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USABILITY EVALUATION DIMENSIONS OF MOBILE HEALTH APPLICATION FOR ELDERLY: A SYSTEMATIC REVIEW

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ABSTRACT

With the increase in the elderly population as a group of potential mHealth users, the need for mHealth applications increases to help overcome the limitations of elderly users. The challenges caused by aging factors in computer use are widely recognized. However, usability studies show that mHealth is still not suitably designed for elderly users. To improve mHealth design aimed at elderly users, we need usability evaluation dimensions that are in accordance with elderly characteristics to identify usability problems in mHealth applications.This study conducting Systematic Literature Review (SLR) using PRISMA to identify the challenges faced by the elderly and usability dimensions that are most widely used to evaluate mHealth applications for Elderly users, then select and propose usability dimensions that match with the elderly characteristics. Six key categories of elderly challenge influencing usability of mHealth and nineteen most-used usability dimensions on mHealth applications were identified. Nine usability dimensions are most suitable for evaluating mHealth applications for the elderly were also selected. The model, however, is incomplete without evaluation criteria and metrics. Criteria and metrics will be developed as a complete model for the next phase of this study.

Keywords: *Usability Evaluation, Usability Dimension, mHealth, mHealth for Elderly.*

1. INTRODUCTION

The world's older population keeps growing rapidly as fertility rates in most regions of the world have dropped to deficient levels, and people tend to live longer. In 2015 the elderly population reached 7.5 billion, and 617 million (or 8.5 percent) were aged 65 and over [1]. As a developing country , Indonesia is facing a demographic change that leads to a decrease in the proportion of under-five children and increases the proportion of the elderly 60 and above. This condition therefore causes the proportion of the elderly population to be greater than the population of under-five children. Decreasing Total Fertilitility Rate (TFR) and the rise of life expectancy are the reason for this condition [2]. The Elderly community plays a vital role as a consumer of technology with a large increase in population. Assistive engineering is an emerging trend related to the elderly. Assistive technology is described as a product or service that helps older people to be independent, such as mobile apps reminders [3], [4].

Mobile apps are developed and used for the processing and presentation of information. After China, India, and America, Indonesia will become the country with the greatest active users of smartphones. Smartphone users in Indonesia are overgrowing [5]. Smartphones are now becoming more essential tools for health protection. The benefits include an increased sense of security, time and expense savings, shortened waiting lines, enhanced quality of life and opportunities for more health-related activities [6]. This situation makes mHealth (Mobile Health), which is the use of mobile technologies for healthcare solutions, seem very attractive. mHealth innovations have developed as an accessible and convenient solution to addressing a range of health and well-being areas for the elderly, including chronic disease management, diet control, exercise promotion and medication management [7].

In recent years, several mHealth applications have been developed to improve the effectiveness of health-related lifestyle improvements, weight loss, chronic disease management, virtual doctor appointments and medical education [8].

According to Research2Guidance, in 2017, there were approximately 320,000 mHealth apps available in the market. Most of the application runs on Android and IOS devices [9]. Commercially accessible mHealth applications have gained influential public interest by enhancing medication adherence and generating efficient outcomes [10].

Elderly people are key populations that can benefit from mHealth, as these apps address different health-focused condition issues. mHealth apps can mitigate the burden of managing complex health and treatment plans, particularly for older people with age-related cognitive declines [11]. However, most elderly miss the technology advantage because, as a digital immigrant and a non-e-literate person, they have trouble using it. [12].

Despite the interest and motives of the elderly for using mHealth, several studies reported that the actual use and adoption of mHealth in this population was low and inconsistent [13], [14]. While mHealth can be used by elderly users, it is important to understand problems potentially impacting the acceptance of mHealth by the elderly. Studies have shown that half users quit using mHealth apps due to various factors such as the hectic process of data entry and lack of interest. The difficult process of data entry is an obvious usability-related factor, while lack of interest can also precede the poor usability of mHealth apps [15]. According to Quintana [16], the elderly face several problems related to terminology, ambiguity, language, color, label, and button when using mHealth apps. Holden[17] also identified several usability issues such as higher error rates, hesitations and the need for assistance on tasks , particularly those that require data entry while using Brain Buddy. Brain Buddy is a consumer-facing mHealth app developed to educate and encourage elderly to take into account the risks and benefits of anticholinergics.

