease (2/18, 11.1%), thyroid (2/18, 11.1%), visual (1/18, 5.5%), and arthritis (1/18, 5.5%). To manage health, participants have used both digital and analog technologies. More than half of the participants (10/18, 55.6%) use the Internet to look up health information, request medical appointments, or review test results. Other participants mentioned the use of a glucometer (4/18, 22.2%) and the use of a blood pressure monitor (4/18, 22.2%). Only one participant (1/18, 5.6%), had used a step counter, oximeter, or smartwatch.

4.3 Data Collection

First, we asked participants to fill out two questionnaires: DIGCOMP and IADL. DIGCOMP is a framework used to assess four areas of digital skills: information, content creation, communication, and problem-solving. This framework allows users to be classified into four possible levels: none, low, basic, and above basic [26] level of digital skills. IADL is Lawton and Brody's Instrumental Activities of Daily Living Scale, which assesses a person's ability to perform the instrumental activities necessary to live independently in the community (e.g., shopping, preparing food, handling money, using the telephone, taking medication) [56]. We also asked participants for demographic information, including country of residence, educational level, and marital status.

Then, the co-design session began, with the goal of discussing their use and perception of current technology, their experience with health data and their preferences regarding data representation. The interview was audio and video recorded, transcribed, and assigned a code (P1 to P18). Each session consisted of six stages, with four main activities designed to help participants think of new ideas, scenarios, or concepts about health data visualization. Each stage is described in detail in Section 4.4.

4.4 Procedure

4.4.1 Stage 1: Welcome. First, the researcher welcomed the participants and explained the main goal of the workshop. They were also informed that the study data would be collected for research purposes and that the results will be made available to them. Following this, questions about informed consent and DIGCOMP and IADL questionnaires were clarified. The declaration to participate or not to participate in the study was audio and video-recorded.

4.4.2 Stage 2: Introduction. Next, the researcher led an ice-breaker activity where each researcher and participant talked about their country of residence, educational level, marital status, and age.

4.4.3 Stage 3: Brainstorming about different types of health data. Participants were presented with slides that provided details of the research and examples of technologies that collect health data (e.g., Alex posture tracker [1]). We showed these technologies to provide examples to broaden participants' knowledge of technologies that monitor health data. We also asked about their health and how they currently use technology to aid with their conditions, e.g., the use of alarms, calendars, notes for the doctor, and particular health devices. Specifically, we asked them: *What tools have you used to record health data? Furthermore, what other information about your health would you like to record?*

4.4.4 Stage 4: Presentation of personal objects. Then, the researcher conducted an exploratory interview with each participant about the personal objects they carry on or near their body. We asked participants to choose three personal objects, present them and describe them. The presentation of objects animates and illuminates subject-object relationships [75], frames everyday experiences [106], and allows researchers to gain insight into users' preferences [73]. The researcher asked participants questions about the objects, framed by the following questions: *Can you describe the objects you have selected? Can you tell me how you imagine the data display when your object records health data?* (see Figure 1).

4.4.5 Stage 5: Molding technological device to imagine visualizations of health data. We challenged our participants to imagine technological devices that allow health data to be recorded from the presentation of personal objects. In stage 4, participants reflected on and imagined how their personal objects could become technological objects that allow for the collection of health data accompanied by a data visualization. Once the participants had reflected and imagined technological objects, we encouraged them to capture those ideas by creating a figure with modeling clay. Each participant was instructed to use modeling clay to mold an easy and comfortable figure for them to wear. Finally, participants imagined what their health data would look like once their device collects data. This activity allowed us to collect new ideas about data representation, which would have been difficult to achieve using standard interviews. Once the device was molded, the researcher asked about the specific data that the device would record to contextualize the data collection and subsequent visualization. Then, using that data as an example, we put participants in different situations (e.g., daily blood sugar monitoring, step counting) to see

[1] https://www.kickstarter.com/projects/891603560/alex-wearable-posture-tracker-and-coach?lang=es

Table 1: Demographics of the participants.

Participant	Nationality	Age	Gender	Education level	Occupation	Labor status
P1	Chilean	66	Male	Secondary Education	Hotel Administrator	Retired
P2	Chilean	65	Male	Professional	Architect	Working
P3	Chilean	66	Male	Professional	Electrical Engineer	Retired
P4	Chilean	72	Male	Professional	Physicist	Retired
P5	Ecuadorian	63	Female	Professional	Teacher	Retired
P6	Chilean	60	Female	Technical	Medical technologist	Working
P7	Ecuadorian	64	Male	Professional	Public administrator	Retired
P8	Ecuadorian	63	Female	Professional	Teacher	Retired
P9	Chilean	61	Male	Professional	Bank manager	Retired
P10	Chilean	77	Male	Professional	Chartered Accountant	Retired
P11	Chilean	67	Male	Professional	Architect	Working
P12	Ecuadorian	64	Female	Professional	Teacher	Retired
P13	Ecuadorian	66	Female	Professional	Teacher	Retired
P14	Ecuadorian	64	Female	Secondary Education	Bilingual Secretary	Retired
P15	Ecuadorian	60	Female	Secondary Education	Salesperson	Working
P16	Ecuadorian	60	Male	Secondary Education	Accountant	Working
P17	Chilean	77	Male	Professional	Lawyer	Retired
P18	Ecuadorian	70	Male	Professional	Teacher	Retired

