7-8-2023

Usage of Mobile Applications Amongst Older Adults: Retrospect and Prospect

Yifan Li
Hong Kong Baptist University, 22481303@life.hkbu.edu.hk

Christy M.K. Cheung
Hong Kong Baptist University, ccheung@hkbu.edu.hk

Usage of Mobile Applications Amongst Older Adults: Retrospect and Prospect

Completed Research Paper

Yifan Li
Department of Management, Marketing and Information Systems
Hong Kong Baptist University
Kowloon, Hong Kong, China
22481303@life.hkbu.edu.hk

Christy M. K. Cheung
Department of Management, Marketing and Information Systems
Hong Kong Baptist University
Kowloon, Hong Kong, China
ccheung@hkbu.edu.hk

Abstract

Addressing age-specific issues related to IT usage is becoming increasingly significant. To consolidate the existing knowledge on the usage of mobile apps amongst older adults, this study synthesizes the research nature, patterns, and theoretical foundations in existing studies through a systematic literature review. Based on our investigation into the 22 identified articles, we find that previous studies on this topic focus mainly on app usage behaviors, app development and evaluation, and app usage learning and training. Prior studies are still fragmented and a more comprehensive and integrated framework is required to guide future research. Finally, we discuss the key antecedents of older adults' app usage identified in reviewed articles and highlight seven heuristic topics with corresponding research questions for future research. Limitations of this review are also discussed.

Keywords: Usage behavior, mobile applications, older adults, literature analysis

Introduction

With the proliferation of mobile devices, particularly smartphones and tablets, the market for mobile applications (hereafter abbreviated as "mobile app" or "app") has become increasingly brisker in recent years. On the Apple App Store, an average of 1,246 new apps are released per day[1], spanning categories such as gaming, business, education, utilities, lifestyle, food & drink, and shopping. Mobile apps' emergence in millions, coupled with their increasing range of applications, has introduced a broader audience to the benefits of mobile app usage. However, despite the increasing accessibility of mobile devices and the ubiquity of apps, certain subgroups of the population, such as the elderly, continue to lag behind in using and benefiting from app usage in their daily lives, leading to the phenomenon of the age-based "Digital Divide" (Niehaves & Plattfaut, 2014).

The rapid aging of the world's population and the ubiquitous nature of mobile apps in all aspects of our lives jointly make it inevitable for older adults to interact with them. Furthermore, in the wake of the COVID-19 pandemic, older adults are increasingly required to move beyond their traditional and basic uses of mobile devices, such as making calls or displaying the date and time, and embrace the development of mobile technologies (Chen & Chan, 2014). Mobile app usage offers older adults another opportunity to fully benefit from technology adoption, from the user's perspective (Czaja & Lee, 2007). From the provider's perspective, this particular age group present specific needs and expectations resulting from age-related physical and cognitive degradation (Niehaves & Plattfaut, 2014). Although previous studies have paid a lot

[1] Retrieved from https://42matters.com/ios-apple-app-store-statistics-and-trends.

of attention to older adults' unique needs, preferences, and capabilities, and app providers have also launched new products or remedied existing ones with elderly-oriented features, the acceptance and continued use of mobile apps among older adults remain relatively lower than those of the younger generation (Liu et al., 2021). Therefore, it is urgent in both research and practice to identify and address age-related issues in mobile app usage.

The topic of mobile app usage amongst older adults has attracted researchers in fields of communication (e.g., Abe et al., 2023), public health (e.g., Haan et al., 2021), ergonomics (e.g., Ma et al., 2016), computer science (e.g., Tsuchiya et al., 2021), and information systems (e.g., Zheng & Gu, 2022). This study focuses on mobile app usage as a crucial case of IT adoption, emphasizing the varying attitudes, beliefs, and intentions of the expanding elderly user group regarding app usage (Niehaves & Plattfaut, 2014). Our preliminary review indicates that existing research lacks an integrative and group-specific (or age-specific) framework to explain the mobile app usage among older adults. There is also a lack of a comprehensive solution for promoting app usage among the elderly. Given the increasing population of senior users and fragmented knowledge in this field, it is of great significance to gather the existing findings from the literature, present a clear picture of the current research state, and propose feasible future research directions for interested scholars. As a result, we hope to facilitate knowledge development in this field in terms of theorizing and contextualizing research on the elderly (Hong et al., 2013; Johns, 2006) and provide practical implications to the industry.

In this study, our goal is to systematically review previous studies on mobile app usage among older adults, identify the current state of research, and provide insights for future research to better understand the mobile app use of this demographic group and facilitate elderly-oriented app designs. In the remainder of this paper, we first clarify the reasons for focusing on this issue in Section 2; we then describe the research methods employed to conduct the systematic literature review; in Section 4, we articulate the state of research on older adults' use of mobile apps in terms of research trends, research foci, theoretical foundations, research methods, research contexts, and research samples. In the last section, we synthesize the identified studies and conclude with implications from our review findings and suggestions for future investigations. Limitations of this review are also discussed.

Mobile Applications and Older Adults

Mobile app refers to the application software developed or designed to run on portable digital devices (e.g., smartphones and tablets) (Liu et al., 2014). Different apps allow users to perform specific tasks to realize their objectives through interaction. Embedded on mobile devices, apps have been extensively adopted for various purposes, including social messaging, news browsing, life and shopping, financial service, travel and transportation, health and pharmacy, entertainment, and education, fundamentally transforming our ways of life. Only in the United States, the ownership of smartphones among older adults has already reached 61% in 2021[2], which still maintains a strong growth momentum. In the meantime, thousands of apps have popped up to provide us with assistance and convenience in all aspects of our lives. Passively and proactively, older adults, with physical limitations and unique preferences, have become an active group in making use of apps, inevitably getting involved in the "digital inclusion" process that aims to facilitate the participation of all individuals, in particular those with disadvantages, in all aspects of the information society[3]. In response to the advocacy of "digital inclusion", service providers have begun supplying elderly-oriented mobile apps with specially designed interfaces and functions, such as medication management, retirement career management, and daily life assistance. Researchers from IS and healthcare domains have also widely investigated the use of mobile apps amongst older adults (e.g., Chiu et al., 2016; Haan et al., 2021; Park et al., 2020; Pywell et al., 2020; Zheng & Gu, 2022).

We focus on this topic for several reasons. Firstly, the accelerating aging global population and the popularity of mobile devices make further investigation into app usage among older adults more urgent and significant. As estimated by the United Nations, the number of senior citizens (65 years old or above) worldwide is going to double, surpassing 1.5 billion individuals by 2050. With the dramatic growth of the

[2] Retrieved from https://www.statista.com/statistics/489255/percentage-of-us-smartphone-owners-by-age-group/.