Some of the mHealth apps are not appropriately developed for the elderly user community, elderly user experience perceptual, motor , and cognitive limitations that may restrict navigation, data entry, and data visualization to multiple tasks [17]. Mobile developers typically didn't have the opportunity to work directly with the elderly [18]. If an elderly-friendly interface is not established, older people will be reluctant to use mobile devices [19].

Many of these mHealth apps are often uninstalled soon after download. Previous research on mHealth found that many of these mHealth apps also see low adoption rates, inconsistent use and long-term lack of user engagement [20], [21]. In a survey examining mHealth usage history, researchers found that within the first three months of the initial download, 35 percent of the apps were abandoned [22]. Low rate adoption and utilization will prevent the usefulness of mHealth apps for the elderly.

Many elderly say they face technological barriers such as mobile phones, wearable gadgets, or tablets. They need help using these technologies. Besides technical problems, along with the aging processes, the elderly also face organ degeneration from many systems, including vision, hearing, haptics, and cognition [23]. Some literature studies have already shown that elderly people differ in their perceptions, preferences, and use of mobile devices from young people. There are also differences regarding the adoption of mobile apps within elderly groups [24]. A study conducted in the United States during June 2016 pointed out that the elderly accessed mobile apps via mobile devices for an average of 42.1 hours in contrast with young people who used mobile apps for 93.3 hours on average [25].

This low usage can be attributed to a number of factors, including ineffective system engagement strategies, burdensome workflow, weak system usability associated with a lack of functional limitations and age-related challenges [7]. Byambasuren (2019) also conducted a systematic literature review for 22 available mHealth that mostly addressed diabetes, mental health, and obesity. They found that only a fraction of the existing mHealth applications were tested, and found evidence that the quality of the applications was low [26].

Usability has become the key reason for the success of mHealth apps as it helps coordinate the functionality for users in a simple and efficient way to achieve their goals [27]. Usability is known as a quality dimension, which can measure how the application is usable for various users profiles [28]; therefore, evaluating usability is a vital task. The word usability also refers to a method used during the early design process to increase ease of use. Focusing on usability is a crucial element in the efficient development of high quality applications. Unfortunately, there are no clear guidelines on how to define usability dimensions, rules, related criteria and how to measure the usability of mobile applications, especially on the mHealth application.

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Some developers prefer to use usability methods with which they are familiar, while some of the methods may not be suitable to apply to mHealth apps with elderly people as target users [17]. Researchers have used a range of approaches and tests in usability evaluations. Usability metrics is one of the approaches used as a guideline for evaluating system quality in many mobile applications [29]. However, the usability metrics for general mobile applications can not be used directly on mHealth applications targeted to the elderly.

The unique features of mHealth and elderly aging barrier consideration become the main challenges in the usability measurement task when used by mobile developers to evaluate mHealth apps. In order to be effectively used by an older population, mHealth apps must suit the elderly characteristics. However, several resources for designing mHealth for elderly people are reported [6], [30], [31], few mobile apps design guidelines available for the elderly [32], especially within the mHealth domain [33].

Some research questions need an answer based on these problems. Especially on a usability challenge to use mHealth apps for the elderly user. The research questions addressed by this research are:

RQ1: What usability challenges faced by the elderly when using mHealth applications.

RQ2: What usability dimensions are most often used to evaluate mHealth applications for the elderly.

RQ3: What usability dimensions are best suited for evaluating mHealth for elderly users by considering elderly characteristics.

The main purpose of this systematic literature review study using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) is to identify relevant and appropriate journal articles that are related to elderly characteristic challenges, mHealth User Interface (UI) components, and usability measurement dimensions.

The elderly characteristic and usability dimensions are required as the basis for developing a usability evaluation model for mHealth applications targeted to elderly users.

2. CURRENT USABILITY EVALUATION MODEL

The idea of usability has existed for some time, and the concept of usability has been defined in many ways [34]. Nielson (1994), Shneiderman (2005), QUIM (2006), and mGQM (2014) are several current usability models [35], [36]. The International Organization for Standardization (ISO) is an international standard organization consisting of members from different national standards organizations. ISO has established over 17,000 Universal Standards on a range of topics [37]. A variety of usability models have also been developed by the International Organization for Standardization (ISO), but no one model covers all aspects of usability. ISO 9241-11 (1998), ISO / IEC 9126-1 (2001), and ISO / IEC 14598-1 (1999) are three major ISO standards [36]. ISO 9241-11 (1998), which is the most widely used model for mobile application usability, identifies three factors that must be considered when evaluating usability, namely: user, goal, and context of use. ISO 9241-11 describes three measurable dimensions for measuring system usability, namely: Effectiveness, Efficiency, and Satisfaction [35].

