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Usability measures used to enhance user experience in using digital health technology among elderly: a systematic review

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ABSTRACT

In 2030, it is expected that 15% of the country's population will be classified as elderly and there is driving up demand for elderly healthcare services. The evolution of digital health technology has emerged as a solution to this issue. However, there has been a recent decline in the elderly adoption of digital health technologies. This issue is worsened by the emergence of interfaces and interaction styles in newly developed technologies. A systematic review was conducted in this article to investigate the usability measures used to improve the user experience of digital health technology among the elderly. This study includes articles selected from the Web of Science and Scopus databases, both of which are well-established. Using thematic analysis, data from 29 articles were analyzed, yielding four main themes: i) effectiveness; i) efficiency; iii) satisfaction; and iv) learnability. The four main themes generated 12 sub-themes. The appearance, functionality, and structure of new digital health technology are the primary barriers to adoption. User interface (UI) design should take into account the limitations of elderly users. Additionally, elderly users require motivation, support, and training to utilize digital health technologies effectively. This study's findings make significant contributions to digital health and gerontechnology fields.

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1. INTRODUCTION

Population ageing is the most important demographic trend of the 21st century because it shows our society's ages. As the proportion of the elderly population compared to the younger generation increases, this is a worldwide phenomenon [1]. Individuals aged 60 and above are considered elderly in Malaysia [2]. The percentage of the elderly population increased from 7.0% to 7.4% in 2020, which accounts for 32.7 million compared to 32.6 million in 2020, with an annual growth rate of 0.2% [3]. By 2030, it is expected that 15% of the country's population will be classified as elderly [4]. The increasing demand for elderly care and health services results from the ageing population. The evolution of digital health technology has emerged as a solution to this issue. Policies to support digital health technologies have been implemented in the past few years [5]–[8]. Collecting, sharing, and analyzing health data via digital information and communications

technology is the main objective of digital health technology, which aims to improve patient health and healthcare delivery [6]. Examples of digital health technologies are mobile health applications (mHealth), wearable devices, telemedicine, and telehealth [6]. The number of potential users of digital health technologies among older adults is increasing. The elderly must live independently at home for longer while remaining close to physical and financial care [7]. However, compared to young people, the elderly have a low adoption rate of digital health technologies for independent living [9].

This issue will most likely worsen when new technologies are developed because interaction styles and interfaces will vary. The reasons could be due to a variety of factors. There could be a plethora of factors for this. First, it is reported that older adults have fewer interests [10] and are less motivated to use technology [11]. Furthermore, they are less confident in their knowledge and abilities to learn and use technologies without guidance and support [12]. Moreover, the ageing process has begun to cause significant changes in older adults' physical and mental abilities, such as visual disease, hearing issues, movement control, and cognition impairment [13]. Besides that, user interface (UI) features that appear not optimized and straightforward will be a significant problem for the elderly [14]. These changes may impact how older adults experience and use digital technologies. Therefore, designers and developers must consider users and usability when developing the product. In addition to better understanding the usability, possible problems, and barriers to adopting and using these technologies by older adults, it is vital to understand the importance of user-centred designs, in which design ideas are based solely on the user's needs and requirements. Many things require the researcher's attention, from the interaction, presentation, content, and functions of the digital health technologies to tailor to older adults [15].

Understanding the relationship between usability and user experience is essential for designing and evaluating interfaces and digital health technologies tailored to the needs of the elderly. Furthermore, user experience is an extension of usability (efficiency, effectiveness, and satisfaction) that includes affect and emotions [16]. As a result, this study aims to identify usability and measures that may enhance the elderly user experience while using digital health technologies.

2. METHOD

The systematic search strategy consisted of three sub-processes, known as identification, screening (which involves the inclusion and exclusion criteria), and eligibility. All the three sub-processess are explained in detail as following:

a. Step 1: identification: the process of identification refers to the process of searching alternate terms for the study's primary search terms, which are "usability," "digital health technology," and "elderly." As shown in Table 1, the keywords used for searching were developed using the boolean operator, phrase searching, truncation, wild card, and field code functions on the two primary databases, Scopus and Web of Science. The search in these two databases yielded a total of 18,438 articles.

