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"What does THIS Mean?": A Collaborative Expert Evaluation of Health Data Representations for Older Adults

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Abstract. Health Data Representations (HDRs) pose significant accessibility problems for people with disabilities and older adults, particularly those with visual, hearing, speech, motor and cognitive impairments, as well as literacy problems. While methodologies like heuristic evaluation and visualisation literacy are valuable, they have limitations in addressing the varied and nuanced range of data representations and perceptual matching issues. This paper presents findings from a collaborative expert evaluation that strategically bridges the gap between domain experts and non-experts. By scoping out representative HDRs, our approach significantly expands the research space for accessibility issues within the designated scope, narrowing critical gaps in existing independent guidelines. Using this methodology, we carefully examined common conventional HDRs, collaborating with experts to identify 179 potential issues specific to older adults. Categorisation strategies highlighted key issues within this broad problem space, showing that existing guidelines fail to effectively address all of the predominant categories. Our paper presents a set of emerging impairment-agnostic recommendations in response, embedding crucial steps towards mitigating these problems. Our study not only identifies challenges but also provides a model for iterative evaluation and adaptation of critical HDR. Beyond informing more accessible system design, we also highlight innovative opportunities for future HDRs.

Keywords: Health data representation · Accessibility · Older adults · Expert evaluation

As the global population of people aged 65 and over increases [1], the need to anticipate and improve healthcare and long-term care systems to support the independence of this demographic group becomes more significant. The demographic shift to a rapidly ageing population accentuates the critical role of health data representations in conveying essential health information to a variety of stakeholders, including clinicians, patients, policymakers and other experts. Health Data Representations (HDRs) are the different ways health information can be conveyed to end-users [3]. It refers to the visual (graphs, charts, tables), textual formats or interactive elements that show trends, patterns or insights from the data. However, the predominant use of visual or textual formats in these often-complex representations for end-users poses a significant challenge, making them inaccessible to people with disabilities or age-related impairments.

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Personal health data, particularly from patient-generated health data using devices such as wearables and smartwatches, is integral to self-management and communication with healthcare providers [2, 8]. Closing the data loop [10] by ensuring the accessibility of represented data to end users becomes essential if these representations are intended to be understood by older adults for the self-management of health conditions.

Often in studies, HDR is referred to as health data visualisation [3, 11, 12], which focuses on understanding a graph and extracting meaning. Considering the critical processes of monitoring and managing health conditions often faced by older adults, the decision-making and significance of the health data presented are as important. Previous studies have focused on the Health Data Representation format for older adults, predominantly addressing visualisation usability (graphs and charts) by exploring better visualisation techniques to help older adults manage and understand their health [11, 14]. Other researchers also identified a need to integrate the context within the representation by having older adults co-design and imagine the data in their everyday objects, establishing that the significance goes beyond just the conventional graph [12, 15]. Two major aspects remain to be addressed. The first is exploring how health data representations typically convey critical physiological data used for self-managing health like blood pressure, heart rate and sleep data. Second, to explore the use of other modality cues beyond visualisations to enhance the accessibility of health data. This study aims to fill such existing gaps by assessing the accessibility of Health Data Representations (HDR) within the context of critical physiological parameters. Although heuristic evaluation [16] and visualisation literacy [17] have been explored for health data, a more refined evaluation is necessary to assess the accessibility of current HDRs to match older adults' needs.

In this study, we aim to identify accessibility issues within a restricted set of existing HDRs by conducting a scoping review of off-the-shelf health apps on smartphones and tablets, focusing on two critical physiological parameters relevant to older people: blood pressure and sleep data. Using a collaborative expert evaluation methodology, this primary investigation with experts explored the complexities of these data representations identified during the scoping review.