Meanwhile, Nielson identifies five dimensions of usability, namely Efficiency, Satisfaction, Learnability, Memorability, and Errors [38]. Unlike the usability model of Nielsen, ISO 9241-11 does not consider learnability, memorability, and errors as usability attributes while ISO 9241-11 may be implicitly included in the concept of effectiveness, efficiency, and satisfaction [39].

ISO / IEC 9126-1 (2001) describes usability as an attribute of software quality which is decomposed into five factors: understandability, learnability, operability, attractiveness, and usability compliance, and ISO / IEC 14598-1 (1999) is intended to measure the quality of use from the viewpoint of the quality attributes of the internal applications [35].

Harrison proposes a new usability model, as they argue that a different usability model is needed for mobile devices. They created the PACMAD model (People At the Mobile Application Development Center), which aims to expand existing usability models, such as the Nielson model or the ISO model [39]. They argue that the previous model originates from conventional desktop applications. The emergence of mobile devices raised new usability problems that are difficult to model using conventional models of usability. The PACMAD model has seven components, namely, Efficiency, Satisfaction, Learnability, Memorability, Errors, and Cognitive Load [40].

The usability evaluation model described earlier does not provide a clear description of how to select the appropriate criteria or metric for each of the usability dimensions. Most of these usability models are made to evaluate general applications so it will be difficult to apply to evaluate mHealth applications [36], [41], [42], especially applications that can be

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used by elderly users who have many limitations. Several usability evaluation models are made to evaluate specific applications [35], [36], [43], but there is no usability evaluation model that focuses on mHealth applications for elderly users.

Table 1 describes a comparison of the existing usability evaluation models found in literature reviews.

Table 1: Usability Evaluation Model

Usability Evaluation Model	Measurement Dimensions	Target Applications
Nielsen (1994) [36]	Efficiency, Learnability, Memorability, Errors, Satisfaction	General applications
ISO 9241-11 (1998) [38], [40]	efficiency, effectiveness, and satisfaction	General applications
ISO/IEC 9126-1 (2001) [44], [45]	understandability, learnability, operability, attractiveness, and usability compliance.	General applications
QUIM (2001) [46]	Efficiency, Effectiveness, Productivity, Satisfaction, Learnability, Safety, Trustfulness, Accessibility, Universality and Usefulness	General application
Shniederman (2005) [46]	Performance speed, Time to learn, Retention over time, Rate of Error by user and Subjective satisfaction.	General application
PACMAD (2013) [27], [39]	Efficiency, Satisfaction, Learnability, Memorability, Errors, and Cognitive Load	Mobile Application
Tan et al (2013) [47]	Efficiency, Effectiveness, Satisfaction, Productivity, Learnability, Safety, Accessibility, Generalizability, Understandability	General applications
mGQM (2014) [42]	Simplicity, Accuracy, Time taken, Features, Safety and Attractiveness	Mobile application
Pavapootanont and Prompoon (2015) [45]	Understandability, Learnability, Operability, Attractiveness, Compliance	Mobile game applications
Tahir (2015) [35]	Effectiveness,Understandability, Efficiency, Learnability, Operability, Satisfaction, Attractiveness	Mobile applications for children.
Saleh (2017) [37]	Efficiency, Effectiveness, Learnability, Memorability, Satisfaction, Errors, Cognitive load, Interruptibility, Simplicity	General mobile applications
Hashim and Isse (2019) [48]	Effectiveness, Efficiency, Learnability, Satisfaction, Error	Mobile Tourism Applications
Hussain and Omar Mohamed (2020) [41]	Efficiency, Effectiveness, Satisfaction, Understandability, Errors, Accessibility	mHealth applications for Visualy Impaired users.

3. RESEARCH METHOD

This systematic review of the literature was carried out using PRISMA reporting guidelines from January 2020 to August 2020 [49]. There are several steps in this study according to these guidelines: 1) defining eligibility criteria; 2) defining sources of information; 3) selection of research; 4) process of data collection; and 5) selection of items data.. Figure 1 describes the steps we take in undertaking a systematic literature review.

