Usability of mobile applications: a concept analysis in health promotion

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With the rise of health awareness in modern societies, health promotion has attracted increased attention in both academia and industry. This, along with the evolution of information and communication technologies, has stimulated the development of mobile applications for health promotion. However, users of the applications do not necessarily achieve their goals because many applications do not provide a smooth user experience. In this study, we identified the defining attributes of app usability in the context of health promotion to guide app design for improved user experience. We first explored app usability by applying Walker and Avant's concept analysis method, which involves the following steps: (a) identifying the use of the concept; (b) determining the defining attributes; (c) considering a model case; (d) considering contrary, borderline, and related cases; (e) identifying antecedents and consequences; and (f) defining empirical referents. We subsequently derived a unified definition of usability. From the health-care perspective, the defining attributes of usability of mobile application are efficiency, user satisfaction, and learnability. Apps with these attributes can achieve their designed goals and reach maximal efficacy because users would continue using the app on a regular basis and recommend it to others. (*Taiwan J Public Health. 2022;**41(2)**:142-155*)

Key Words: concept analysis, usability, mobile applications, health promotion

INTRODUCTIONS

As a result of rapid technological development and high levels of informatization, mobile phones have become a necessity for people to acquire information. The rising prevalence of mobile phones has also led to the development of mobile applications (commonly called "apps"). According to the State of Mobile in 2019 report by App Annie [1], the largest app research institute in the world, mobile apps were downloaded more than 194 billion times worldwide in 2018-35% more downloads than in 2016. These apps were used for an average of nearly 3 h per day, and the duration of use continues to increase. These data reveal that apps have become essential to mobile device users [1].

Although apps are widely used in social communication aimed at social cohesion,

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and users are increasingly using them for their social needs [2,3], an increasing number of new apps focus on medical or nursing interventions aimed at health promotion [4]. In particular, app-based health-promotion programs are considered ideal platforms for effective interventions [5,6] because they are convenient for the target population [7] and are more cost-effective than other interventions [8]. Many innovative health-promotion mobile apps have also been developed as user-friendly human–machine interfaces and free-of-charge interactive electronic care systems. These apps are designed to help users become aware of their care needs, achieve optimal health, prevent health problems, and take responsibility for their health [9].

Self-directed learning in health profession education is associated with modest improvements in knowledge domains compared with traditional health-promotion teaching methods and is equally effective in skills and attitudes domains [10]. Apps can be effective for self-directed learning. One example of this approach is Body Quest: Food of the Warrior, an Alabama Cooperative Extension System initiative to prevent childhood obesity, which successfully engaged students in independently learning about healthy eating through apps [11]. Compared with paper-based screening methods, mobile apps are more cost effective and can reach a greater number of people at minimal additional cost; apps are thus highly effective tools for health promotion [8].

Given the high prevalence of risky health behaviors and the scalability and widespread adoption of apps, health-promotion apps can be deployed to benefit a large proportion of the population. Therefore, rather than focusing only on the effectiveness of mobile apps for specific health behaviors, stakeholders should understand how and to what extent apps are used, what purpose they serve, and how they influence various human health behaviors [12]. In this study, we explored the usability of apps related to health promotion. In addition, considering the increasing demand for health-promotion programs among the population, the use of mobile application programs is a suitable option for health promotion [13].

These apps provide feedback to users in three manners—health information delivery, users' self-monitoring, and data indicator presentation—to help the users individually review the effectiveness of their app use and ultimately achieve short-term enhancement or long-term management of health-promotion behaviors [14]. Numerous successful apps have been used to promote healthy behaviors [15,16]; these apps can be used for medical institutions' exclusive health promotion initiatives [17], government sectors' health education [18], exercise management [19], and dietary records [20].

Despite the numerous health-promotion apps [21], many of them lack a smooth user experience, resulting in users not achieving health-promoting behaviors [22,23]. This difficulty is intricately connected with the app's user interface, which is a critical aspect of ensuring user satisfaction. These apps lack user friendliness, are inefficient, and result in low adherence [24]; these problems related to app usability should be addressed by developers. These factors underscore the importance of a conceptual analysis of app usability. A guide to help health-care providers recommend an appropriate app for health promotion may somewhat address this problem.