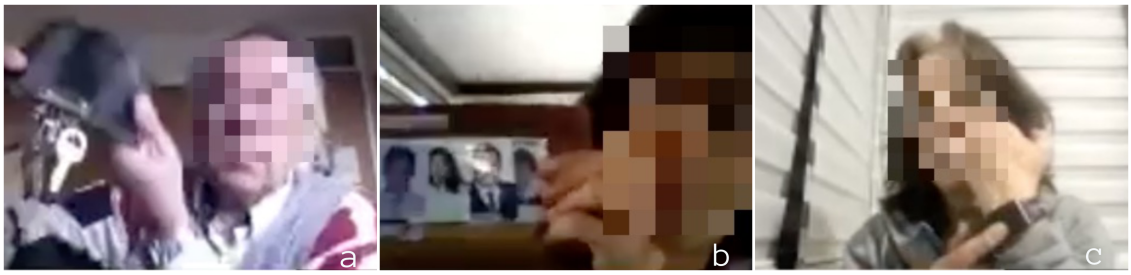

Figure 1: Personal objects: (a) keys, (b) wallet, and (c) watch were some of the objects chosen by participants during the interviews. These objects acted as probes to allow older adults to explore and imagine representations of health data

what functions their device would have or what they imagine the data would look like. The researcher asked questions like: *How would you know if there is an irregularity in your data? What would your data look like? How would you notice a disturbance in the data? What representation would help you find out if your data is within the range of your condition?*

4.4.6 Stage 6: Conclusion. Finally, the researcher thanked the participants for their time and comments.

4.5 Analysis

All audio interviews were transcribed verbatim and thoroughly reviewed by two researchers. The researchers conducted open code analysis, using the grounded theory methodology as a basis. The choice of this stategy was because the purpose of the study was to explore, describe and understand the participants' perspectives [15]. In this way, we were able to generate codes and organize them into categories, as follows.

First, the data was analyzed line-by-line using open coding to determine initial categories. Subsequently, axial coding was used to identify relationships and create concepts from the initial categories. Consequently, the aim of this step was to reduce the number of categories by identifying similarities between categories and making the data clearer and more understandable. The ATLAS.ti program was used to organize the information. In order to ensure the methodological accuracy of the results, a triangulation strategy [94] was used, which consisted of generating codes from the perspectives of two researchers. We paused after the first four interviews; this allowed us to discuss and reflect on the granularity of the coding scheme. As a result of this discussion, a list of codes was generated and applied to the remaining interviews. As subsequent interviews matured, we moved to more focused coding, fleshing out the concepts and themes. Regular meetings were held to evaluate and adjust the generated codes. During these meetings, the codes and transcripts were re-read to identify the main themes. These themes were generated through a process of interpretation, synthesis, and iterative theorizing. Finally, a consensus was reached on the generated categories.

5 FINDINGS

In this section, we highlight themes that when older adults imagined the representation of health data and molded technological devices for displaying health data. We also discuss older adults' engagement with our design method in a remote environment, and their qualms about technology. We illustrate each theme with quotes from our participants (all quotes have been translated from Spanish). Table 2 summarizes our findings

5.1 Imagining the Representation of Health Data

From our analysis of how older adults imagine the representation of health data, two themes are conceptualized: trust in the things near where health data is displayed and the format of representation of health data.

5.1.1 Trust in Things Close to Them. Over half of the participants (13/18, 72,2%) expressed interest in using technology that records health data as long as they feel comfortable with it. Participants talk about things close to them that they trust, things they are familiar with, such as a belt. *"The thing is, I am lazy (...)... if it were as easy as that, just like putting on a belt, yes, I would definitely see my heart rate to know whether it has accelerated or not"* (P2). Another participant mentioned objects that are easy to wear, allow to see social information, and stated the possibility of embedding technology in ordinary objects. *"You could incorporate into a ring, something that is easy to wear, or otherwise for users who always wear a watch (...) Some people talk on the phone, see their calendar, check their e-mails, check their WhatsApp messsages, etcetera. So maybe it [the phone] suits them better, but I think that, when you develop technology, you can attach it to other things, and those other things can be more than one"* (P9).