3.1 Eligibility Criteria

The following inclusion criteria (IC) for the review guidelines have been defined:

- IC1: Initial and peer-reviewed articles published in English;
- IC2: Research aiming to investigate usability challenges faced by the elderly when using mHealth applications.
- IC3: Research aimed at investigating usability dimensions is most often used in mHealth applications for elderly.
- IC4: Research aimed at investigating usability dimensions is best suited for evaluating mHealth for elderly users by considering elderly characteristics.

Only articles written in English (IC1) have been chosen, since English is a major language used by academic community researchers. IC2, IC3, and IC4 were included to answer the research questions.

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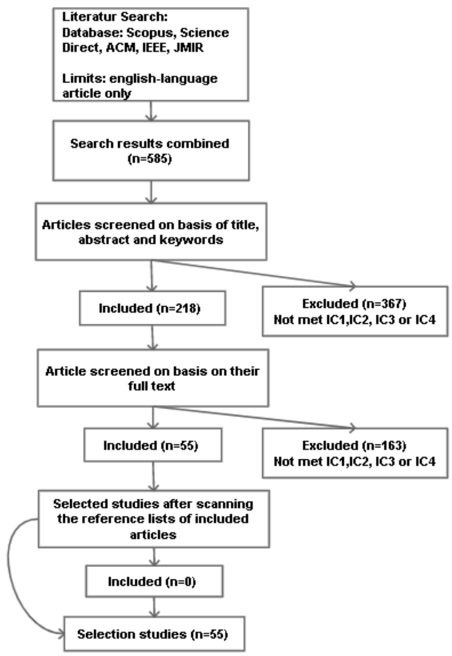

Figure 1: PRISMA flow diagram

3.2 Data Sources

We reviewed online databases with large academic repositories including SCOPUS, Science Direct, ACM, JMIR, and IEEE. We remove articles that are not completely accessible to the author. Additionally, we scanned the list of references included in the article to find related studies.

3.3 Study Selection

Selection of the sample was carried out in the following four phases:

1) Search terms have been considered top-down. First, broad search terms such as “mHealth usability barrier”, “mHealth usability evaluation dimensions” and “mHealth usability evaluation” have been surveyed. Then, more precise and relevant search terms such as “mHealth usability barrier faced by elderly,” “mHealth usability evaluation for elderly,” “mHealth usability measurement model for elderly,” and “mHealth usability measurement framework for elderly” have been used to survey literature which was published since 2014-2020. Due to limited research terms, no keyword has been deleted.
2) The exploration and selection of the titles, abstracts and keywords of the identified articles was carried out based on the eligibility criteria.
3) A full or partial reading of an article not omitted in the preceding process is performed to decide whether the article should be included in the review according to the eligibility criteria.
4) The list of article references is scanned to find related studies and continues to start this phase from Phase 2.

In an iterative authorship assessment process these steps were performed in collaboration by four researchers. Thus the four writers resolved any inconsistencies before consensus was reached unanimously.

3.2 Data Collection Process

Data processing was performed manually using the extraction of data from the following contents: article type, name of journal or conference, year, topic, title, participant, keyword, research methodology, usability problems for the elderly, usability evaluation dimensions, usability, and usability evaluation metrics. Every author has evaluated potentially relevant articles. The assessment consisted of reading the full text and the data extracted. Some issues were addressed by the four authors having a discussion.

3.2 Data Items

Information extracted from each article was comprised of:

1) Usability problems faced by the elderly when using mHealth applications.
2) Usability dimensions are most often used to evaluate mHealth applications for the elderly.
3) Usability dimensions are best suited for evaluating mHealth for elderly users by considering elderly characteristics.

4. RESULT

4.1 mHealth Usability Challenge for Elderly Users

According to the studies reviewed from selected literature review, it can be concluded that the usability challenge faced by elderly users when interacting with the mHealth applications have their causes in six broad categories: (1) Cognitive; (2) Psychomotor; (3) Perceptual; (4) Motivation; (5) Psychosocial, (6) Security and Privacy.