The concept of usability has been applied in various fields, such as information technology, modern arts, and architecture. Most studies on product usability have failed to provide comprehensive and accurate definitions of usability, and only a few studies have examined the usability of health-promotion

apps [25]. Because the concept of usability can be applied to many domains and thus has multiple possible definitions depending on said domains, a unified definition specifically for application in health promotion remains lacking. Such a disciplinary perspective can guide the further development of research and professional practice. In this study, we applied the concept analysis method, proposed by Walker and Avant [26], to examine the usability of health-promotion apps. Our results may guide the application of this concept in information technology and health care, with health-care professionals being able to recommend apps that have high usability, thus reducing users' stress and frustration and increasing their loyalty and attachment to those apps.

METHODS

Concept analysis is a formal and rigorous process in which scientific steps are applied to clarify an ambiguous concept [27], and numerous approaches have been described for conducting such analysis. Concept analysis aims to determine certain defining attributes and further elucidate nursing knowledge to guide research and professional practice [26]. The application of concept analysis began in the early 1990s and has been used in many disciplines, especially philosophy and linguistics, to refine and clarify concepts in theory, practice, and research and to obtain precise theoretical and operational definitions for research or for instrument development. Approaches to concept analysis have been described by Rodgers and Knafl [28], Walker and Avant [29], Morse [30], and Chinn and Kramer [31]. Because of its simplicity and straightforwardness, Walker and Avant's method is the most commonly used in nursing [29] and was therefore used in this study.

With reference to Walker and Avant's concept analysis method [26], research into app usability comprises several steps. First, app usability is clarified by reviewing the current literature and identifying all the implications of usability in different domains. A critical step is to identify the defining attributes of app usability and to start grouping most attributes that occur in the context of the concept: usability-defining attributes are the most frequently mentioned. The highest-quality analyses refine the defining attributes to the fewest number where the concept of interest can still be distinguished from related concepts. This phase represents the core of concept analysis. The researcher must conduct a repetitive and iterative process to examine the definitions, essence, attributes, and benefits of usability. The logical conclusion used to determine the defining attributes is based on the appropriateness and accuracy of information from the literature [32]. Using this approach, a definition of app usability that focuses on health-promotion apps was derived. This definition includes all defining attributes and explicitly excludes other elements associated with the concept.

In the subsequent phase, the role of app usability in health promotion is examined by considering model, contrary, borderline, and related cases. The fifth step is to identify antecedents and consequences. According to Walker and Avant, antecedents refer to events that must occur prior to the introduction of a concept and consequences correspond to the subsequent effects of the concept after its introduction [26]. Both antecedents and consequences were derived from the literature. This step is critical for research because it can be used to identify the appropriate user goals for different health-promotion apps and to better understand the effects that users can achieve after using the apps. The final step

of concept analysis is to identify empirical references or approaches for measuring the usability of the mobile app, which in turn can be used to test whether the health-promotion app provides a high-quality user experience.

RESULTS

Definition of the Concept

To date, no concept analysis has been conducted on app usability in health promotion worldwide. Therefore, the definition and usage of the concept were clarified by reviewing dictionaries and relevant literature. Studies were obtained by consulting the following databases: PubMed, ACM Digital Library, EBSCO, IEEE Xplore, PsycINFO, Communication and Mass Media Complete, Computers and Applied Sciences Complete, ProQuest Computer Science Collection, Computer Source, and Web of Science.

According to the Cambridge Dictionary, "usability" refers to "the fact of something being easy to use, or the degree to which it is easy to use," [33] and "mobile application" is defined as "a software program that runs on a mobile phone." [34] Accordingly, app usability was defined as the ease of use of a software program on a mobile device.

The concept of "usability" was proposed in the 1980s in relation to the concept of "user friendliness" [35]. Because no clear definition and assessment method for "user friendliness" were available, the term was replaced with "usability," which emphasizes a user-centered design, particularly in human–computer interactions, that meets users' daily needs and matches their habits.