Table 1. The search string

Database	Search string
Scopus	TITLE-ABS-KEY (("usability*" OR "utilit*" OR "usefullness*" OR "usableness*") AND ("evaluation*" OR "testing*" OR "analysis*") AND ("digital health techno*" OR "digital techno*" OR "digital healthcare*" OR "digital health*" OR "digital*" OR "health*" OR "techno*" OR "mHealth*") AND ("old* adult*" OR "old* person*" OR "elderl*" OR "senior citizen*"))
Web of Science	TS=(("usability*" OR "utilit*" OR "usefullness*" OR "usableness*") AND ("evaluation*" OR "testing*" OR "analysis*") AND ("digital health techno*" OR "digital techno*" OR "digital healthcare*" OR "digital health*" OR "digital*" OR "health*" OR "techno*" OR "mHealth*"))

b. Step 2: screening: all 18,438 articles were screened for this study. The selection criteria were determined using an automatic sorting function built into both databases. First, articles were selected based on the requirements listed in Table 2. Following that, only publications in the form of articles were included to ensure the quality of the reviews. Therefore, the article selection criteria did not include any other types of publications. Only articles originally published in English were considered for this review to reduce the possibility of translation errors. The articles chosen are limited to two fields: science computer, and medical informatics. Detecting duplicate articles is another aspect of the screening process. Because the articles were obtained from two different databases, some would be present in both, resulting in duplication. Five papers were removed because they were duplicates, leaving 103 articles for the third process, eligibility. Only papers from 2017 were chosen for this review to ensure that current and updated issues were addressed. As a result, digital health technologies are rapidly evolving with numerous new elements.
c. Step 3: eligibility: the third process of the systematic search strategy is eligibility, in which the retrieved articles are reviewed manually by the author to ensure the articles that passed the screening process fit the

criteria determined earlier. The article titles and abstracts were read and analyzed to determine eligibility. Seventy-four articles were excluded due to a heavy focus on the medical domain rather than health technology or a focus on developing health technology rather than learning how to use it.

Table 2. The inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Timeline	2017-2021	<2017
Doc. Type	Article journal	Article review, chapters in the book, book series, book, conference proceeding
Language	English	Non-English

d. Step 4: quality appraisal: two experts aligned the quality assessment to ensure the content of the eligible articles. According to Petticrew and Roberts [17] stated that experts should classify eligible articles into high, moderate, and low quality. After determining the rankings, only high-and moderate-ranking articles should be reviewed for the study. The quality specialists ranked 27 articles as high and the remaining two as moderate. In conclusion, all 29 articles met the criteria for inclusion in the review.
e. Step 5: data abstraction and analysis: the process of identifying, analyzing, and reporting sub-themes in this study was based on thematic analysis, or qualitative analysis techniques developed by [18]. In the first step of a thematic analysis, researchers must immerse themselves in the collected data through repeated reading. The second step involves the creation and formation of initial codes. Peer debriefing is the third step, in which the initial codes are sent to co-authors for verification to avoid bias during data interpretation. The fourth step is to search for sub-themes. At this stage, the researcher must analyze all subthemes derived from the initial codes. This process yielded a total of twelve subthemes. The process of sorting and arranging relevant sub-themes within the identified themes represents the search for the themes. This resulted in the formation of four themes from the selected articles. Then, sending the themes and subthemes to the experts for evaluation. Once experts have agreed upon the themes and subthemes, the results are considered final.

3. RESULTS AND DISCUSSION

3.1. Background of the selected articles

From two central databases, Scopus and World of Science, 29 eligible articles were derived for this study. Based on the thematic analysis, four themes were developed: efficiency, effectiveness, satisfaction, and learnability, and further data analysis resulted in 12 sub-themes. Table 3 shows seven studies conducted in China and three in Malaysia. In addition, the Netherlands, Ireland, the United States, Spain, and Korea each contributed two studies. Finally, one study was conducted in Italy, Canada, Germany, Slovenia, Portugal, Norway, the United Kingdom, and New Zealand. Four of the 29 selected articles were published in 2021, fifteen were published in 2020, three were published in 2019, two were published in 2018, and five published in 2017. In each of the 29 studies, respondents ranged in age from 50 to 90.

3.2. The themes and sub-themes

3.2.1. Efficiency

This study found four sub-themes that fit under the efficiency element. The first theme was flexibility. A medication reminder app, for instance, offers flexible scheduling that allows elderly users to personalize the app to suit their needs and change medication dosage [19]. Health technology should be tailored to the needs of elderly users' diversity [20]. Personalizing medical services for various population groups, such as medical visits websites and home monitoring for chronic patients [21], assisted in fitting digital health applications into the lives of elderly users [22]. The second sub-theme is known as features (appearance). Digital health technology features are among the top issues discussed by scholars. Digital application interfaces should be designed according to elderly user preferences. For instance, the use of larger symbols and buttons, easy-to-read text, a simple icon with a simple layout, and high-contrast colours [10], [14], [19], [23]–[27]. According to Abdullah and Hamid [28], sans-serif fonts with a size of 12-14 points, short lines, and left-justified text may help elderly users with poor vision read. The layout and fonts of a website or smartphone UI must be consistent for daily use to be more efficient [10], [29]. Moreover, a digital health application should avoid displaying unnecessary information that could cause screen overload [29]. For elderly users, more detailed instructions to operate digital health technologies are needed to guide them [13] and the interface should be attractive enough [30]. Developers of digital health game applications should consider board games' tangibility and physical appearance [11]. To cater older adults having vision or motor disabilities, it is suggested that digital health technology to be equipped with voice-enabled interfaces [14] and warning tones [31]. Place UI elements, particularly sensitive elements, in a visible location that is preferably reachable with the user's thumb [29]. The internet contains rich and comprehensive health information that can satisfy the needs of elderly users to a certain extent, increasing the elderly's internet usage [5].