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1) *Cognitive Challenge:* Cognitive challenges are related to a reduced capacity of working memory. Memory skills will decrease with age. Generally, capacity working memory decreases significantly with age. For long-term memory, however, the decline was not significant. In addition, the weakening of prospective memory, namely the ability to remember to perform the desired action, is common among the elderly [25]. Cognitive decline has been shown to be affected not only by age but also past experiences, environment, social situation, and level of education [50]. The impact of increasing age is that the elderly process less information at any given time, and the ability to remember also decreases more rapidly [33]. For example, elderly people have difficulty remembering tasks that need to be completed in the future (such as taking a pill after a few hours) that become harder to complete [51]. Besides, elderly people need more time to learn new skills. In addition, difficulty understanding numbers also hinder humans from understanding content on mHealth applications, such as tables and graphs [32]. Elderly with cognitive impairments show a lower percentage of success in performing tasks than elderly users without cognitive impairment when using the mHealth application [6]. The major challenge experienced by elderly users is due to cognitive decline when use of mHealth applications can be seen in **Table 2**.

Table 2: Cognitive Challenge

mHealth Component	Problems	Cognitive Decline
Navigation	Complex text and deep and complex menu hierarchy on navigation [7], [50], [52], [53]. Movable menus that use animation or transition effects cause elderly users to get lost when working with navigation [17], [51], [54]. Non-standard menu display causes users difficulty in understanding the menu hierarchy [16].	Working memory [6], [25], [32], [33]. Spatial Cognition [25], [32], [33].
Graphics and Icon	Use of graphics that are incompatible or irrelevant [16], [25], [55], [56]. The use of many meaningless or ambiguous icons with decorations, or animations, and no short text descriptions to explain functions [25], [50], [56]. The graphics of the mHealth application is cluttered or too complex [57]. Using similar icons to label elements or buttons that have a function will be difficult for elderly users [6], [53], [56], [58]. Use non-standard versions of icons or different sizes and shapes that make it hard for elderly users to recognize what the icons are [7].	Spatial Cognition 24], [32], [33]. Semantic Fluency [50], [56]. Reasoning [16], [25], [50].
Ambiguous Uncommon Term	The use of terms that are difficult to understand and the language used is unclear, meaningless, and uses jargon that is too complicated [59]. Uses unclear instructions on how to use certain functions [60], [61]. Lack of directions, unintuitive direction and lack of support [25], [50], [59].	Semantic Fluency [50], [56]. Vocabulary [25], [50], [59].
Long content	The use of long memory-requiring content affects elderly users with cognitive impairments [50], [51], [53]. Use long and unclear instructions on how to proceed with using a particular function [7], [25], [32].	Working memory [6], [25], [32], [33]. Vocabulary [25], [50], [59]..
Feedback	Feedback is not presented in a clear and intuitive way, making it difficult for seniors to understand the message [50], [52].	Semantic Fluency [50], [56]. Vocabulary [25], [50], [59]..

2) *Psychomotor Challenge:* Psychomotor activity refers to cognitive motor control, especially upper limb motor control such as grip, dexterity, balance, manipulation, and mobility [50]. Psychomotor functions are very important when use of the mHealth application by elderly users, particularly when using the touch screen. Psychomotor impairment due to aging problems is difficult to measure in general. The deterioration in psychomotor activity as a person ages can be measured by the loss of

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muscle power, reduced range of joint motion, and increased fine motor movement variability caused by motor disability [44]. The general rule is that elderly take about 50–100 percent more time than adults under 30 to complete a task [44]. Some of the interfaces for mHealth applications allow very smooth movements; consequently, many mistakes made by elderly users are frustrating [25]. For example, the diminished motor abilities make small pressing buttons in the mHealth application interface more challenging for older users [33]. Another example is if older people accidentally delete files or mistakenly drag and drop files, they have to start over and over again [50]. The major challenge experienced by elderly users is due to psychomotor decline when use of mHealth applications, can be seen in **Table 3**.