For this concept analysis, the term "usability" was used in the search for relevant literature; this search only included studies published from 1980. The inclusion criteria were as follows: (1) journal articles, conference proceedings, book chapters, e-books or websites; (2) published in English; (3) both title and keywords include the term "usability." Articles that were not full-text, as well as those lacking definitions of the term "usability" were excluded. Table 1 lists the results of the key terms searched.

As presented in Table 1, the attributes of usability are defined differently depending on the professional fields of the respective authors. However, a multidisciplinary, consistent definition of usability is still absent.

Christensson defined apps as software programs on mobile devices (e.g., smartphones and table computers) [36]. Mobile apps differ from personal computer software programs and are comparatively easy to install. Apps can be downloaded and automatically installed from online app stores on mobile devices. Since the introduction of Apple's App Store in 2008, apps have only grown in popularity.

Health promotion refers to the process of motivating people to improve or control their health [37]. Apps can serve as a key tool for changing or promoting health behaviors [38], especially when recommended by health professionals. As a means of promoting physical activity, apps can monitor, educate, and motivate users [39] and are an essential lifestyle-changing intervention to achieve health-promotion goals [40].

Defining Attributes

App usability refers to the likelihood of it meeting users' expectations. According to Walker and Avant, defining attributes are those that are most frequently mentioned [26]. Several attributes have been used to define the concept of usability. To ensure the quality of the data extraction performed and to identify the most appropriate defining attributes in case of disagreement, discussions between the authors

Table 1. Summary of the characteristics of usability definition

Source	Field	Attributes of usability
Booth, 1989 [66]	Computer Science	Usefulness, Effectiveness, Learnability, Attitude
Shackel, 1991 [67]	Ergonomics	Effectiveness, Learnability, Flexibility, User attitude
Dumas and Redish, 1993 [68]	User Interface Design	Perform tasks quickly and easily.
Hix and Hartson, 1993 [69]	User Interface Design	Initial performance, Long-term performance, Learnability, Retainability, Advanced feature usage, First impression, Long-term user satisfaction
Preece and Benyon, 1993 [70]	Ergonomics	Safely, Effectively, Efficiently, Enjoyably
Bastien and Scapin, 1993 [71]	Ergonomic	Ease of learning, Consistency, User control, Flexibility
Nielsen, 1994 [54]	Computer Science	Learnability, Efficiency, Memorability, Errors, Satisfaction
Carey, 1995 [72]	Ergonomics	Effectively used by target users to perform tasks.
Guillemette, 1995 [73]	Information Science	Effectively used by target users to perform tasks.
Gluck, 1996 [74]	Geospatial Metadata	Useableness, Usefulness, Ease of use.
ISO, 1998 [75]	Ergonomics	Effectiveness, Efficiency, Satisfaction
Michelle et al., 1998 [76]	Document Design	Successfully learn and use a product to achieve a goal.
Clairmont et al., 1998 [77]	Information Science	Successfully learn and use a product to achieve a goal.
Kengeri et al., 1999 [78]	Library Science	Effectiveness, Likeability, Learnability, Usefulness
Brinck et al., 2001 [79]	User Interface Design	Functionally correct, Efficient to use, Easy to learn, Easy to remember, Error tolerant, Subjectively pleasing
Kim, 2002 [80]	Library Science	Interface Effectiveness
Preece et al., 2002 [81]	Computer Science	Effectiveness, Efficiency, Safety, Utility, Learnability, Memorability
Oulanov and Pajarillo, 2002 [52]	Library Science	Affect, Efficiency, Control, Helpfulness, Adaptability
Furtado et al., 2003 [82]	Information Science	Ease of use, Learning
Nielsen, 2003 [83]	Brand Design	Learnability, Efficiency, Memorability, Errors, Satisfaction
Dix et al, 2004 [84]	Computer Science	Ease of Learning, Flexibility, Reduction of excess, Visibility system status
Alonso-Rios et al., 2010 [53]	Computer Science	Knowability, Operability, Efficiency, Robustness, Safety, Subjective satisfaction
Zhang and Walji, 2011 [50]	Biomedicine and Healthcare	Learnability, Efficiency, Ease of use
Nassar, 2012 [85]	Various Field	Consistency, User control, Ease of learning, Flexibility, Errors management, Reduction of excess, Visibility of system status

were held until a consensus was reached.