The third sub-theme is called features (function). According to a study by Keogh *et al.* [32] participants who valued the app's simple graphs found a wavelet to be the most useful device. As for digital health game applications, functions equipped with sound, greeting messages, changing speed function [11], and a countdown evoke the eager feeling to play the game [23], [25]. The monitoring system and the app are useful, especially for the caretakers to monitor elderly remotely [28]. Medication reminder applications are among the useful app for elderly. It provides a medication summary function and alarm reminder [19] while helping them familiarize themselves with their health conditions [13]. However, it is essential to inform the elderly about all the app's processes through feedback [29], instructions, and training [13]. The diary feature in the eHealth portal, as reported by [21], allows elderly users to express positive impressions. The pop-up messages were generally acceptable and served as essential communication tools between healthcare professionals and patients [22]. Aside from that, the virtual agents feature is made up of virtual humans designed to foster long-term socio-emotional relationships with elderly users [33] and is suitable for the elderly with limited digital health technology awareness [33]. In this pandemic era, the availability of automated COVID-19 screening and daily symptom monitoring via digital solutions is critical for disease control and prevention, particularly for elderly users [34]. The last sub-theme is known as features (structured). According to Yeong *et al.* [10] digital health technology for older people needs to have a structured information hierarchy, easy-to-read content, and clear description links [23], [35]. A health digital app should comply with well-established conventions, allowing users to complete tasks in a familiar, standard, and consistent manner [24].

Table 3. The themes and the sub-themes

Paper ID	Year	Region	Usability					Learnability	Emotions			Functionality	Visual aesthetics		Trustworthiness
			S	E	SF	I	U		EX	A	AF		ST	UIA	
P1	2020	US	/	/		/	/	/				/	/	/	
P2	2021	Korea						/	/			/			/
P3	2018	Dubai	/	/		/	/		/	/		/		/	
P4	2020	Taiwan	/	/	/	/	/	/	/		/	/	/	/	
P5	2020	Ireland		/			/	/	/						
P6	2020	Netherland	/	/			/		/			/	/	/	/
P7	2020	Sweden	/	/	/	/	/		/			/	/		/
P8	2020	Sweden	/	/				/							
P9	2019	Netherlands	/	/	/	/	/					/		/	
P10	2017	Sweden	/	/			/	/							
P11	2021	Sweden				/	/	/			/	/			
P12	2021	Malaysia	/	/			/	/	/				/		/
P13	2019	Malaysia	/	/	/	/	/							/	
P14	2017	Spain	/					/				/			
P15	2018	Malaysia	/	/	/	/	/								
P16	2020	Germany	/	/	/	/	/		/		/	/		/	/
P17	2017	US	/	/		/	/							/	
P18	2018	US				/						/			
P19	2019	US	/	/		/	/	/							
P20	2020	UK	/	/		/	/		/			/			
P21	2019	Spain	/	/			/		/	/	/	/	/	/	
P22	2022	Taiwan	/	/		/	/		/			/	/	/	/

*Usability: S=Simplicity; E=Efficiency; SF=Safety
*Emotions: EX=Excited; A=Angry; AF=Afraid
*Visual aesthetics: ST=Satisfaction; UIA=UI aesthetics

3.2.2. Effectiveness

There is one sub-theme under this theme, namely simplicity. It is stressed in several articles that digital health technologies should be designed with a simplicity concept in mind as this could suit the need of elderly users [14]. For instance, a health website should have a simple home page [10], stable and easy to navigate [36], simple web sequence and interactions [31], [37], and provide visual monitoring for training progress monitoring purposes [26]. In terms of mobile health apps, smartphones are recommended to be simple to use regardless of the user's familiarity with mobile apps [26]. For instance, use easy-to-find documentation and help [29], [31], simplify the ordering of food and take picture function in dietary apps [38]. For exergame apps, simple and straightforward graphics are needed to observe their achievement [23]. As for a wearable device, it is convenient for the participants by enabling them to collect data themselves [32] and, at the same time, assist in the patient's scanning strategy conveniently and efficiently [39]. Digital health technologies should avoid complexity to lead to better experiences among elderly [24], [35], [40] and the emergence of new technology, such as wrist-worn sensors, is seen as the most versatile and easy to use for the long-term [32].