1 Expert Evaluation Methodology

1.1 Materials

Given the widespread use of wearable devices and the increasing integration of mobile technologies [7, 15], our evaluation focused on a scoped set of HDRs and physiological parameters. To create the set of HDRs, we examined popular wearables on the market that track critical Physiological parameters and have companion apps. With the increasing number of mobile companion apps, we identified common conventional representations across these supporting apps. Criteria for selection involved identification of established devices meeting validation from reputable organisations like the FDA, Health Canada, and European standardisation bodies. The selection criteria prioritised parameters such as Blood Pressure and Sleep, known for their high tracking rate among individuals with chronic conditions [4], and the availability of standards and support from international regulatory bodies [5]. For the expert evaluation, HDR examples were presented as a

mobile screen of a mobile health app as a whole instead of individual graphical or textual elements on a particular screen. Four different screens with the most common conventional representation were selected: two screens for Blood Pressure and two for Sleep.

1.2 Participants

For this expert evaluation, we assessed the four selected HDRs for accessibility, usability, and understanding, with a specific focus on perceptual nuances for older adults. We recruited eleven experts with diverse backgrounds in Digital Health, Human-Computer Interaction (HCI), Universal Design, Accessibility, Usability, Caregiving, and User Experience. At least two experts identified as older adults, ensuring consideration of the aged-affected demographic. Seven experts had extensive experience designing and evaluating technology with older adults, and two were experts in accessibility and usability auditing.

1.3 Procedure and Data Collection

We adapted Petrie and Buykx's [6] Collaborative Heuristic Evaluation without the predefined use of heuristics. We conducted seven evaluation sessions hosted via MS Teams, ensuring automatic data recording and collaboration (each session included 1 to 5 experts). A session facilitator asked participants to provide verbal consent and introduced all four (4) selected HDRs. For each data representation, the facilitator asked experts to collaboratively identify potential problems related to accessibility and usability, assessing clarity and user-friendliness for older adults. Although no specific heuristics were used, experts were asked to focus on the following questions: What problem do they spot with the HDR? What do they notice could hinder an older adult's understanding of it? At this stage, experts do not have to agree on all the reported problems. A scribe noted the reported problems, and for each problem, the scribe asked each expert to assign a severity score, adapted from Nielsen's rating (0 = No Problem, 1 = Cosmetic, 2 = Minor, 3 = Major, 4 = Critical), to rate issues. The severity varies from zero, for disagreeing that the reported problem is indeed a usability problem, to four, meaning the problem is catastrophic and imperative to have been fixed before use. After each HDR evaluation, experts are asked some open-ended questions: which specific issue requires further data and investigation to gain a better comprehensive understanding? Which multimodal cues most likely would cover the age-related impairments? Are there any examples of good representations or bad representations?

For the analysis, we structured and organised all the data collected during the recorded sessions, including details of each screen, the list of reported problems, and the severity scores assigned by each expert. We later transcribed the recordings. The transcripts of the recordings were then reviewed extensively for evidence and expert recommendations relating to each issue. All the reported problems across all sessions were grouped as each of the problems can't be generalised for all mobile health apps. Each problem was categorised, considering similarities to age-related conditions. This categorisation represented a broad problematic and representative area of common problems across the four HDRs and when potentially examining other apps. Categories were then sorted in

descending order based on the number of severity scores reported by experts to highlight the most problematic categories. We then analysed the answers to the open-ended question asked at the end to identify expert recommendations on what could work in remediating the main problem categories. Problem categories were then associated with impairment-agnostic emerging recommendations generally targeting Vision, Hearing, Attention and Motor skills, as discussed in previous work evaluating mobile interfaces for older people [13], summarising key steps in mitigating these issues based on existing guidelines and expert recommendations.

2 Findings

Experts identified 190 problems across the four HDRs assessed. 179 of these were categorised as issues, falling within the Nielsen severity rating range of 1- 4, with 11 pre-defined fixed problems also reported. The four top critical problematic categories include "Colour Coding and Contrast," "Visual Impact, Readability, and Interpretability," "Understanding and Clarity," and "Interaction Design" (Fig. 1).