The relevant app usability attributes were as follows: (a) efficiency of an app in meeting users' expectations, (b) overall satisfaction of users toward an app, and (c) learnability of an app. Through these attributes, certain health behaviors can be implemented, leading to health promotion. The usability of a health-promotion app can be the same as that of a general app, with the difference that health-promotion apps are aimed at achieving certain health-promoting behaviors.

Cases

1. Model Case

Walker and Avant defined model cases as examples that satisfy the defining attributes of the concept in question [26]. A study evaluated long-term and regular blood glucose control in people with diabetes and indicated that patients with diabetes who used a blood glucose management mobile app had, on average, a 1.78% greater reduction in glycohemoglobin than those who did not use the app [41], suggesting that the use of this mobile app was efficient in improving self-care. This finding also implies that when individuals effectively manage their own chronic disease, they can more easily achieve lifestyle change, thus helping them reach health-promotion goals.

The aforementioned study introduced the Mobil Diab blood glucose management mobile application, which has a simple interface with an intuitive approach for data entry. The application can also be used to set the frequency of medication use and provide relevant medication instructions. The app provides appropriate diabetes self-care health education to help patients increase their self-care knowledge and eventually develop behaviors beneficial to self-health management. This simple and informative design makes Mobil Diab an easy-to-learn app.

The study participants evaluated the Mobil Diab system on the following metrics: usability and design, efficiency and therapy satisfaction, and acceptance and evaluation. The users were satisfied with their experiences.

To summarize, the Mobil Diab application had the following benefits for people with diabetes: efficiency in self-health management, learnability, and user satisfaction.

2. Contrary Case

According to Walker and Avant, contrary cases are examples that do not satisfy the defining attributes of the concept at all [26]. In this case, common mobile diet apps continue to show promise in facilitating healthy eating and nutrition management.

In this study, apps that involve food journaling were examined. Food journaling apps mainly use ingredient identification technology to reduce the physical or psychological burdens of the paper-and-pencil recording process. When the user adds a new food item record, the apps tend to have a function for either searching through a diet database or adding a new item to the database. After the item is identified, the app prompts the user to input the portion size.

Studies have indicated that inaccurate recording can occur when food journaling apps are used [42,43]. Further analysis revealed possible causes: users' lack of ingredient measurement skills, users' inability to accurately estimate portion size, and apps' inability to determine the exact ingredient composition of mixed dishes [44,45].

In fact, many apps can only identify one ingredient at a time, and the various food items in the database are limited. This makes it challenging to analyze dishes with multiple ingredients, which affects the apps' efficiency in health promotion. Furthermore, if users are

not familiar with food exchange principles, they may encounter difficulties in accurately recording the contents of their diet. This implies low learnability, which affects user adherence. Users' low intention to regularly use the app would jeopardize the ultimate goal of food journaling; consequently, user satisfaction would be low. Therefore, food journaling apps in general do not satisfy any of the usability attributes.

3. Borderline Case

Borderline cases are defined as examples that partially satisfy the defining attributes [26]. A physical activity app was used as an example because regular physical activity is a key component of health [46]. A fitness center chain launched the "My Fitness Factory" app, designed to provide a convenient and comprehensive service for its members. The app can (a) automatically calculate the amount of calories burned during an exercise session after relevant data are input, (b) record the users' daily diet in detail and provide complete nutritional information of tens of thousands of food items from a database in the system, and (c) record more than 10 values related to the training regimen and also present the changes of these values in graphs and charts, thus enabling users to obtain an overview of their progress.

This app has many user-friendly features and is designed to meet the user's needs and enhance user satisfaction; moreover, the fill-in-the-blank interface for each option makes app operation simple and learnable. However, the app does not have a real-time busyness indicator that would help users avoid peak exercise hours at specific gym locations. The app was thus unable to provide users with comprehensive support for achieving their exercise goals, which was the main goal of the app. Clearly, this case only partially satisfies the necessary attributes, making it a borderline case.