3.2.3. Satisfaction

There are six sub-themes under this theme. The first sub-theme is reliability. In a study held in China, reliability of the health web-based system content used for internet elderly users with vision impairment is the main factor influencing user traffic [10]. Whereas a study by [41] in Korea highlighted that elderly users should be provided with accurate and valuable [27] information in searching results from the system to gain their interest in using it. A health mobile application from a government initiative will increase elderly reliability towards using the apps [40].

The second sub-theme is known as trustworthiness. Among issues reported by elderly users in using health web systems in China is the lack of sufficient trust in internet security systems [5], [36]. Elderly users raised their fear that their personal information may be leaked [5] and therefore suggested having an authority endorsing a website [10]. In Netherlands, there is a problem disclosing medical issues through apps for elderly due to a low level of trust in the evaluator [12] in an online platform.

The next sub-theme is safety. CoronaMelder app among the elderly improves life safety by providing current infection and virus viral information in the Netherlands [40]. Elderly users consider technology as a way to monitor their safety at home [36]. For instance, medical robots protect the elderly from physical accidents [41]. Privacy emerged as the fourth sub-theme. There are several privacy concerns highlighted by elderly users in using health technologies. Information security needs to be clearly communicated to potential users to maintain privacy when using the health web system, whereby online information should be retrieved and stored securely [36]. Elderly users express doubts and fears about privacy issues while engaging the CoronaMelder app [40]. Excitement is developed as the fifth sub-theme under satisfaction. There is a high satisfaction level among elderly users when using a telepsychology web system as it increases their happiness and reduced anxiety [27]. In addition, virtual reality for health creates an element of excitement [11], especially when the elderly need to do activities such as dancing that also promotes fun and entertaining feeling [20], [24], [30]. It shows that virtual reality games act as a therapy to enhance motivation and improve the psychological well-being of elderly [30]. Using nostalgic objects evoked positive emotions and specific memories in participants [11].

The sixth sub-theme is related to stimulated feeling. The use of image objects in the augmented reality game's visual materials, as stated by [11], could stimulate a positive cognitive response in elderly users. This result was supported by the study that proves the reduction of pain while elderly users play serious games [20]. In addition, when older people play board games with other people in person, they may have vivid images, emotional responses, and social satisfaction [11]. Also, healthcare professionals said that the more the elderly used the apps, the more confident they became [22].

3.2.4. Learnability

One subtheme is identified in this theme, namely, learnability. Learnability relates to the quality of systems, apps, and interfaces that allows users to quickly become familiar with, even without knowledge or past experiences in using it [41]. A study by Bente *et al.* [40] in the Netherlands using COVID-19 contact tracing app indicated elderly users understand how the use app operates from the information they read in app store. Hence, precise instructions in telepsychology web and virtual reality systems guided elderly users very well to use the systems [27]. Elderly users can learn to swallow effectively without a clinician physically present using the m-health apps [23], which provide short and simple steps that enable the elderly users to run the digital health application successfully [29]. Games technology has been shown to cultivate peer learning, allowing the elderly to learn new technology in a fun way [11], and elderly users require adequate information on the game's purpose [13].

4. CONCLUSION

This paper aims to systematically review how usability measures are used to enhance the elderly user experience using digital health technology. The study contributes significantly to both practical purpose and the body of knowledge. Using the systematic search strategy, which included the identification, screening, eligibility, and quality appraisal process, 29 articles were deemed suitable for analysis. This led to the formation of four themes and twelve subthemes. According to extensive research and analysis, no "one-size-fits-all" digital health technologies can satisfy all levels of users. However, we understand that designing for elderly users can be considered as designing for universal users. The primary barrier to acquiring new digital health technology is the technology feature issues, including the technology's appearance, functionality, and structure. This is due to elderly cognitive, physical, and behavioural impairments. The UI should be designed considering several aspects, such as the use of colours for interface and background, button layout, button and text size, graphics, and animation. Only meaningful functions for digital technology and information should be designed hierarchically and structured. Despite features, motivation and support would be the impetus to increase digital health technology among elderly. The gameplay concept in digital

health games may increase regular engagement to achieve the desired cognitive benefits among the elderly. The elderly should be provided with guidance and support. Although design guidelines and recommendations are beneficial, they are insufficient. Perhaps, training and workshop with the adherence of the instructor/facilitator to assist in using digital health technology are needed. In conclusion, there are still many things that require the researcher's attention, from the interaction, appearance, content, and features of digital health technology to tailor to elderly users' needs.

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