[3] Retrieved from https://digital-strategy.ec.europa.eu/en/policies/digital-inclusion.

senior population, a lot of aging issues have become increasingly serious, one of which is the age-related "Digital Divide". The popularization of information technologies, represented by mobile devices, may serve as effective tools to bridge this divide. Secondly, despite the benefits of mobile app usage and the request for elderly-oriented improvements, the ideal "inclusive information society" has still not yet been achieved (Niehaves & Plattfaut, 2014). Older adult face varying degrees of physiological deterioration with the growth of age, leading to greater difficulties in using apps compared to the young and limiting their ability to effectively enhance their quality of life through mobile app usage. Consequently, many older adults are still suffering from low adoption intention and unsatisfying app user experiences due to their unique behavioral patterns and preferences (Niehaves & Plattfaut, 2014). Lastly, focusing on one subgroup's usage of a specific technology allows for a more focused review, enabling a comprehensive overview to guide future research and practice. By concentrating on one concrete kind of mobile technology (i.e., mobile apps), we aim to identify generalizable knowledge that can help interpret older adult's adoption of IT and uncover contextualized findings within the elderly context to further boost the potential of mobile apps in improving older adults' quality of life.

Research Method

Following the suggested procedures for writing an IS literature review (Webster & Watson, 2002), we first generated a dataset through searching on pertinent electronic databases, which included Web of Science (including SSCI, SCI, AHCI, and ESCI), ProQuest, SAGE, PubMed, Medline, and Scopus. The chosen databases were selected for their inclusion of high-impact and high-quality articles. Considering the physical and cognitive deterioration of older adults, we also searched two medical databases, PubMed and Medline, to obtain a more complete set of related studies. Figure 1 depicts the literature search and identification procedures of this review.

Specifically, we first conducted the abstract search[4] on the six databases with well-selected searching terms. The searching terms were drawn from related studies (Gera et al., 2020; Liu et al., 2021) and could be separated into three categories: app-related terms (i.e., "mobile app*" OR "smartphone app*" OR "mobile phone app*" OR "tablet app*" OR "mobile device app*"); elderly-related terms ("older adult*" OR "elder*" OR "senior citizen*" OR "old people"); and usage-related terms (usage OR "intention to use" OR adoption OR acceptance OR diffusion). All searching terms were combined with the AND operator. During the search process, we did not limit the time frame of publications. The first-stage literature search generated a dataset of 461 articles. After removing duplicates resulting from the overlapping resources of the six databases, there were 249 articles.

In the second stage, we applied the inclusion and exclusion criteria to the initial literature search results to ensure that we can finally obtain a manageable sample set with specific foci and high quality. To be specific, we only included regular research articles that were peer-reviewed and academic in nature. To get publications that are most relevant to our research focus, we also refined the initial dataset to empirical studies in which mobile app was the core focus and older adults were critical users in the investigation. In addition, we identified all studies that paid attention to mobile apps and elderly users during the inclusion process. This inclusion strategy preliminarily ensured that all identified studies were at least to some extent relevant to our research questions.

For the exclusion process, we applied stricter criteria to further refine the sample set. First, we excluded studies that did not provide an in-depth examination of older adults, as indicated by exclusion criteria (1), (2), and (3) (see Figure 1). Second, we eliminated studies that did not solely focus on mobile app usage, as indicated by exclusion criteria (4) and (5) (see Figure 1). Further, we excluded studies in which mobile apps examined were not designed for the general elderly population but rather for those with specific career backgrounds or diseases. Ultimately, we got a sample set of 22 papers, which were deemed suitable for subsequent review and analyses.

[4] On Web of Science, we searched the title, keywords, abstract, and keywords plus.

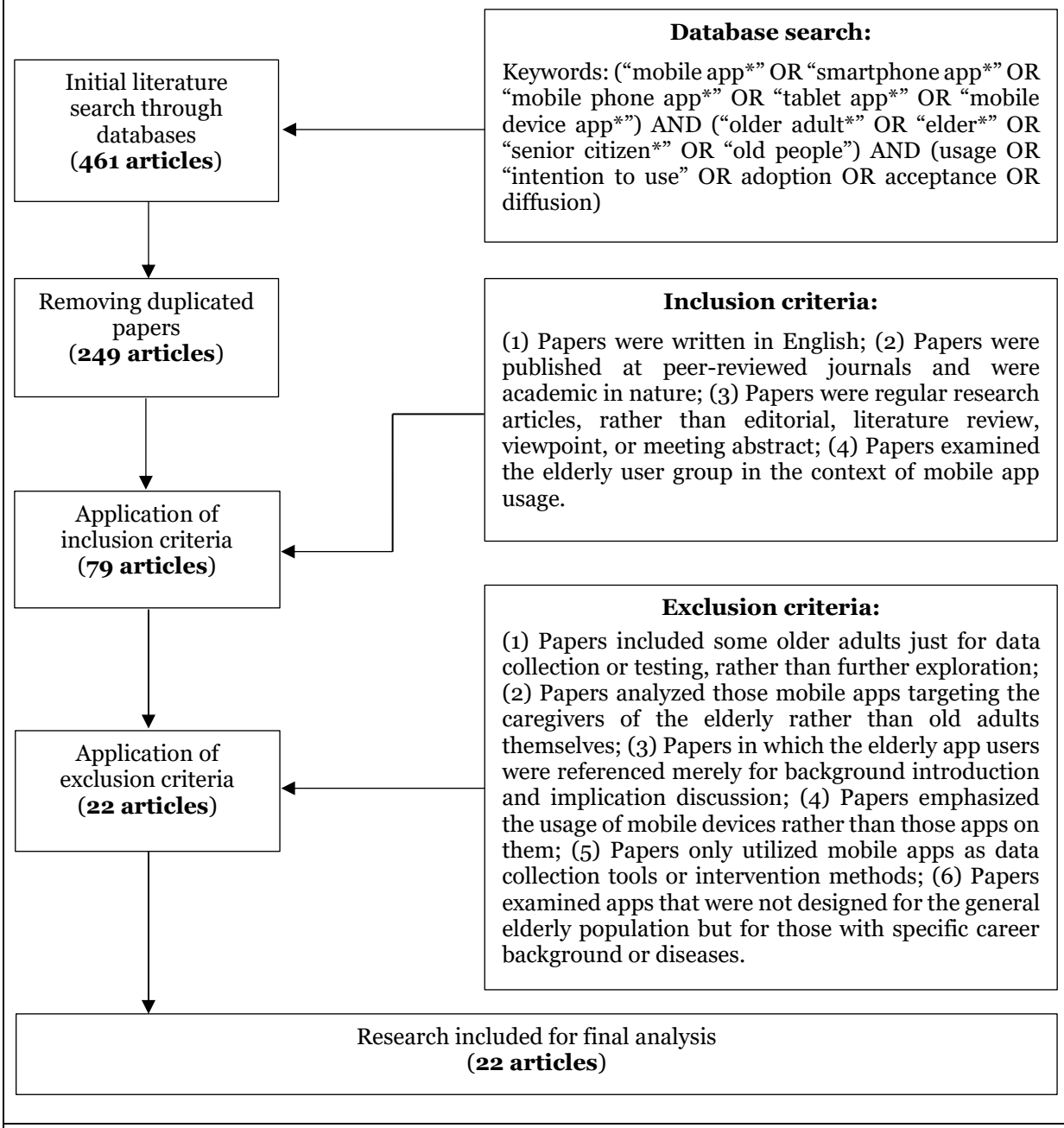

Figure 1. Literature Search and Identification Procedures

The State of Research on the Usage of Mobile Apps Amongst Older Adults

To structurally analyze the identified articles, we raised the following five research questions as Chan, Cheung, and Lee (2021) did to lead our following discussion:

1. What research trends can we identify from the literature?

2. What were the research foci of the literature?

3. What theories or frameworks did the literature adopt?

4. What research methods did the literature use?

5. What were the research contexts and samples?

Guided by the aforementioned five questions, we conducted a thorough analysis of the relevant information, including the disciplines involved, types of mobile apps, research streams and focuses, units of analysis, theories or frameworks employed, research methods utilized, research contexts, and samples under investigation. The literature analysis results are presented as follows.