5.1.2 Format of representation of health data . Representing health data should not necessarily be associated with a statistical graphical representation. One participant mentioned *"I would like, say, to have images: something visible and educational, so that I can understand what is happening, so that the camera can capture it and it can be easily interpreted. If it shows, for example, statistical tables or graphs, bars, I could be in trouble, I would not be able to understand"* (P7). Often, technical information is obscure for older adults and they would like simpler representations, like numbers and reference values: *"No, not graphs. Just numerical data, that is, comparisons... well, of course you have to know some rules, like with a measuring tape, it starts at 0 and ends at some number (...) "* (P3). One participant notes that the only way their blood glucose is shown in healthcare devices is through numbers, yet the user wants the technology to interpret the data for them. *"I've seen so many, so many, so many times the values of my glycaemia [laughs], that I understand that there is no other way. For example, when it comes to my glycaemia, there is no other way, only numbers (...) But ideally, it would just tell you: 'you're doing very well' [laughs]"* (P5). One participant stated a preference for seeing information in the form of figures or emoticons rather than numbers. *"A code could be displayed, (...) a figure that tells you what is going wrong at that moment or what the information that is going to be shown to you refers to. And then you can give it a touch, and it will give you more information about it. It doesn't give you a number immediately - rather, it first gives you a figure, an emoticon, let's say, that tells you what the information refers to, and then you can find out more "*(P11).

Data could be presented in various ways; for example, three participants have associated their health data with photographs stored in a mobile phone gallery. *"So if at some point I go to the doctor, I review my photographs, for example, from May 2021. 'Doctor, I had these...', but also for me to look at because memory is fragile"* (P14). The participants imagine simple data representations like a photo gallery where they can organize the information chronologically and visually comfortable for them. For one participant, representing data on activities of daily living through pictures fills their spirit, and it is easy for them to retain that information. *"The picture of when I exercise, that would be a picture of walking (...). The image of when I have stayed home would be two images: either I am working in my prayer workshop, or I cleaning my house in an exaggerated way... (...) What I can see visually registers in my mind, it registers in my soul"* (P5).

Health information could also be represented abstractly on the body to fit the users' needs. Six participants commented on the difficulty of looking at information on small screens; they prefer to see information on external devices, not directly on the monitoring devices; e.g., they prefer to see data on computer screens. *"The graphs are so difficult sometimes to read on a small screen here (...) you have to start by making the one on top bigger, then see what you are measuring, enlarge the one below, but you can rarely read the whole picture, (...) I go back to my computer and my laptop, here it shows me the whole thing and I can zoom in like this, I can read it, I have no difficulty, that is what I prefer "* (P1). Another participant makes a comparison between phone screens and computer screens. *"I prefer the PC screen. When I have to interact on the mobile screen, it always makes me uncomfortable (...) either because several of the pages are not suitable for all platforms, or because in this adaptation I lose my macro vision, I find it hard to read, it's too tight, and if I make the letters bigger there are too few words, so it makes me feel uncomfortable. So I prefer to watch on a big screen "* (P2). One participant mentioned that the most pleasant and understandable way to see information is through an analog representation. *"(...) everything is analog, nothing digital. Why? The reason is straightforward: you recognize more quickly an analog image than a digital image. For example, this needle is showing here, 'Oh! The engine got hot!'. I don't know how hot, danger, but if, for example, it shows you a display that says 99.99. What the hell does 99.99 mean? It's the temperature of the engine, and how much can that vary? It could be 199, or it could be 10. It takes you much, much longer to mentally work out digital information than analog information "* (P4).

The information displayed to users has to make sense to them; they have to understand it, and it also needs to be simple, but they have to feel comfortable and familiar with it. One participant points out the benefit of having contextual information to support health assessment regarding the relevant information to visualize in health devices. *"So putting the two things together: on one hand, the information that the environment can provide, and on the other hand, three things: the activity that you are doing, how it affects your life according to your biological health parameters, and that it can suddenly give you an alarm, or say 'you know, just go on, it's fine' "*(P11).

Table 2: Overview of themes and sub-themes, brief description, and illustrative quotes from participants

Themes/Sub-themes	**Description**	**Example Quote**
Imagining the representation of health data		
a) Trust in things close to them	Close ordinary objects that could record health data	The thing is, I am lazy (...) if it were as easy as that, just like putting on a belt, yes, I would definitely see my heart rate to know whether it has accelerated or not
b) Format of representation of health data	Need for simple representations of health data	No, not graphs. Just numerical data, that is, comparisons well, of course you have to know some rules, like with a measuring tape, it starts at 0 and ends at some number
Technological device for displaying health data		
a) Health devices connected to their contextual factors	Health technologies closely related to user beliefs and preferences	So it could be something in between [laughs], between a badly made doll and a little crucifix (...) Because if I'm going to wear something, it has to be something I like, right?
b) Fashion sense in health data representation	Technological devices that allow showing their style and aesthetic preferences	Something easy to wear inside the clothes, on top... something so pretty. If I'm going to wear it like that, if I'm going to wear it next to my chest, it has to be something so pretty, so soft and that catches my attention when I see it
Technology Resistance and Adoption	Unobtrusive technology that does not create dependency	As far as I know, as doctors have often commented, people are enslaved by it; hey live in suspense of how many steps they have left, of what they have to do, if it is necessary they will interrupt any activity to go jogging for a while. So they transform their life into a kind of machine to achieve their goals. I don't like that kind of thing.