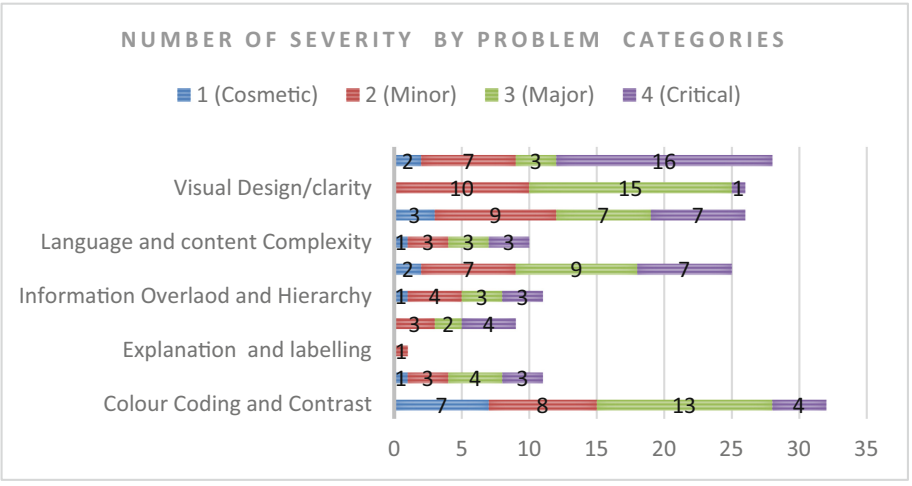

Fig. 1. Occurrence of each severity rating per reported problem categories

The experts emphasised the need for improved understanding and clarity across different health data representations, particularly in Severity 3 (Major) and 4 (Critical), where issues with explanations and labelling were highlighted. Instances of major clarity problems were reported, potentially hindering the comprehension of information conveyed. For example, expert P1G4 noted ambiguity in the first HDR (screen 1) due to minimalistic elements (Fig. 2a), stating, "***There are just numbers going up on the side and no numbers on the bottom… Are you presuming that this is a time series (measurement of Blood pressure)?***" Similarly, experts throughout the sessions were confused themselves by some sections within the HDRs, P4G4 pointed out ambiguity in the sleep data representation, where date measurements were represented by "***25, 1/10,***

5,10" with no labels, stating, "which 10 does that mean, October or the 10th? …you're running around in circles there. Uh, it's quite confusing …, particularly an older person, and they would likely miss the seven days, 31 days, 12 months (at the top)". These instances highlight the importance of precise communication strategies in health data representation but as well that these accessibility issues are inherently confusing even to users with no age-related impairments.

Fig. 2. a – Example part of a blood pressure HDR (screen 1) presented to experts

In terms of "Visual Impact, Readability, and Interpretability," experts reported a lack of general understanding of the HDR elements, which may influence significance. This critical category had the highest severity count, indicating the significance of visual impact and interpretability in Health Data Representations. Reported problems, such as unengaging visual information, cramped displays, and difficulties in understanding graph information, underline the recurrent presence of readability challenges. For instance, expert P1G5, a domain expert, experienced confusion interpreting one of the Sleep Data representations, stating, "***I'm thinking, …that dotted line, does that represent 8 h?"*** This confusion highlights the need for better communication of the significance and importance of health data.

Regarding "Interaction Design", experts emphasised the need for appropriate interactions to complete or extract the contextual meaning within the data representation. Interactions should be simplified for older adults, as their age-related conditions may affect motor control actions, including dexterity, which many existing health applications rely on. The reported issues highlight navigation difficulties arising from poor data mapping, reliance on dexterity (slide, swap, tap), confusion in selecting measurements on graphs, and the lack of alternative disability modality, which is inherent to many visual graphs. For example, P2G2 pointed out dexterous issues, stating, "***tapping outside of the box (graph popup detail) …, that's not going to be obvious …which could lead to feelings of panic (for older adults)***". An interesting finding is that built-in OS navigation and in-app navigation for the data representation may be confusing for older

adults. For instance, although the use of tab buttons is useful to segment the data from one time frame to another (month, 6 months, year), their position, whether at the top of the graph or its bottom, matters. At the bottom, experts agreed it may be confused with existing in-app bottom navigation. Experts agreed that improved signposting is crucial for maintaining older adults' attention during data interaction and serving as a reference to where they are.