Research Trends

As depicted in Figure 2, researchers remained lukewarm on the topic of mobile app usage amongst older adults till the end of 2019. The number of studies on this topic peaked in 2020 and performed strongly in the following years. Studies published after 2020 (n=15) accounted for more than 68% of all the identified articles, reflecting the increasing academic interest in this topic, which can be partially attributed to the expanding senior population due to socioeconomic developments. Such a sudden surge can also be in part a result of the outbreak of COVID-19 and related lockdowns, during which the lack of mobility, physical or mental problems, and the scarcity of social resources forced the elderly to rely more on mobile apps to fulfill their various needs. Among the 22 identified studies, almost 82% came from the areas of information systems (n=4), public health or health informatics (n=5), computer science (n=5), and ergonomics (n=4), while researchers from communication, business & management, and social psychology, showed limited interest in this topic.

Of the 22 identified studies, 15 of them explicitly stated the types of mobile apps they examined. Figure 3 displays the proportion of each app type. More than half of the studies focused on mobile health apps, indicating the high prevalence of health-related app usage among the elderly and the eagerness of service providers and developers to offer such apps. Among these mhealth-related studies, app usage demonstrated inspiring preventative power for health risks and strong intervening capabilities towards certain physical disorders. The studies also paid attention to the social demands of older adults, delivering corresponding services through not only mobile social media (e.g., Zheng & Gu, 2022) but also newly developed apps for multiple ends (e.g., Abe et al., 2023; Goumopoulos et al., 2017).

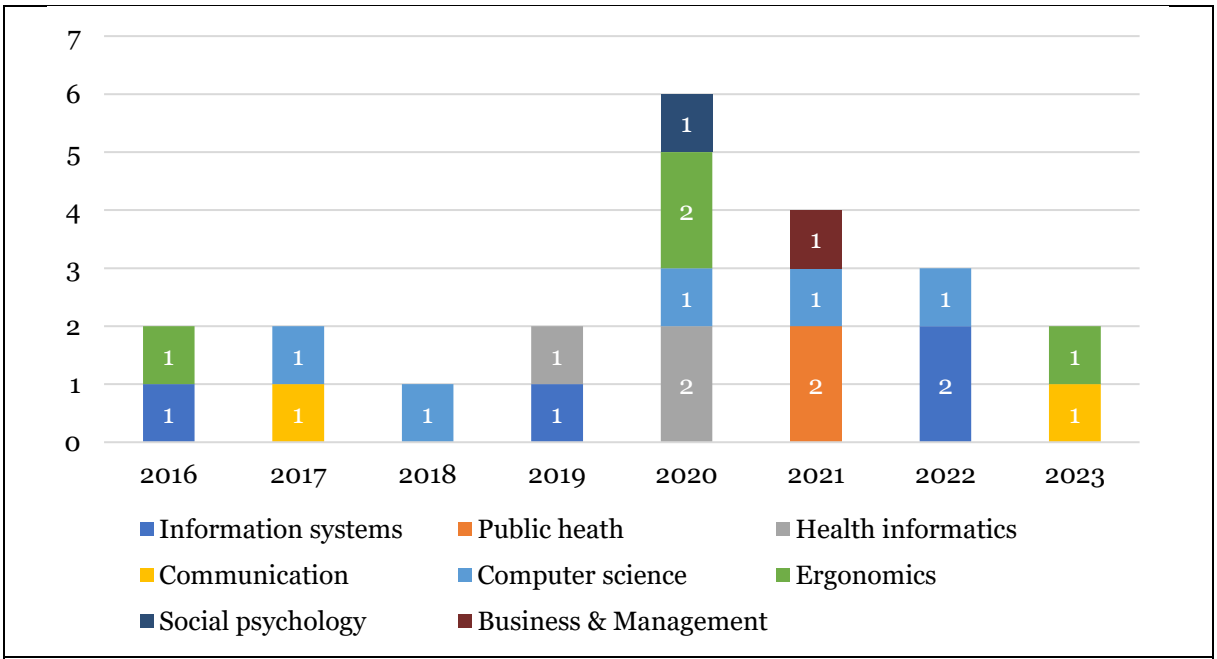

Figure 2. The Timeline of Publications (by Discipline)

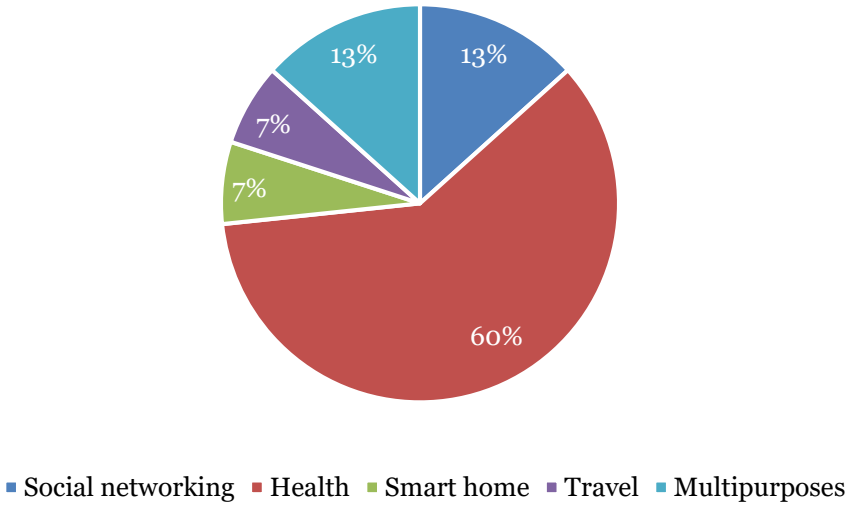

Figure 3. Types of Mobile Apps Studied

Research Foci

We recognized three apparent streams of research based on the primary concern of each identified study. An overview of each research stream and corresponding research focuses is presented in Table 1. The first stream of research examined the underlying psychological mechanisms of older adults' mobile app usage and its consequences. Many studies in this stream explored the antecedents of older adults' use of mobile apps. For example, Ma and colleagues (2016) identified the intrinsic attitudes and beliefs, as well as social structural factors, that may affect the acceptance of smartphone technologies, in particular smartphone apps, among older Chinese adults. Traditional technology acceptance factors, such as perceived ease of use and perceived usefulness, and certain individual differences, including cost tolerance, self-satisfaction, and demographic characteristics (e.g., marital, working, and economic status), were found to be important predictors of older adults' intention to use mobile apps. Studies also identified a number of barriers to older adults' uptake of mobile apps. For instance, older adults with poor e-health awareness, limited skills at interacting with technology, poor therapeutic progress (with mhealth), high perceived effort, preference for face-to-face contact, and privacy concerns showed very limited interests in leveraging mobile-based mental health interventions (Pywell et al., 2020). Another focus of the first stream of research was the consequences of mobile app usage. It is evident that mobile app usage benefits the overall well-being of the elderly. In Liu and Tang's (2022) study, they extended the existing technology acceptance model and verified that younger elderly's adoption of age-appropriate apps had a significant impact on their subjective well-being.