5.2 Technological Device for Displaying Health Data

In stage 4, participants presented their personal objects. The personal objects presented by participants ranged from "necessary objects", such as keys, glasses, or mobile phones, to personal objects, such as a wallet, a pencil, or a watch. Participants talked about the origin of the objects, the main characteristics, and the place on the body where they carry them. During their interaction with the personal objects, participants shared stories and secrets, recreating memories.

In stage 5, they molded a technological device to imagine the representation of health data. In these sessions, each participant used three personal objects that they carry on or near their body and used modeling clay to mold a technological device that would allow them to imagine the representation of health data. The older adults' ideas included health devices connected to their beliefs and their fashion sense.

5.2.1 Health devices connected to their contextual factors. In molding the technological device, we encouraged participants to think about the shape of the device, where it would be worn, and how they would like to see the data the device collects. Participants imagined several devices to collect health data, including cards, coins, crucifixes, bracelets, and earrings. Some of these devices are shown in Figure 2. The created devices are closely related to their beliefs and preferences. For example, one participant shows a proclivity for religious figures (e.g. a crucifix) that can be worn near the chest *"... So it could be something in between [laughs], between*

a badly made doll and a little crucifix (...) Because if I'm going to wear something, it has to be something I like, right? To hang it from a chain here (...) That would be the idea. And while I'm carrying it, it's going to give me some good information"(P5). The creation of technologies that record health data should not have shapes that overwhelm or are disconnected from users' reality; participants wanted to feel receive health information but identify with their device. One participant molded a device that was easy to carry in the pocket. *"Yes, yes, yes, yes... I imagine it should be like something simple, like a card, a light and flexible thing that I can simply keep in my wallet"* (P2). There were also participants that created figures according to their style and comfort in carrying these objects on the body. *" So, a handle on the left arm with little circles that would change color, for example, if my blood pressure goes up, one circle would light up for blood pressure, one for oxygen saturation, and the other one for glucose"* (P14).

5.2.2 Fashion sense in health data representation. The imagination of the participants was stimulated through the presentation of personal objects. Participants presented personal objects such as keys, mobile phones, handkerchiefs, or watches. Personal objects express a need or a person's style [64]. One participant mentions the use of green pencils to differentiate himself from others. *"(...) regarding Literature, I love Pablo Neruda, and Pablo Neruda in his life wrote everything with green ink (...) And maybe I thought I was a poet. I'm joking, I've never written a poem, but sometimes you find people you want to identify with or you want to be like them, and in this case, it seems like I only the ink color"* (P4). One of the participants also points out her enthusiasm for wearing beautiful, delicate things that catch her eye. *"Something easy to wear inside the clothes, on top... something so pretty. If I'm going to wear it like that, if I'm going to wear it next to my chest, it has to be something so pretty, so soft and that catches my attention when I see it [laughs]"*(P5).

Regarding colors for the representation of health data, 11 out of 18 participants (61.1%) associated the traffic light metaphor with representing the status of their health data. One participant described the meaning of the colors associated with the seriousness of the information collected. *"So, the red light would be something about danger, that you have to ask a doctor or something like that and, but if everything is green, or maybe a very light green, it means everything is very well. Or a bit of a faint green could mean it is not so, so, so good, but if it is disastrous, then a red light"* (P15).

5.3 Technology Resistance and Adoption

One participant expressed resistance to using new digital technology tools; for him, traditional tools (e.g., ruler, pencil) are simpler and easier to use. *"One thing is for certain: while I was studying architecture, all I did was freehand drawing and maybe a plan or a model, but maybe with a ruler and other drawing equipment; but don't ask me to draw now with Autocad, because it is impossible. I have never known how to do it, and I am not going to try either, because the things I do draw, I do them with a pencil and with a board on my desk, with my simple tools"* (P3). Another participant expressed their feeling of non-dependence towards technology – they felt technology could turn them into a machine: *"As far as I know, as doctors have often commented, people are enslaved by it; they live in suspense of how many steps they have left, of what they have to do, if it is necessary they will interrupt any activity to go jogging for a while. So they transform their life into a kind of machine to achieve their goals. I don't like that kind of thing. I'm a great admirer of an individual's freedom, so I would not be voluntarily enslaving myself with that kind of thing that tells you what you have to do and what you don't have to do. If one day you feel like running 100 kilometers and another day you don't feel like moving, why do you have to make it an obligation, a sacrifice? Hey, in short, you're wasting your life with that thing if you can't do what you want to do"* (P17). Participants were also wary of how others would perceive the devices. One proposed that the device should be discreet so as not to alert people nearby. *"I imagine a chip, more or less like the one I have in my hand; it's a little thing I could even have behind my ear, attached to my earring. That is, it's not necessarily going to be in my chest, but it can be attached to my earring, and nobody will know what I am wearing it. That chip can beep when my blood pressure goes up or when my blood pressure goes down because it would be monitoring my blood pressure, and if it controls my saturation the moment my saturation is too low, it could also beep, and I would look for a way to solve the problem. Maybe the people next to me wouldn't even know how I realized because I would use a very tiny thing attached to my earring"* (P8).