4. Related Case

Related cases are those that have some connection to the concept but do not contain all the defining attributes [26]. Herein, a mobile e-nursing cart was considered; in this case, the user is considered, but instead of an app, the item is an ergonomic product. Ergonomics is a field of engineering technology that specializes in the way humans interact with tools, systems, and the environment [47]. The height of the screen, mouse, and keyboard on the e-nursing cart can be adjusted from sitting mode to standing mode, depending on the user's habits and height. An inability to adjust the height can increase the inconvenience of use; in this scenario, some users may need to use additional tools or be unable to use the cart at all. In this case, ergonomics was used to evaluate effectiveness, but assessment of learnability or user satisfaction requires the examination of the implementation of the product. Thus, learnability or user satisfaction could not be assessed.

Antecedents and Consequences

The overall design of an app affects the user's perception of the application experience, which in turn affects the user's willingness to use it [48]. Specifically, when users regard the system as efficient and learnable and also have a positive perception of it (that is, the system is usable), the system is more likely to be accepted by users, positively influencing their willingness to use it [49]. A successful design must therefore be predicated on usability.

The antecedents of app usability include mobile phones, human users with adequate mobile phone literacy, technical applications, and goals [50,51]. These antecedents result in practical consequences: users continue to

use the app on a regular basis to achieve their goals and intend to recommend it to other users [52,53].

Empirical Referents

In the final step of concept analysis, empirical referents are used to present how the concept is to be measured [26]. Defining attributes must pass referential tests of their consistency with a concept. The defining attributes that need to be tested for app usability are efficiency, satisfaction, and learnability. According to *Usability Engineering* [54], the nine most commonly employed empirical referents for testing defining attributes are heuristic evaluation, performance measures, think alouds, observation, questionnaires, interviews, focus groups, logging actual use, and user feedback.

According to Hollingsed and Novick, several empirical referents can be applied to test a research concept [55]. We referred to an empirical study that specifically investigated the application of usability testing techniques to improve a health-promotion app by using questionnaires, observation, and interviews, which are commonly used in nursing studies [56]. Our results also demonstrate the application of usability testing in the design and modification of health-promotion applications and illustrate areas or topics that can be used as a framework for testing and modification.

The remainder of this section presents three empirical referents suitable for testing the defining attributes of app usability, which should be jointly applied to obtain quantified and qualified data.

1. Questionnaires

Questionnaires on system performance and user satisfaction are generally designed according to the usability assessment criteria specified in *Usability Engineering*. The questionnaires are used to record users' evaluation of system performance in addition to their preferences and satisfaction regarding the usability of an app. Statistical analysis is performed on valid questionnaire responses to obtain accurate results.

For evaluating system performance, the System Usability Scale developed by Brooke records quantified performance data from the user and obtains an indication of the learnability and usage efficiency of an app. It is a free and publicly available scale with 10 easy-to-understand questions graded on a 5-point scale, with a total score between 0 and 100 [57]. A study using this scale in a large-sample trial obtained a reliability coefficient as high as 0.91 and a mean score of 68, with a score below the mean indicating a failure in usability [58,59].

The Questionnaire for User Interface Satisfaction is an example of a tool for measuring preference and satisfaction. It comprises 16 questions across four domains: overall reaction, screen, terminology and system information, and learning. Each question is scored on a 7-point scale (maximum score: 112 points). A higher score indicates a higher satisfaction level.

2. Observation

This method involves observing users' actual actions while they use an app to evaluate whether the app satisfies their needs; relevant findings can be used as the basis for follow-up interviews. Additionally, both quantitative and qualitative data can be obtained for various aspects of user–app interaction.