The second stream of research focused on the development and evaluation of certain mobile app prototypes or interface designs. Studies within this stream started with identifying the specific needs of the demographic group based on which they developed age-appropriate app prototypes (e.g., Taheri-Kharameh et al., 2022), elderly-oriented functions (e.g., Tsuchiya et al., 2021), elderly-friendly modes of interaction (e.g., Li & Luximon, 2020), or various specially-designed user interfaces (e.g., Alsswey et al., 2018). These designs or artifacts were then rigorously assessed for their acceptability and usability via well-executed evaluation methods. Not only did the evaluation target the designs or apps themselves but also the effectiveness of implementation or application. The other focus of the second research stream mainly related to whether or not the ultimate design or development objectives to benefit the elderly group besides improving the acceptability or usability of apps were realized. For example, Li and Luximon (2023) compared two typical navigation design patterns (2D list and 3D card) and validated the effectiveness of interface metaphors that aim to refer, identify, or quantify various interface concepts in improving older adults' understanding and acceptance with technological systems. Riboni and colleagues' (2022) study

validated the effectiveness of a tablet/smartphone app intervention designed for older adults, highlighting the main mindfulness-benefits reported by senior participants through qualitative analysis. Other two effectiveness-related studies indicated that certain app suites developed for multiple purposes could help motivate the elderly in new activities, maintain social connectedness, give joy and self-confidence, and improve health conditions (Abe et al., 2023; Goumopoulos et al., 2017).

The third stream of research, which emerged from health informatics, public health, and information systems, focused on the learning and training of mobile app usage. Studies in this stream aimed to identify factors that affect the learning process of older adults when it comes to mobile app usage (Chiu et al., 2016; Haan et al., 2021). Research in this stream also investigated the training programs that can enhance older adults' competency of app usage and facilitate their adoption, consequently benefiting their lives (Zhao et al., 2020).

Stream	Focus	Study
Usage behaviour	Psychological mechanisms	(Hua et al., 2021; Kim & Han, 2021; Liu & Tang, 2022; Ma et al., 2016; Pywell et al., 2020; Yang & Lin, 2019; Zheng & Gu, 2022)
	Consequences	(Liu & Tang, 2022)
Development and evaluation	Acceptability and usability	(Ali et al., 2022; Alsswey et al., 2018; Li & Luximon, 2020; Salim et al., 2017; Taheri-Kharameh et al., 2022; Thamutharam et al., 2021; Tsuchiya et al., 2021; Zhong & Rau, 2020)
	Effectiveness of design or use	(Abe et al., 2023; Goumopoulos et al., 2017; Li & Luximon, 2023; Riboni et al., 2022)
Learning and training	Learning to use	(Chiu et al., 2016; Haan et al., 2021)
	Effectiveness of training	(Zhao et al., 2020)

Table 1. An Overview of Research Foci

Theoretical Foundations

The investigation into older adults' mobile app usage has been informed by a diverse range of theories or frameworks. Here, we presented a summary of the theoretical foundations utilized by reviewed articles and explained how they were applied to justify older adults' adoption of mobile apps, as well as to direct the development and design processes.

In the reviewed literature, traditional technology acceptance models (e.g., TAMs and UTAUT), together with the theory of planned behavior and the theory of reasoned action, dominated the studies on older adults' mobile app usage behaviors, in which individual attitudes or beliefs played critical roles in predicting the elderly's intention to use mobile apps. Ma, Chan, and Chen (2016) combined those technology acceptance factors to develop a comprehensive model that unravels the predictors of older adults' acceptance of smartphone technology, with a specific focus on mobile apps. Additionally, Liu and Tang's (2022) study expanded on the existing technology acceptance models and took one step forward to uncover

the significant impact of age-appropriate app usage behaviors on the subjective well-being of the young elderly. In certain development and evaluation studies, constructs from traditional technology acceptance models, such as perceived usefulness and perceived ease of use, were instrumental in assessing the acceptability or usability of apps or designs (Alsswey et al., 2018; Salim et al., 2017).

Theories or models from social psychology and communication served as alternatives to explain why the elderly chose or refused to use mobile apps. Drawing on the social cognitive theory, Zheng and Gu (2022) examined the mediating role of emotional attachment and the moderating role of reverse intergeneration influence in the process through which media richness affects older adults' routinized use of mobile media. Similarly, a study on determinants of continuance intention to use health apps among the elderly revealed the predicting roles of health technology self-efficacy, self-evaluative outcome expectations, self-regulation, and privacy risk on the basis of the social cognitive theory of health behavior (Kim & Han, 2021). As complements, psychological and communication theories also worked synergistically with those technology acceptance models to guide the design and development of mobile apps. For instance, the uses and gratification theory, media richness theory, and social cognitive theory were integrated in Yang and Lin's (2019) study, aiming to construct an integrative model for predicting the adoption of ubiquitous mobile social services. Moreover, Chiu et al. (2016) designed a training course under the guidance of the diffusion of innovation theory and TAM to explore the attitudes, impacts, and learning needs of older adults who use apps on touchscreen mobile devices.

In the reviewed design science studies, certain design principles and evaluation criteria offered guidelines for related design and development practices. For example, studies related to software development or interface design were guided by the human-centered design approach, either explicitly or implicitly (Iancu & Iancu, 2020). Such studies (e.g., Goumopoulos et al., 2017) placed the subgroup of the population, i.e., older adults, at the center of the app development process, enabling their apps to precisely meet the elderly's needs and requirements (Iancu & Iancu, 2020). Evaluation criteria, such as the System Usability Scale, served as a potent endorsement of those newly-designed apps' quality (Ali et al., 2022; Thamutharam et al., 2021; Zhong & Rau, 2020).

In summary, the majority of existing studies interpreted the elderly's mobile app usage from the individual user perspective (Bagozzi, 2007; Venkatesh et al., 2003) while several studies have attempted to introduce certain group, institutional, social, and cultural elements to the discussion of older adults' adoption of mobile apps. Furthermore, some studies extended the mechanism beyond the established intention-behavior linkage to explore the ultimate goals of app usage (Bagozzi, 2007). Notably, traditional technology acceptance theories or models were proposed mainly for the general public and general technology adoption contexts. Their compatibility towards the elderly, applicability to the mobile app scenario, and the validity of age-specific factors that have been used to predict older adults' technology adoption require further scholarly attention.