Among the participants, 11 expressed interest in customizable technologies (11/18, 61.1%), wanting to make the device their own. One participant considered that health technology functions should be able to be associated with the user's illnesses. *" Well, we could put alternatives, for example, Monday would be pain, hyperglycemia, temperature rise. So I would use symptoms, typical symptoms of each disease. So when you buy it or you get it as a gift or whatever, you input the disease you have, you know? So the language will be associated with the illness you have"* (P6).

6 DISCUSSION

This study demonstrates that remote co-design activities enable older adults in Chile and Ecuador to imagine future health technologies through their personal objects; these activities provide a voice to an underrepresented group that is typically neglected in technology development. Although the creation of new technologies to support the health monitoring of older adults has been explored [38, 86], it is advantageous to examine the process of designing representations of health data for older adults through their personal objects, which can generate novel concepts and perceptions about future health technologies.

6.1 Design Insights for Health Data Representations

6.1.1 Contextualized data. Graphs, charts and numerical representations (e.g., bar, line, pie charts) have typically been used to represent health data collected by mobile devices (e.g., Fitbit). However, participants in this study expressed interest in other types of visualizations. For them, it is appropriate to have representations of data that are connected to their previous life experiences. For example, some participants mentioned their preference for analog representations because they see these data representations on the controls of a car or a clock with hands. For them, it is important to know the possible range of values to make sense of the data. It has been noted in the literature that although much of society has

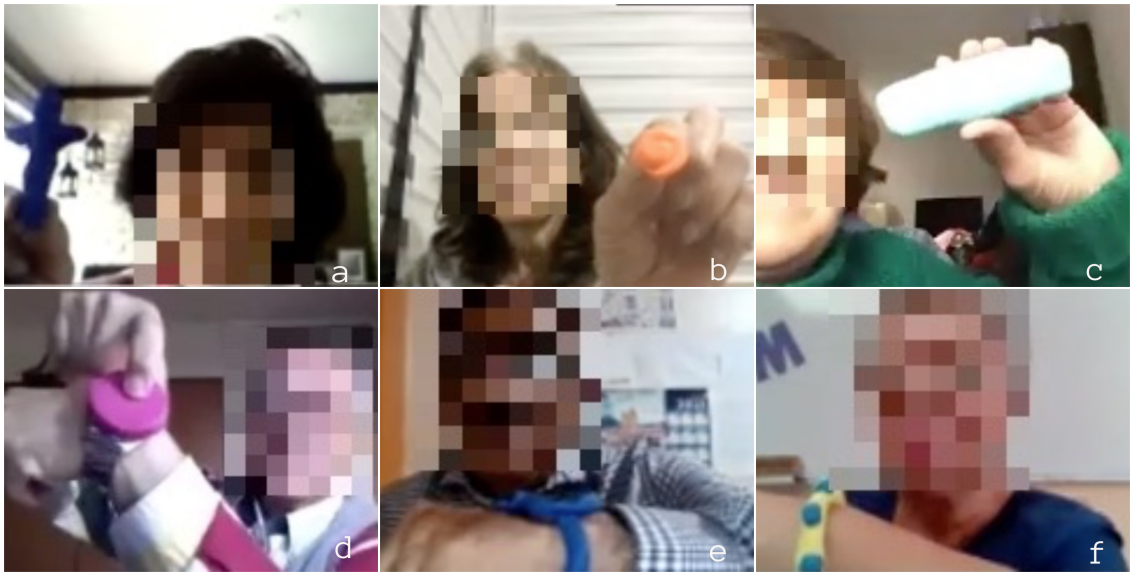

Figure 2: Technological devices for collecting health data: a) crucifix, b) earrings, c) card, d), e) and f) bracelet.

incorporated digital technologies into their lives, older adults tend to opt for offline, analog, and face-to-face alternatives [29, 109]. In line with the above, it has been shown that numeracy may be lower in the older population [5] due to age-related analytical processing and reasoning [78]. Health technology can offer new ways of representing health data, especially for users who have little experience handling health data and difficulties processing digital information.