Table 3: Psychomotor Challenge

mHealth Component	Problems	Psychomotor Decline
Moving Text and Targets	If an item moves suddenly in an application, elderly will have difficulty interacting with it. Elderly users also have difficulty using the virtual keyboard to enter text [25], [44], [50], [33].	Flexibility of joints [25], [33], [50] Hand-eye coordination [33], [50]
Navigation	Elderly find it difficult to use the navigation menu, especially if they have to choose the navigation menu by holding a smartphone with one hand [17], [25]. Navigation combined with the scrolling feature makes it difficult for elderly to select menus [52].	Grip strength [33], [50] Precision Steadiness [7], [50] Retention in hand movement [16], [33], [52]
Drag, drop, zooming and pinch an object	Using gestures to drag, drop, pinch, and zoom objects such as images or files is difficult for elderly people because of the performance decline in finger coordination [50], [52], [58].	Flexibility of joints [25], [33], [50] Hand-eye coordination [33], [50] Precision Steadiness [7], [50]
Scroll component	Using a scrollbar that is placed on the right or top of the screen will make it difficult for elderly to use it [50], [53], [58].	Flexibility of joints [25], [33], [50] Retention in hand movement [16], [33], [52] Hand-eye coordination [33], [50]
Button Tap, or Long Tap	Elderly users have difficulty interacting with buttons that are not positioned correctly, or are too small [25], [50].	Flexibility of joints [25], [33], [50] Precision Steadiness [7], [50]

3) *Perceptual Challenge:* Perception refers to the activities of the actual senses such as sight, hearing and touch, smell, and taste. As elderly people use the mHealth application, sight, hearing, and touch are the three senses that are most relevant in application experiences [50]. Almost all interactions with the mHealth application involve visual activity. The decrease in vision function is inevitable as a person ages, such as the ability to see detailed objects, the ability to focus on close objects, the ability to distinguish colors (violet, blue and green), the ability to detect contrast, the ability to adapt to darker conditions, the vision becomes glare [33]. Visual acuity is a concept used to describe the clarity or acuity of vision, which can be measured under different ambient lighting conditions [32]. In addition to visual decline, as you age, your hearing ability will decrease over time. Loss of hearing was related to a risk of falling and cognitive decline. In general, hearing quality is measured by the hearing threshold. The average pitch threshold is measured, without background noise, over the minimum audible frequency range. This threshold will increase with age [50]. Although audio is rarely an interaction choice when using the mHealth application, there are several application functions that utilize audio, for example, for video content and alerts. In addition, the elderly with moderate to severe hearing difficulties have a lower performance in using the application than users without hearing difficulties [33], [51]. The major challenge experienced by elderly users is due to perceptual ability when use of mHealth applications can be seen in **Table 4**.

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Table 4: Perceptual Challenge

mHealth Component	Problems	Perceptual Decline
Unclear Visual Element	Elderly has difficulty seeing small and unclear objects such as characters, icons, images or graphic content, charts, chart fonts and buttons [6], [7], [56].	Visual acuity[25], [50]
Discriminating colours and contrast	Elderly people find it difficult to distinguish between colors (especially violets, blues and greens) and contrast, especially in low light settings [6], [7], [32], [51].	Color vision [6], [50] Contrast detection [25], [59]
Glare Screen	Elderly was unable to overcome the glare on the screen or maintain concentration when looking at the glare [52].	Glare [50]
Dark Screen	Elderly needed more light to see sharply [6], [25], [32].	Dark Adaptation [25], [32]
Acoustic Cues	Elderly found it difficult to distinguish acoustic cues of short duration [25], [50]. Elderly has difficulty receiving beeps or alarms that are above 2 kHz or have low amplitudes [25], [50].	Audiotory acuity[50]
Perceiving verbal feedback	Elderly has difficulty understanding vague verbal feedback [50], [53], [56].	Audiotory acuity [25], [50], [53]

4) *Motivation Challenge:* Studies of technology acceptance by the elderly show motivational issues as a barrier [61]. Several studies have reported that elderly people are less likely to use technology if the benefits of the technology are not clear [7], [25], [32], [50]. For example, in a usability study on a pill reminder application to remember drugs, the elderly felt positive about the benefits of the application, but they found it difficult to input data into the application. They feel that the benefits of the application are insignificant, resulting in frustration and a desire to stop using the application [32].