Research Methods

Previous studies on older adults' mobile app usage adopted various research methods to realize their research objectives. The dominant research approach in studies related to interface design and app development was the design science methodology. Those studies targeted life problems encountered by senior citizens (e.g., Taheri-Kharameh et al., 2022), formed viable technological solutions (e.g., Salim et al., 2017), and finally showed the feasibility and value of them (e.g., Goumopoulos et al., 2017). Experiments were also employed to investigate the effectiveness of specific interface design patterns to lead to significant behavioral changes among the elderly (e.g., Li & Luximon, 2020; Li & Luximon, 2023) and the results of training programs to facilitate older adults' adoption of mobile apps (Zhao et al., 2020). Beyond the above two research methods, interviews were also widely applied to qualitatively identify facilitators or barriers to older adults' adoption (Pywell et al., 2020) and to collect their opinions or preferences for app interface design features and functions, which provided valuable insights for industrial design standards and app development practices.

Survey was the most commonly used research method in studies investigating the underlying psychological mechanisms and consequences of older adults' mobile app usage. It is worth noticing that questionnaire surveys in those studies were mostly administered through face-to-face interviews (e.g., Ma et al., 2016; Zheng & Gu, 2022) or with the assistance of researchers (e.g., Liu & Tang, 2022) in order to ensure high-quality responses from the elderly with limited patience or comprehension difficulties.

Research method	Frequency	Study
Survey	7	(Alsswey et al., 2018; Hua et al., 2021; Kim & Han, 2021; Liu & Tang, 2022; Ma et al., 2016; Yang & Lin, 2019; Zheng & Gu, 2022)
Interview	2	(Haan et al., 2021; Pywell et al., 2020)
Experiment	3	(Li & Luximon, 2020; Li & Luximon, 2023; Zhao et al., 2020)
Design science	8	(Ali et al., 2022; Goumopoulos et al., 2017; Salim et al., 2017; Taheri-Kharameh et al., 2022; Thamutharam et al., 2021; Tsuchiya et al., 2021; Riboni et al., 2022; Zhong & Rau, 2020)
Mixed-method approach	2	(Abe et al., 2023; Chiu et al., 2016)

Table 2. An Overview of Research Methods

Research Contexts and Samples

Although all identified studies focused on individual elderly users as the unit of analysis, there were discrepancies in how the elderly sample was defined. Table 3 provides a detailed look at the classification criteria used for determining "old" in the reviewed articles. Half of the studies (n=11) utilized the threshold of "60 years old" (e.g., Kim & Han, 2021; Li & Luximon, 2020; Liu & Tang, 2022) while other studies tended to be "younger", involving those aged between 50 and 60 in their investigations (e.g., Ali et al., 2022; Chiu et al., 2016; Ma et al., 2016). Taking the increasing accessibility of mobile devices and the rapidly aging population into account, four recent studies approached the much elder cohort of senior users aged 65 or above (Abe et al., 2023; Haan et al., 2021; Thamutharam et al., 2021; Riboni et al., 2022).

Definition	Frequency	Study
Aged 50 or above	5	(Ali et al., 2022; Chiu et al., 2016; Hua et al., 2021; Pywell et al., 2020; Yang & Lin, 2019)
Aged 55 or above	2	(Ma et al., 2016; Salim et al., 2017)
Aged 60 or above	11	(Alsswey et al., 2018; Goumopoulos et al., 2017; Kim & Han, 2021; Li & Luximon, 2020; Li & Luximon, 2023; Liu & Tang, 2022; Taheri-Kharameh et al., 2022; Tsuchiya et al., 2021; Zhao et al., 2020; Zheng & Gu, 2022; Zhong & Rau, 2020)
Aged 65 or above	4	(Abe et al., 2023; Haan et al., 2021; Thamutharam et al., 2021; Riboni et al., 2022)

Table 3. The Definition of Elderly Samples

Of the 22 reviewed articles, nineteen specified the countries or regions where their studies were conducted. The majority of studies on older adults' usage of mobile apps were carried out in the Asia-Pacific region (n=13), followed by those in Europe (n=4), and the remaining two involved elderly users from West Asia and Latin America.

Context	Region	Frequency	Study
China	Asia Pacific	4	(Liu & Tang, 2022; Zhao et al., 2020; Zheng & Gu, 2022; Zhong & Rau, 2020)
Hong Kong	Asia Pacific	3	(Li & Luximon, 2020; Li & Luximon, 2023; Ma et al., 2016)
Korea	Asia Pacific	1	(Kim & Han, 2021)
England	Europe	1	(Pywell et al., 2020)
Taiwan	Asia Pacific	1	(Yang & Lin, 2019)
Brazil	Latin America	1	(Tsuchiya et al., 2021)
Iran	West Asia	1	(Taheri-Kharameh et al., 2022)
Italy	Europe	1	(Riboni et al., 2022)
Malaysia	Asia Pacific	3	(Ali et al., 2022; Salim et al., 2017; Thamutharam et al., 2021)
Netherlands	Europe	1	(Haan et al., 2021)
Greece	Europe	1	(Goumopoulos et al., 2017)
Japan	Asia Pacific	1	(Abe et al., 2023)

Table 4. An Overview of Research Contexts

Discussion and Conclusion

The usage of mobile apps amongst older adults has received a lot of attention from academia. Studies on this topic covered the disciplines of information systems, public health, computer science, communication, ergonomics, social psychology, business & management, and health informatics, with multi-faceted focuses on usage behavior, app development and evaluation, and usage learning and training. Following the guideline to conduct literature reviews related to IS (Webster & Watson, 2002), we first scoped this review, conducted a comprehensive literature search with predefined terms on 6 major databases, and then discussed the research trends, research streams and focuses, theoretical foundations, research methods, research contexts, as well as research samples. In Table 5, we further classified the key antecedents of older adults' app usage identified in the reviewed articles.

	Personal factors	Situational factors
Barriers	• Inertia • Limited knowledge or technical skills • Lack of trust • Unrealistic outcome expectation	• Reverse intergeneration influence (in the presence of media richness) • Incongruent role of the general practitioners (for mhealth) • Privacy and confidentiality risk • Task complexity • Content similarity • Perceived effort • Perceived absence of interpersonal communication
Facilitators	• Attitude towards using • Prior technology use experience • Perceptual behavioural control • Demographic characteristics (age, gender, education, marital status, working status, economic status) • Gratification motivations • Self-evaluative outcome expectations • Self-regulatory behaviour • Extended practice • Cost Tolerance • Self-Satisfaction • Emotional attachment • Technology self-efficacy	• Perceived ease of use • Perceived usefulness • Perceived ease of learning • Perceived interactive richness • Reverse intergeneration influence (in the presence of emotional attachment) • Subjective norm (e.g., social influence from family members) • Facilitating conditions • Design factors (e.g., interface metaphor, cultural designs, large font size, step-by-step introductions and frequent repetition) • Media richness • Compatibility with daily lives • Relative advantages • Product-related values

Table 5. A classification of key antecedents discussed in reviewed articles

Finally, we reflected on the previous review results and formulated specific research questions for future IS studies on older adults' use of mobile apps. Table 6 provides an overview of all potential topics and corresponding research questions.