This study also identified the need for health data visualizations that include contextual information. Participants imagined a photo gallery, where they can see information about their physical activity, the clothes they wore, and the place where they did the activity. Displaying information about the clothes they wore allows them to deduce whether they stayed at home or went for a walk. We also identified that our participants were interested in having information from the environment, from the activity being undertaken so that this data supports a comprehensive assessment of their health. This data representation could be feasible for an older adult population that is detail-oriented when looking at a picture or has a low numerical ability.

Providing older adults with a familiar object that displays health data, such as a photo gallery with contextual information, could make them feel more motivated to consult their data, which is in line with previous studies that have found that physical objects make users aware of their data [51, 110]. Physical forms also activate perceptions beyond the visual and provide pleasurable multi-sensory experiences [47]. Interviewees mentioned the importance of writing down their medication and medical appointment schedules on paper to process and remember the information.

6.1.2 Acceptance and Trust in Technology. Although older populations in Chile and Ecuador generally have less experience with technology, our participants had basic to intermediate digital skills. Having some knowledge about technology may have helped them imagine new types of data visualizations and devices. Still, some of the participants did not readily accept the idea of displaying health data. Although they understood its usefulness, they worried about becoming dependent on a device whose information could alter their health status, i.e., constantly checking health information could damage their mood.Our participants also reflected on the appearance of devices that display health information. They prefer small devices such as an earring that are not noticeable to the people around them. Other researchers have come to similar conclusions; for example, not all older adults readily accept the idea of using activity trackers to be more physically active [25], and older adults have been found to prefer unobtrusive and non-medicalized health technology[99]. Alarm pendants are perceived as dehumanizing technology for older adults [81].

The creation of technology for health monitoring of older adults has generally considered usability factors and the accuracy of these technological tools [17]. However, little attention has been paid to trust. Older adults need to discard the embarrassment of interacting with new technologies (e.g., robots) before they allow themselves to build a relationship with them [17]. So why not create technology from things close to older adults, things they already trust? Some work has addressed constructs related to the role of trust in older adults' adoption of technology. One study showed that physical personas were indeed more trustworthy but less empathetic than the virtual persona for self-management of the health of older adults with diabetes [62]. Some authors have investigated ways to increase trust through affective aspects (e.g., reducing anxiety) [28]. We propose that technology for monitoring the health of older adults could have the starting point of things that are close to them, things they already trust.

How data is displayed is critical to the older adults interviewed; it is essential to them that these data do not cause unnecessary pressure or unease. An essential dimension of the close experiences they have seen of self-tracking is the ambivalence that people may

feel in reversing their reliance on numbers and altering their perceptions to adapt to the demands of the technologies they use. At the same time, participants have expressed fear that the technology could turn them into a machine where they lose control of their decisions . This resistance to quantifying their health is not only seen in older people. Some authors argue that resistance to the dominant ways of living with data is a "soft resistance" - a partial resistance, which alters according to idiosyncratically changing priorities and goals [65].

6.1.3 Personal and Cultural Connections. Participants in this study talked about their personal styles, about the things that distinguish them from others. There is an obvious connection with spiritual objects and objects that make them feel different from others, for example, a green ink pen (for one participant, talking about his style means talking about old man quirks).The co-design of technology can help us design devices with the styles, tastes, and "old people's quirks" of its intended users. This is in line with previous research stating a need to include the experience of older adults in the technology research process and to move away from relying on stereotypes of gerontology [91, 100]. Social and cultural aspects also need to be considered, as the meanings of these aspects play an essential role in the design of technologies [8, 95]. It becomes even more critical when research on technology and the representation of health data for older adults has been studied primarily in first-world countries, where the context, preferences, and tastes may differ from other countries [82]. A contextual understanding of the complex and diverse life experiences and needs of non-first-world older adults is required. Chile and Ecuador, for example, have collective interests over individual interests [33]. Older adults in these countries prefer to live their last years with their families or with people close to them. In addition, religion plays an essential role in shaping political, cultural, social, and family life. Some participants in this study imagined seeing their health data on religious objects; for example, a crucifix.

Most of the participants in this study completed their university education. They worked in professional fields, which presupposes an advantage in accessing technology, and can take much greater control over their lives than older people who live in a disadvantaged situation. However, more than half of older adults (54%) live in common or poor social conditions in Ecuador, and 23% in extreme poverty or indigence conditions [30]. The literature has shown that older people, those with low levels of education, lower incomes, people with disabilities and chronic health problems, and those living in rural areas have less access to digital technologies and fewer skills to use them [7, 50, 58]. In Chile, Older adults (57.9%) are much more likely to report having no computer experience than the OECD average of 31.8 percent [82]. Although technology use by older adults in Chile increased between 2013 and 2016, gaps persist based on age and education level, with those over 75 and individuals with lower education levels being the least likely to engage with technology [34]. There is a need to incorporate sociocultural characteristics that could influence the design of health information and data visualization; it is necessary to explore the perception and knowledge of older adults about health data from the social and cultural aspects of Latin America.