For example, Mendes and Dias-Neto used the observation method to investigate Flipboard, an app that aggregates content from different social media platforms [60]. Tests were conducted mainly by giving participants designated tasks, such as "log in using your account," "search and add categories of news

in the feed," "select some interesting news and select the 'read later' option," "link your Facebook account to Flipboard," and "create a new public magazine." The following information was collected as metrics: the number of completed tasks, number of attempts, total number of key presses, and time taken for task completion. These observations can reveal relevant difficulties that affect usability attributes.

3. Interviews

This assessment method involves interviewing users and offers flexibility to researchers, enabling them to acquire unexpected information from users and understand their true feelings and needs in greater depth.

Kenteris, Gavalas, and Economou combined questionnaires and interviews to evaluate user experience with myMytileneCity, a system that generates customized apps for users to explore the Greek city Mytilene [61]. Data gathered by interview included user satisfaction, the attitude of users toward using the application; simplicity, the ease with which users can accomplish tasks; comprehensibility, how easily users can understand content presented on the mobile device; perceived usefulness, to what extent the application has met its implementation objectives; and system adaptability, how the system adapts to the user requirements. The feedback collected from the participants was compiled and analyzed with respect to app improvement.

DISCUSSIONS

Concept analysis focuses on the concepts that explain or describe the phenomenon under study. Although our study was nonexperimental, we attempted to make sense of abundant relevant data by using the observations of others. The modern scientific method is in fact a combination of empirical and conceptual research [62]; this combination leverages the strengths of each research type.

A feasibility study on health-promotion apps has proven the efficiency of such apps [12]. However, the challenge is how program designers can employ the attribute elements of usability so that health professionals can subsequently recommend appropriate apps to different individuals and ensure consistent use. Therefore, we examined app usability and attempted the concept to health promotion.

We used actual cases from the literature to provide practical examples for the usability of health-promotion apps. This contrasts with the approach of other researchers using concept analysis [63-65], who limit their account of the defining attributes of the concepts under discussion by using hypothetical scenarios. Although this approach may be a useful method of clarification, the lack of engagement with practical and theoretical examples hampers the clarification of scientific overlap.

This study has some limitations. First, we considered only English-language articles that also drew on earlier research literature. Because the concept is new and rapidly evolving, its empirical references may change. Second, no robust studies exist on health-care professionals' perceptions of mobile app usability and its association with health outcomes.

CONCLUSION

In response to the evolution of information and communication technologies and the rise of health awareness in society, health-promoting apps have grown in popularity. An app with satisfactory usability is more likely to achieve its design goals in an efficient manner. We explored app usability from the user perspective to clarify usability attributes

for program designers' reference. Our findings may help health-care professionals recommend appropriate health-promotion apps to users according to their individual needs, thus promoting their use of apps and facilitating healthy behaviors and habits.

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CONFLICTS OF INTEREST

None declared.

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健康促進相關行動應用程式的使用性概念分析

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伴隨現代社會健康意識的抬頭，健康促進觀念逐漸備受學術及產業界的重視，同時，在資訊科技高度發展的現今，健康促進相關的行動應用程式亦雨後春筍般地開發。然仍諸多健康促進行動應用程式的設計，未能提供用戶擁有順暢的使用經驗，進而導致用戶無法透過健康促進行動應用程式達成健康促進目標；有鑑於此，釐清行動應用程式的使用性定義屬性，並嘗試應用於健康促進領域，期能協助程式設計者瞭解用戶角度之使用性屬性，終能滿足用戶擁有流暢的使用經驗。本文採用Walker及Avant所提出之概念分析方法，進行「行動應用程式使用性」概念分析，步驟依序為(1)瞭解概念範疇(2)釐清概念定義屬性(3)建構典型案例(4)建構相反、邊緣與相關案例(5)確認概念前因與後果(6)確認實證參考指標。基於健康促進觀點的概念分析結果，本文歸納出行動應用程式之使用性定義屬性包括：(1)產品具效率的、(2)用戶滿意的(3)易於學習的。良好的健康促進行動應用程式，可提高用戶對行動應用程式的忠誠度與黏著度，亦能協助其達成健康促進目標，並樂見用戶勇於分享健康促進行動用程式。（台灣衛誌 2022；**41**(**2**)：142-155）

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