5) *Psychosocial Challenge:* Technology users can generally be classified into five categories: Innovators, Early Adopters, Early Majority, Late Majority, and Laggard. According to this classification, the elderly are categorized as Late Majority and Laggards, who are slow in adopting new technology compared to other populations. This category is usually more conservative, skeptical, cautious, less educated, isolated, risk-averse, traditional, and distrustful of innovation [50], [62]. Although it is clear that technology has the potential to play an important role in promoting independence and improving the quality of life among older users, negative technological attitudes also hinder the adoption of new technology in this population group [63]. Elderly people are less likely to use technology, which is deemed less useful and harder to use. While many elderly people are enthusiastic about technology when they are young, they do not show great enthusiasm for adopting new technology, and they tend not to use technology for various reasons [62]. Furthermore, several studies have shown that seniors with a rich, supportive network of friends and relatives are more likely to adopt complex technology, whereas those who are lonely or lack help prefer simpler technology [33], [50], [62]. The conclusion emphasized that the elderly social network has a profound effect on their perception of technology. Just because a technology is considered useful or easy to use, it does not mean that the elderly will want to use it, especially if the technology does not fit their personal goals. The following is a summary of the reasons for the psychosocial aspects of elderly people may not accept the use of the mHealth application:

- Previous Technology Experience: In the lack of familiarity or prior experience with similar devices, elderly users can be hesitant or ignorant of their possible uses when using mobile applications [51], [64], [65], [65], [66].
- Number of Experiments: Lack of opportunity to use the device experimentally, or lack of social exposure to the new application [25], [50].
- User Context: The application is incompatible with your personal or lifestyle goals [50], [62], [67].

6) *Security and Privacy Challenge:* As part of a broader set of considerations when using the mHealth application for the elderly, it should be considered how this application also maintains dignity for elderly users [66]. Several studies indicate that engagement with the mHealth app

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will improve confidence as it leads to feelings of pride and self-control [32], [66], [68]. However, the elderly can also have concerns about the ethics of data storage and the submission of data from the mHealth application and whether the data entered will be kept confidential [66]. Another critical challenge is elderly user data security and privacy, particularly in remote surveillance systems. Such devices not only monitor vital signs but can also detect anomalies and relay data in real-time to healthcare professionals. It can pose a significant threat to these data security and privacy systems, both in terms of patient identification and medical information confidentiality [69]. This problem has not been completely addressed, and in order to meet medical and ethical requirements, changes are required in the design and operation of such a system [70]. A survey of the 600 most commonly downloaded mHealth applications for iOS and Android showed that only 30% of users had privacy policies at their control [68]. A systematic review of the literature found that only one of the 20 most popular mHealth apps allowed users to remove all of their personal information, and only two required user authentication before a user logged in to the app [70]. These results suggest that developers of mHealth apps need to work to make data on their apps safer.

4.2 Most Widely Used Usability Measurement Dimensions of mHealth Applications for Elderly

To answer the questions from RQ2, an analysis of previously selected literature reviews was conducted. **Table 5** below shows the measurement dimensions that are most widely used to evaluate usability in mHealth applications for elderly users.

Table 5: Measurement Dimensions Most Used in mHealth

Dimensions	Count	Included in the study
Effectiveness	28	[57], [71], [72], [73], [74], [75], [31], [65], [17], [63], [76], [77], [78], [79], [80], [81], [82], [83], [84], [85], [86], [87], [88], [30], [89], [90], [91], [92]
Efficiency	29	[57], [71], [72], [73], [74], [75], [31], [65], [17], [63], [76], [77], [78], [79], [80], [81], [82], [83], [84], [85], [86], [87], [88], [30], [89], [90], [91], [92], [93]
Satisfaction	28	[57], [71], [72], [73], [74], [75], [31], [65], [17], [63], [76], [77], [78], [79], [80], [81], [82], [83], [84], [85], [86], [87], [88], [30], [89], [90], [91], [92]
Memorability	3	[71], [78], [93]
Errors	3	[71], [78], [93]
Cognitive Load	2	[39], [41]
Information Security	2	[38], [41]
Usefulness	1	[93]
Attractiveness	1	[83]
Controllability	1	[83]
Self-descriptiveness	1	[83]
Learning Suitability	1	[83]
Engagement	1	[86]
Acceptability	1	[88]
Accesibility	1	[93]
Flexibility	1	[93]
Accuracy	1	[93]
Realibility	1	[93]
Simplicity	1	[41]

From the findings shown in **Table 5**, it can be shown that the measurements of Effectiveness, Efficiency, and Satisfaction, which are the three measurement dimensions in the ISO 9241-11 standard (1998), are the most widely used for evaluating mHealth applications for elderly people.