6.2 Remote Co-Design Experience with Older Adults

The needs for physical distancing resulting from the COVID-19 pandemic [1] led to limitations in the possibilities of face-to-face interaction. Researchers and co-design practitioners had to rethink ways to carry out the co-design process.

In this paper, we used remote co-design with older adults as an innovative approach to the ideation of health data representation. The literature notes unique value in leveraging exposure to technology in co-design [22, 31]. The results of this work show that developing ideas about technologies that visualize health data through remote co-design can be particularly valuable when working with older adults.

In stage 4 of the co-design session, we invited participants to select and present three personal objects they frequently use and wear on or near their bodies. This activity provided a tangible and concrete way to initiate discussion on the representation of health data, allowing participants to bring their opinions and multiple perspectives from the beginning of the session. This presentation of personal objects also generated an atmosphere of trust between participants and researchers. Thus, for the participants to present their personal objects meant going back to the time they acquired them and their value. They shared stories and secrets by recreating periods of their lives. This presentation allowed them to explore and devise new representations of health data that can be integrated into personal objects that are frequently used and close to these participants. At the same time, this activity encouraged participants to imagine which part of the body they would like to wear the health technologies.

Sending out the box of materials before the session allowed participants to prepare, e.g. to calmly read the informed consent, fill out the questionnaires, and raise questions about the development of the co-design session. All questions and recommendations were indicated in the introduction stage. In addition, giving the participants materials used in their childhood, such as modeling clay, helped them to easily shape their ideas and engaged them in the activity. Some co-design studies with older adults have noted that by offering a kit of materials (e.g., Makey Makey), participants felt pressure to accept the technology rather than create the new technology [86]. Other studies have suggested using various materials in co-design sessions with older adults to encourage more visual concepts among these users [38]. In our case, most participants were initially reluctant to manipulate the modeling clay, with comments such as *"I suck at arts and crafts"*, *"arts were not my forte at school"*, *"my skills are bad, this was my worst subject at school"*. However, after the first impression and interaction, the adults were satisfied when they shaped the device in modeling clay. The simplicity and familiarity of the material helped older adults remain relaxed, open to discussion, and imagine the functions of the technology. For example, the smell of the modeling clay allowed one participant to devise feedback according to the odor levels of this material.

Some studies that applied online co-design claimed to have fewer visual cues to interpret the emotions and experiences of child participants as they had control over turning the camera on or off [57], another study showed that participants showed resistance to Zoom interviews as they were adapting to long periods of Zoom

sessions [37]. The older adults in this study felt comfortable having the camera on; they could show their personal objects and the prototypes created in detail (color, shape, size, or functioning); this excited them, and they felt accompanied. It should be noted that the sessions conducted in this study were individual. However, during the co-design sessions, there were external distractions, such as a ringing doorbell, the presence or noise of pets, or taking medication.

In the face of sensitive conversations from participants, such as recovery from chemotherapy, death of family members, or the anguish of retirement, the researchers improvised emotional reactions to these factors. For example, we gave positive feedback to make participants feel welcomed and listened to. Other improvisation situations led us to change the order of the questions, but we kept the activities in the pre-established order. As for the external distractions generated during the sessions, these were subtly inserted into the conversations; for example, when the pet barked, the topic of conversation was about the type of pet we have, then we returned to the topic of co-design.

6.3 Lessons Learned from Applying Co-Design with Older Adults Remotely

In this section, we discuss the considerations to consider when co-designing online with older adults. We present three sub-themes that emerged about the individual experience of the participants and researchers during the online co-design session: 1) Atmosphere of trust; 2) Playful activities; 3) Unforeseen situations.

6.3.1 Atmosphere of trust. In general, the participants were optimistic about the execution of our design sessions. For example, in phase 4, presenting their personal objects meant going back to the time when they acquired them and the value they had. They shared stories and secrets by recreating periods of their lives. This presentation created an atmosphere of trust between researchers and participants. For example, when one participant described his wallet, they also talked about their photographs with their family and remembered each family member. *"This is a pocket diary of mine, which also has photos (...) This is the last photo before my spouse died. Here, on the side, my son, my daughter-in-law, this grandson of mine is now 15 years old..."* (P5).

6.3.2 Playful activities. The presentation of objects also helped participants imagine the shapes of the technology where health data would be displayed and think about the part of the body where they would like to wear the technology. One participant expressed interest in a card that would be as portable as a mobile phone. *"It is like a card, but thin, not a credit card, more like a long card, which will have a screen (...) I would carry it in my pocket, like a mobile phone with a casing so that it does not break; it does not spoil, a glass sheet on top to prevent an accident, because everything falls out of your hands, so a glass sheet and a keyboard down here"*(P6). Another participant reflected on what object he often carried close to his body. He identified that it was the belt and imagined a device that would attach to it. *"What I always carry with me, because I think it's creative, is a belt; so actually if you want, on my belt, I would put this on my belt like this, attached to my belt, like this"* (P2).