First, the reviewed articles on usage behavior have predominantly adopted the traditional technology acceptance theories (e.g., TAMs and UTAUT) to examine personal or social contextual factors that may affect older adults' use of mobile apps. However, relatively little attention has been given to the elderly's continued or routinized use of mobile apps. Additionally, existing studies related to routinized or continued use gave limited "continuance-specific" explanations of older adults' sustained usage of mobile apps. Given the challenges posed by age-related incompetence and poor elderly-appropriate designs, long-term use is always problematic for elderly mobile app users. This is particularly relevant for mobile apps focusing on promoting the well-being of older adults, such as mhealth ones, which rely even more heavily on continued or routinized usage to achieve their desired effects (Li et al., 2019). Therefore, it is of great significance for future research to explore "continuance-specific" explanations of older adults' sustained use of mobile apps.

Second, due to the physiological deterioration and senile diseases that older adults may experience, previous studies on mobile app usage among this population mainly focused on health-related apps that support adjuvant therapies and health management, as well as some life tool apps developed for improving the elderly's overall well-being. However, recent studies have indicated that older adults are increasingly showing a preference for "younger" mobile apps as they age. As we noticed from the literature, senior users have also taken an active part in adopting some social networking, travel, and smart home apps for instant messaging, sharing their moods, fulfilling their mobility needs, and improving their quality of life. Hence, future studies can expand beyond mobile health and examine older adults' app usage in broader life scenarios, including their behavioral patterns in different application settings or the development of app

suites that cater to the needs of the elderly in areas such as retired life management, health management, and offspring raising.

Third, extending the present "intention-behavior linkage" to some end-state goals or objectives of technology use may be of great significance to maintain the value of IS research for the well-being of individuals, groups, work units, organizations, and society (Bagozzi, 2007; Benbasat & Zmud, 2003). Existing studies have provided evidence of mobile apps' role in promoting older adults' quality of life. However, there were also some studies declaring the negative impacts of mobile app usage on the elderly and providing effective mobile app interventions to relieve those undesired physical effects (e.g., Wilaiwan & Siriwong, 2021). Therefore, future research can also switch to explore the potential side effects of mobile app usage among senior users. For instance, as mobile apps are becoming more and more efficient tools to reduce social isolation, facilitate communication with friends and increase their health conditions, older adults are accordingly becoming more and more dependent on those mobile technologies, especially mobile apps. In this case, future studies may examine addiction-related topics such as mobile SNS addiction or even mobile game addiction (Kwon et al., 2016), analyzing the attraction and addiction factors of mobile apps on older adults and the consequences.

Fourth, as the base of elderly mobile app users continues to expand, there has been a lack of research examining its business value. It is important to recognize that senior users not only represent significant growth potential for the industry but also have the potential to influence the behavior of their families or friends. Consequently, it is essential to investigate several key research questions to generate the business value of this demographic, such as the willingness of elderly mobile app users to share their opinions on products, the impact of word-of-mouth among them, the trust that elderly users place in the user-generated contents on online purchasing apps, and how mobile apps can be designed to collaborate with other marketing tools to most efficiently promote the click-through rates and subsequent purchases of the elderly users. Addressing these research questions will provide valuable insights to marketers and businesses looking to effectively engage and cater to this increasingly important age group.

Fifth, older adults' mobile usage is a sophisticated phenomenon that receives influences from various factors located at different levels of society, as well as from IT artifacts. Echoed with Bagozzi's (2007) call for a paradigm shift, studies on older adults' mobile app usage, which have been predominantly governed by traditional technology acceptance views, may also need to reconceptualize and specify the decision-making process of traditional technology acceptance models in philosophy on plural subject theory (Bagozzi, 2000). Nowadays, the elderly's mobile app usage has become more of a "socially determined" behavior. For example, an older adult may choose to use WeChat just in order to keep in touch with their kids (Haan et al., 2021), or a grandma may use the pedometer and communication application developed by Abe and colleagues (2023) to keep up with the "fashion" among her besties. Under such circumstances, the personal intention to do something has, in essence, become a collective intention to do with a group of people, which rooted in an individual's self-conception as a member of a particular group or a commitment of an individual to engage in joint action (Bagozzi, 2007; Tuomela, 1995). Actually, the explanatory power of "we" has been verified through a series of studies, concerning the play of social games (e.g., Li & Suh, 2021; Morschheuser et al., 2017), the usage of social media or social networking sites (e.g., Chen et al., 2020; Cheung et al., 2011; Shen et al., 2013), and the interaction in virtual communities (e.g., Bagozzi & Dholakia, 2006; Shen et al., 2014). From the "we-intention" perspective, future studies may involve IT artifacts, together with all related factors ranging from the individual level to the interpersonal, institutional, community, and organizational levels to derive a synthetical framework for understanding older adults' mobile app usage (Lee & Coughlin, 2015).

Sixth, design features matter a lot in shaping older adults' user experience. With advancing age, the elderly may more or less experience vision impairment, hearing loss, cognitive and memory deterioration, and touch insensitivity (Liu et al., 2021). Prior research has examined interface design features that may influence older adults' navigation behavior and performance (Li & Luximon, 2020; Li & Luximon, 2023). Some cultural designs have also been suggested to meet the unique needs of senior users from certain religious regions (e.g., Alsswey et al., 2018). In 2021, the Ministry of Industry and Information Technology of China released the General Specifications for Elderly-Oriented of Mobile Internet Applications, which aims to guide the elderly-oriented remodeling of the entire industry. Larger font sizes, simpler interaction gestures, and filtered advertisements are all commonly-seen methods of improvement. Future research

may further examine the effectiveness of those design guidelines across different contexts such as countries or cultural regions and explore how they can be combined to optimize acceptability and usability.

Seventh, the ongoing discussion on the differences between older adults and the general adult population in mobile app usage (e.g., Jaana & Paré, 2020) can now be migrated within the elderly group. In 2020, a report from the Word Health Organization (WHO) changed the definition of the elderly from 60 years old or above to 65[5]. Those who were once classified as the "old" have recently become the "middle-aged", leaving the rest of those above 65 being classified into three subgroups (i.e., the young old, the old, and the longevity). Such a classification brought to our attention the need for a further comparison of mobile app usage patterns or preferences within the elderly group. In other terms, the elderly cannot be considered a fully homogeneous group with respect to mobile app usage. The young old who are preparing for postponed retirement may still be subject to the influence of workplace referents (Brown & Venkatesh, 2005) while the much older cohort have started to interact with those mobile apps designed for their empty-nest conditions. With the growing number of easily accessible mobile devices, future studies should consider including larger samples of elderly users with diverse backgrounds and comparing differences among sub-groups to better understand the nuance of mobile app usage among the elderly.