Memory and Errors, which are usability measurement dimensions in the Nielson model, are the second most widely used.

4.3 Usability Dimensions for evaluating mHealth Applications for Elderly

Based on the findings in RQ1 regarding the challenge factors that affect elderly users in using mHealth applications and the measurement dimensions most often used in evaluating the usability of mHealth (RQ2), 9 measurement dimensions will be selected that are most suitable to evaluating mHealth applications for elderly users.

All of these 19 dimensions were then simplified into 7 measurable dimensions as shown in Figure 2 after reducing the redundancy and similarity in terms of measurement and also by taking into consideration the simplicity to the utmost concept by ISO 9241-11 (1998), and Nielsen model. In addition, some dimensions are intentionally omitted because the application is only intended for mHealth applications. In general, it is not specific for elderly users. The usability model, which consists of many dimensions, is not necessarily good unless the dimensions chosen are determined based on interests, user needs, and application functionality [38]. Thus, craftily chosen dimensions are required to ensure that the proposed model meets the needs of the mHealth application for elderly users when

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considering application functions can be properly implemented.

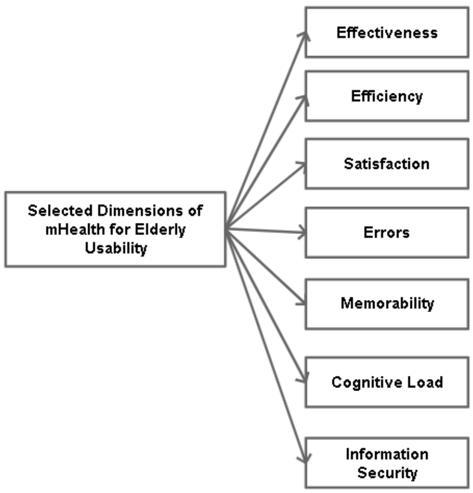

Figure 2: Selected dimensions for mHealth for Elderly Usability Model

Efficiency is considered as one of the important dimensions. Efficiency includes compatibility, loading time, and accuracy. It refers to the extent to which the user interface is compatible with the mHealth application and the capabilities of the elderly user, which have several limitations. Problems caused by elderly specific challenges such as physical and perception can be measured using efficiency dimensions, for example, to determine the length of response required when accessing the mHealth application [37].

The effectiveness dimension can also be used to measure how elderly users understand the logical presentation of menu buttons, graphics, interface layout, and output readability. The cognitive decline that occurs in elderly users can affect how users understand logical presentations, and the ability to remember menu structures on navigation [40].

The satisfaction dimension can be used to measure the satisfaction level of elderly users when using the mHealth application. Satisfaction itself is a subjective measurement dimension, different from the effectiveness and efficiency that can be measured objectively [39]. Satisfaction is also related to motivational challenges, which are one of the obstacles experienced by elderly users; if users are satisfied using the mHealth application, it will increase their motivation to continue using the application.

Memorability dimensions are important to include, considering that elderly users have problems with working memory, making it difficult to remember and do things that are too complex [38].

It is also important to use the error factor to measure how many errors are made and how severe the error is due to the limitations on physical motor and vision (visual, hearing) of older users. It will have the potential to make mistakes [73].

Cognitive load is one of the specific dimensions for elderly users. To use the mHealth application, good cognitive abilities are needed, unfortunately elderly have a barrier in the form of a decrease in cognitive function, so it is necessary to measure the extent to which the cognitive load can still be tolerated by elderly users [27].

The last dimension entered is information security because most mHealth applications will store health data and personal data from users. One of the problems found is that the elderly feel insecure when using the mHealth application [38].

4. CONCLUSION

This paper discusses the factors that challenge elderly users in using mHealth applications and determines the appropriate dimensions that can be used to measure usability in mHealth applications for elderly users. As previously known from the literature review, the current dimensions used to evaluate mHealth applications for elderly are too general and not specific to consider the factors that limit elderly users to use mobile applications. Therefore, a range of dimensions was chosen from the previously filtered literature review to satisfy the needs of a particular usability model for elderly users. However, the model is incomplete without criteria and metrics for the evaluation process. Criteria and metrics will be developed and suggested as a complete model for the next phase of this study. There will also be a focus group session, expert assessment, and usability testing to validate and verify the future model. This process is expected to be used to validate the effectiveness of the proposed model.

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