Another theme that stood out in our observations of the co-design sessions was the participants' reaction when they were asked to use modeling clay to mold a technological figure. Most participants were initially reluctant to manipulate the modeling clay, with comments such as *"I suck at arts and crafts"*, *"arts were not my forte at school"*, *"my skills are bad, this was my worst subject at school"*. However, after the first impression and interaction, the adults were satisfied when they shaped the device in modeling clay. One participant commented that in the end, it was a relaxing activity *"And by the way, it even was relaxing. I found it to be a relaxing activity"* (P13). After manipulating the modeling clay, one participant imagined functions of the technology that they would not have imagined without the contact with this material. For him, the smell of modeling clay may be an indicator of health status. *"Now that I'm inspired (...). You could incorporate another sense: the smell so that it has a pleasant smell (...). When it's green, it smells like cologne, and when it's something wrong, it smells terrible"* (P1). One participant also acknowledged that the modeling clay activity helped him generate more ideas about technology. *"you could add a scroll here (...). You did well to push me to do the activity and put up with my usual reluctance to do things in the modeling clay "* (P2).

6.3.3 Unforeseen situations. This subtopic covers unforeseen situations that arose during online interactions. One of the challenges for the researchers in conducting the remote co-design with older adults was to improvise the interview guideline in the face of sensitive topics from the participants. For example, when they spoke of a chemotherapy recovery *" (...). In 2002 I was diagnosed with breast cancer, and I had surgery. They removed my entire breast with the lymph nodes from my arm"* (P14). When a personal item reminded them of dead family members. *"(...). This is the last photo before my spouse died"* (P5). Or distress when talking about their retirement *"When I had just retired, I had an anxiety problem, I could not find my way around "* (P15). Another challenge generated was the difficult task of identifying the mood of the participants; a camera gives us fewer clues as to what is happening on the screen or behind the camera. Also, speaking through a camera is less close than speaking face-to-face.

In our session, improvisation depended not only on the sensitive issues of the older adults but also on the external situations. There were short moments of distraction on the part of participants and researchers; when the doorbell rang, when pets barked and peered at the screen, or when the participant needed to pause the session to take medication.

6.4 Limitations and Future Work

First, we would like to acknowledge the limitations of the present study. Regarding external validity, we used a sample of 18 older adults living in Chile and Ecuador. The results of this study may not be generalizable to older adults in other places and different populations. The participants in this study had a university degree and worked in professional fields. The leading indicators of a person's position in contemporary society are income, occupation, and educational level [80]. Furthermore, studies have shown that socioeconomic status is a strong predictor of technology use [108] and health information literacy [32]. Therefore, the sample in this study could imply greater access to and experience with technologies and digital skills, resulting in a better ability to imagine various interaction modalities and representations of health

data. The data analysis conducted in this study is interpretive so that it may present possible biases due to our beliefs, values, and assumptions.

Designers or researchers of health technologies for older adults might consider using everyday, normal things that this population uses to introduce technology. To achieve this requires that older adult users are provided with various means to encourage reflection and dialogue around the things they trust and identify with during the design process, as in the design probes that have been used to elicit information from older adults [101], as the tangibility and physicality of the probes facilitates the discussion and the objects mediate the dialogue. In this way, we can leverage the objects that older adults already feel comfortable with and trust, and we may be able to help these feelings transfer to the technologies. This study broadly discusses health data - however, the health information needs of a specific person are highly dependent on their specific health conditions, and older adults are a heterogeneous group, as any other age group. Therefore, future work should focus on a narrower group of older adults with specific health needs, to focus on a "situated community" [85], in which design is informed by the needs of the specific population.

7 CONCLUSION

This study presents design ideas for the representation of health data for older adults. We conducted a remote co-design session with 18 older adults from Chile and Ecuador. The co-design activities consisted of brainstorming about types of health data, a presentation of personal objects, and the molding of devices to encourage participants to explore, imagine, and create representations of health data and the form of the object or device where this health data is displayed. When older adults in this study talked about representations of health data, they reflected on their usefulness and appearance. They imagined representations of health data in analog formats, and images, where contextual information would be included. Visualization designs can be integrated into tools or devices that older adults use frequently or are close to them. We suggest that these devices be unobtrusive and that the design of these devices considers the cultural context and idiosyncratic needs of older adults. We encourage developers and designers to create technologies that display interpreted health information, which could benefit older adults who have lower levels of numeracy and health information literacy.

The remote co-design approach, including object presentation and the molding of devices, allowed us to understand and reflect on the needs and preferences of older adults regarding the representation of health data. The older adults enjoyed the activity and were able to propose new objects and discuss their properties and affordances.

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