Table 1. Emerging recommendations synthesising guidance to address the problem and their problem counts.

No	*Emerging Recommendations*	*Number of Severity*
1	Enhanced Visual Elements	57
2	Consistent Colour Coding	36
3	Clear and Concise Labelling	31
4	Improved graph-label Mapping	11
5	Simplified Language Use and semantics	10
6	Easy and Common Chart Design	9
7	Differentiated Value Points	6
8	Instructional Tooltip or Information for first-timers	4
9	Clear Identifiable Support Explanation	1

Additionally, Table 1 summarises the emerging recommendations derived from our evaluation, highlighting key areas for improvement in health data representation (HDR) for older adults. From the reported problems, detailed recommendations were extracted from open-ended questions and session transcripts, then categorised into 11 groups based on similar problem areas. Sorting these recommendations by severity coverage reveals that the top five recommendations primarily address visual-related issues. Subsequently, recommendations with lower severity coverage focus on aspects not reliant on visuals, potentially enhancing the overall significance of HDR by integrating additional context.

Integrating contextual information into HDR can significantly strengthen the understanding and implications of data for older adults with age-related impairments or cognitive decline. It amplified the substantial opportunities in utilising alternative modalities or stimuli to match older adults' diverse needs and preferences. For example, recommendations like simplified semantics extend beyond visuals, emphasising improvements in information hierarchy across all types of modalities. Similarly, differentiated value points ensure that thresholds and key indicators are distinguishable irrespective of the modality used to convey significance. Particularly for critical physiological parameters, it is much more important to identify those critical values clearly. Incorporating such enhancements can significantly enhance the accessibility and usability of HDR, facilitating improved comprehension and engagement among older adult users.

3 Discussion

The expert evaluation found substantial issues in existing conventional HDRs, particularly in severity levels 3 (major) to 4 (critical), indicating the pressing need for targeted improvements tailored to older adults. A critical analysis of these results establishes the impact of the evidence, emphasising the gap in addressing accessibility and usability challenges for older adults. The emergence of recommendations predominantly focusing on visual cues signals an opportunity for more inclusive alternative modalities, as supported by evidence from experts advocating for improved interaction and extracting significance from critical data. This aligns with previous research [3, 9], highlighting existing challenges and pinpointing opportunities such as content-specificity, trust-building, and innovative multimodal or cross-modal approaches. The severe accessibility and usability issues identified in this evaluation highlight the importance of conducting expert evaluations to proactively mitigate issues before engaging in specific testing with end-users. A limitation of this study was the use of static screen capture for the evaluation of the selected health data representation. Further work will explore the design of an accessible HDR with an interactive prototype which will be evaluated with both accessibility experts and older end users.

4 Conclusion

As the global population ages, it is becoming increasingly essential to focus on age-related impairments. An overloaded healthcare system would require a shift toward self-independence for affected demographics, most importantly older adults. The increasing reliance on wearable devices to monitor physiological parameters offers potential access to personal health information, but the reliance on visual cues introduces a gap in how older people can interact with and understand their personal health data. The expert evaluation utilised in this study explored new considerations for this demographic. The analysis identified 179 potential accessibility issues in emerging health data representation focusing on blood pressure and sleep. Using categorisation strategies, key issues were identified, and gaps in existing guidelines that do not effectively address the predominant categories were highlighted. To address these concerns, our paper outlines a set of emerging recommendations to address accessibility issues in HDRs. Beyond the categorisation of problems, our study provides a model for the iterative evaluation and adaptation of critical representations of health data. The recommendations presented aim to mitigate the problems identified and provide a potential guide for unlocking innovative and inclusive opportunities in future health data representations.

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