Potential topics for future research	Corresponding research questions
1. Antecedents of older adults' continued or routinized use of mobile apps	RQ1: What are the facilitators or barriers to older adults' continued use of mobile apps? RQ2: What are the underlying "continuance-specific" explanations of older adults' continued use of mobile apps? RQ3: How can existing theoretical frameworks be adapted to interpret older adults' continued use of mobile apps?
2. Usage of emerging categories of mobile apps among older adults	RQ4: What are the differences in older adults' usage behavior patterns across various categories of mobile apps? RQ5: What are the potential new opportunities for app developers or service providers to meet the niche needs of older adults? RQ6: How can we design app suites for older adults to satisfy their needs without sacrificing usability and acceptability?
3. Well-being-related consequences of older adults' mobile app usage	RQ7: What are the positive consequences of older adults' mobile app usage in terms of the well-being of individuals, groups, work units, organizations, and society? RQ8: What are the potential side effects of older adults' mobile app usage? RQ9: Are older adults, compared with the younger generation, more vulnerable to the dark side of mobile app usage?
4. Business value of older adults' mobile app usage	RQ10: What are the antecedents of elderly users' willingness to share their opinions on products on mobile apps? RQ11: Compared with the traditional purchasing channels, what are the predictors of the elderly's trust in those user-generated-contents when they are purchasing through mobile apps? RQ12: How can we leverage elderly app users to generate greater business values resulting from their families and friends? What are the underlying mechanisms? RQ13: How can we design apps to effectively promote the click-through rates and subsequent purchases of elderly users?

[5] Retrieved from https://www.who.int/publications/i/item/9789240014886.

5. Alternative theoretical perspective to understand older adults' mobile app usage	RQ14: How can existing theoretical frameworks be contextualized for the elderly user group? RQ15: How does collective intention influence older adults' mobile app usage? RQ16: How can existing theories and models be integrated as a comprehensive framework covering individual, interpersonal, institutional, community and organizational elements to understand older adults' mobile app usage?
6. Effective app design and development to improve acceptability and usability	RQ17: What design features significantly influence older adults' mobile app usage? RQ18: How can different design features be combined to effectively promote the acceptability and usability of mobile apps among older adults?
7. Usage of mobile apps among different subgroups of the elderly users	RQ19: What are the specific needs and expectations of different subgroups of older adults? RQ20: What are the differences in mobile app usage behavior patterns across different subgroups of older adults?

Table 6. An overview of potential topics and future research questions

Although we have elaborately designed the whole review process, this literature review still has some limitations. Firstly, the use of inclusion and exclusion criteria to achieve a relevant and manageable dataset may have inadvertently excluded some important articles related to the topic at hand. For instance, by limiting the search to peer-reviewed journal articles, potentially valuable materials such as books and conference papers may have been overlooked. Additionally, we eliminated studies that examined mobile apps that were not designed for the general elderly but for those with specific backgrounds or diseases, e.g., veterans or patients with hip disorders, to obtain a manageable sample set and make the findings more generalizable. We know very well that such an exclusion criterion will also unwittingly miss some interesting findings related to this topic. Incorporating them as a stream of studies that focuses on studying people with specific backgrounds or diseases may provide more precise and specified guidelines for related research and practice. Secondly, as studies on this topic are accumulating, a more comprehensive and integrated paradigmatic framework that draws upon more extensive theories or models may be required to guide future research. Albeit the limitations above, the reflections and prospects presented in this review can still direct future research towards a more promising research area.

References

Abe, H., Kamishima, T., Ojima, R., Onishi, R., & Hirano, M. (2023). Social and physical effects of a pedometer and communication application among older men: A mixed-methods, pre/post pilot study. *Information, Communication & Society, 26*(3), 459-478.

Ali, N. M., Salim, M. H. B. M., Qurniawan, D. F., Vanoh, D., & Shahar, S. (2022). Initial design and evaluation of Wesihat 3.0 for older adults. *Journal of Theoretical and Applied Information Technology, 100*(9), 2826-2834.

Alsswey, A., Umar, I. N. B., & Bervell, B. (2018). Investigating the acceptance of mobile health application user interface cultural-based design to assist Arab elderly users. *International Journal of Advanced Computer Science and Applications, 9*(8), 144-152.

Bagozzi, R. P. (2007). The legacy of the technology acceptance model and a proposal for a paradigm shift. *Journal of the Association for Information Systems, 8*(4), 244-254.

Bagozzi, R. P. (2000). On the concept of intentional social action in consumer behavior. *Journal of Consumer Research, 27*(3), 388-396.

Bagozzi, R. P., & Dholakia, U. M. (2006). Open source software user communities: A study of participation in Linux user groups. *Management Science, 52*(7), 1099-1115.

Benbasat, I., & Zmud, R. W. (2003). The identity crisis within the IS discipline: Defining and communicating the discipline's core properties. *MIS Quarterly, 27*(2), 183-194.
Brown, S. A., & Venkatesh, V. (2005). Model of adoption of technology in households: A baseline model test and extension incorporating household life cycle. *MIS Quarterly, 29*(3), 399-426.
Chan, T. K. H., Cheung, C. M. K., & Lee, Z. W. Y. (2021). Cyberbullying on social networking sites: A literature review and future research directions. *Information & Management, 58*(2), 103411.
Chen, J. V., Hiele, T. M., Kryszak, A., & Ross, W. H. (2020). Predicting intention to participate in socially responsible collective action in social networking website groups. *Journal of the Association for Information Systems*, *21*(2), 341-363.
Chen, K., & Chan, A. H. S. (2014). Gerontechnology acceptance by elderly Hong Kong Chinese: A senior technology acceptance model (STAM). *Ergonomics, 57*(5), 635-652.
Cheung, C. M. K., Chiu, P. Y., & Lee, M. K. O. (2011). Online social networks: Why do students use Facebook?. *Computers in Human Behavior, 27*(4), 1337-1343.
Chiu, C. J., Hu, Y. H., Lin, D. C., Chang, F. Y., Chang, C. S., & Lai, C. F. (2016). The attitudes, impact, and learning needs of older adults using apps on touchscreen mobile devices: Results from a pilot study. *Computers in Human Behavior, 63*, 189-197.
Czaja, S. J., & Lee, C. C. (2007). The impact of aging on access to technology. *Universal Access in the Information Society, 5*(4), 341-349.
Gera, R., Chadha, P., & Ahuja, V. (2020). Mobile app usage and adoption: A literature review. *International Journal of Electronic Business, 15*(2), 160-195.
Goumopoulos, C., Papa, I., & Stavrianos, A. (2017). Development and evaluation of a mobile application suite for enhancing the social inclusion and well-being of seniors. *Informatics, 4*(3), 15-41.
Haan, M. d., Brankaert, R., Kenning, G., & Lu, Y. (2021). Creating a social learning environment for and by older adults in the use and adoption of smartphone technology to age in place. *Frontiers in Public Health, 9*, 568822.
Hong, W., Chan, F. K. Y., Thong, J. Y. L., Chasalow, L. C., & Dhillon, G. (2013). A framework and guidelines for context-specific theorizing in information systems research. *Information Systems Research, 25*(1), 111-136.
Hua, C., Cole, S., & Xu, N. (2021). Rethinking trust in tourism apps: The moderating effect of age. *Journal of Hospitality and Tourism Technology, 12*(3), 548-562.
Iancu, I., & Iancu, B. (2020). Designing mobile technology for elderly. A theoretical overview. *Technological Forecasting and Social Change, 155*, 119977.
Jaana, M., & Paré, G. (2020). Comparison of mobile health technology use for self-tracking between older adults and the general adult population in Canada: Cross-sectional survey. *JMIR Mhealth Uhealth, 8*(11), e24718.
Johns, G. (2006). The essential impact of context on organizational behavior. *Academy of Management Review, 31*(2), 386-408.
Kim, E., & Han, S. (2021). Determinants of continuance intention to use health apps among users over 60: A test of social cognitive model. *International Journal of Environmental Research and Public Health*, *18*(19), 10367.
Kwon, H. E., So, H., Han, S. P., & Oh, W. (2016). Excessive dependence on mobile social apps: A rational addiction perspective. *Information Systems Research, 27*(4), 919-939.
Lee, C., & Coughlin, J. F. (2015). Perspective: Older adults' adoption of technology: An integrated approach to identifying determinants and barriers. *Journal of Product Innovation Management, 32*(5), 747-759.
Li, L., Peng, W., Kononova, A., Bowen, M., & Cotten, S. R. (2019). Factors associated with older adults' long-term use of wearable activity trackers. *Telemedicine and e-Health, 26*(6), 769-775.
Li, M., & Suh, A. (2021). We-intention to continue playing mobile multiplayer games: The role of social play habit. *Internet Research, 31*(4), 1153-1176.
Li, Q., & Luximon, Y. (2020). Older adults' use of mobile device: Usability challenges while navigating various interfaces. *Behaviour & Information Technology, 39*(8), 837-861.
Li, Q., & Luximon, Y. (2023). Navigating the mobile applications: The influence of interface metaphor and other factors on older adults' navigation behavior. *International Journal of Human–Computer Interaction, 39*(5), 1184-1200.
Liu, C. Z., Au, Y. A., & Choi, H. S. (2014). Effects of freemium strategy in the mobile app market: An empirical study of Google Play. *Journal of Management Information Systems, 31*(3), 326-354.

Liu, N., Yin, J., Tan, S. S. L., Ngiam, K. Y., & Teo, H. H. (2021). Mobile health applications for older adults: A systematic review of interface and persuasive feature design. *Journal of the American Medical Informatics Association, 28*(11), 2483-2501.

Liu, W., & Tang, W. (2022). Effects of age-appropriate mobile app use behavior on subjective well-being of young elderly. *Security and Communication Networks, 2022*, 3209804.

Ma, Q., Chan, A. H. S., & Chen, K. (2016). Personal and other factors affecting acceptance of smartphone technology by older Chinese adults. *Applied Ergonomics, 54*, 62-71.

Morschheuser, B., Riar, M., Hamari, J., & Maedche, A. (2017). How games induce cooperation? A study on the relationship between game features and we-intentions in an augmented reality game. *Computers in Human Behavior, 77*, 169-183.

Niehaves, B., & Plattfaut, R. (2014). Internet adoption by the elderly: Employing IS technology acceptance theories for understanding the age-related digital divide. *European Journal of Information Systems, 23*(6), 708-726.

Park, L. G., Ng, F., Shim, J. K., Elnaggar, A., & Villero, O. (2020). Perceptions and experiences of using mobile technology for medication adherence among older adults with coronary heart disease: A qualitative study. *Digital Health, 6*, 2055207620926844.

Pywell, J., Vijaykumar, S., Dodd, A., & Coventry, L. (2020). Barriers to older adults' uptake of mobile-based mental health interventions. *Digital Health, 6*, 2055207620905422.

Salim, M. H. M., Ali, N. M., & Noah, S. A. M. (2017). Mobile application on healthy diet for elderly based on persuasive design. *International Journal on Advanced Science, Engineering and Information Technology, 7*(1), 222-227.

Shen, X. L., Cheung, C. M. K., & Lee, M. K. O. (2013). Perceived critical mass and collective intention in social media-supported small group communication. *International Journal of Information Management, 33*(5), 707-715.

Shen, X. L., Lee, M. K. O., & Cheung, C. M. K. (2014). Exploring online social behavior in crowdsourcing communities: A relationship management perspective. *Computers in Human Behavior, 40*, 144-151.

Taheri-Kharameh, Z., Fänge, A. M., Hansson, E. E., Bashirian, S., Heidarimoghadam, R., Poorolajal, J., & Barati, M. (2022). Development of a mobile application to screen and manage fall risks in older people. *Disability and Rehabilitation: Assistive Technology, 17*(3), 362-367.

Thamutharam, Y. N., Mustafa, M. B. P., Musthafa, F. N., & Tajudeen, F. P. (2021). Usability features to improve mobile apps acceptance among the senior citizens in Malaysia. *ASM Science Journal, 16*(3), 1-7.

Tsuchiya, L. D., Braga, L. F., de Faria Oliveira, O., de Bettio, R. W., Greghi, J. G., & Freire, A. P. (2021). Design and evaluation of a mobile smart home interactive system with elderly users in Brazil. *Personal and Ubiquitous Computing, 25*(2), 281-295.

Tuomela, R. (1995). *The Importance of Us: A Philosophical Study of Basic Social Notions*. Stanford University Press.

Riboni, F. V., Sadowski, I., Comazzi, B., & Pagnini, F. (2022). Mindful age and technology: A qualitative analysis of a tablet/smartphone app intervention designed for older adults. *Integrative Psychological and Behavioral Science, 56*(3), 739-754.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly, 27*(3), 425-478.

Webster, J., & Watson, R. T. (2002). Analyzing the past to prepare for the future: Writing a literature review. *MIS Quarterly, 26*(2), xiii-xxiii.

Wilaiwan, W., & Siriwong, W. (2021). Effectiveness of the healthy e-elderly people intervention (HEPI) mobile application for the reduction of physical health effects caused by smartphone usage among elderly individuals in Thailand. *Journal of Health Research, 35*(6), 553-563.

Yang, H. L., & Lin, S. L. (2019). The reasons why elderly mobile users adopt ubiquitous mobile social service. *Computers in Human Behavior, 93*, 62-75.

Zhao, X., Wang, L., Ge, C., Zhen, X., Chen, Z., Wang, J., & Zhou, Y. (2020). Smartphone application training program improves smartphone usage competency and quality of life among the elderly in an elder university in China: A randomized controlled trial. *International Journal of Medical Informatics, 133*, 104010.

Zheng, S., & Gu, J. (2022). Effect of media richness on older adults' routinized use of social media in mobile applications. *Mobile Information Systems, 2022*, 8836431.

Zhong, R., & Rau, P. L. P. (2020). A mobile phone–based gait assessment app for the elderly: Development and evaluation. *JMIR Mhealth Uhealth, 8*(5), e14453.