The Use and Design of mHealth apps for Chinese older adults: Systematic review of literature and mHealth apps

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Abstract

Background: There has been a significant growth in mobile health (mHealth) to enable individuals to access health information, assessments, and treatments for managing their health conditions and enhancing their quality of life. However, research on how Chinese older adults perceived and utilized mHealth technologies for aging in place is limited.

Objective: The study aimed to identify the benefits mHealth technologies for older adults in Hong Kong and to explore factors that can maximize their use and positive experience of mHealth technologies.

Methods: The study systematically reviewed the literature related to mHealth technologies and their utilization patterns among Chinese older adults and randomly selected six mHealth apps for critical review using the User Version of the Mobile Application Rating Scale (uMARS).

Results: Eleven out of 2399 records from databases including Medline, BMJ Journals, CINAAHL, Emerald Insight and Google Scholars and 8 out of 110 mHealth apps were selected for review. Five key themes were identified from the systematic review, including ‘Benefits of using mHealth technologies’, ‘to use or not to use mobile applications’, ‘Trust and belief in mHealth technologies’, ‘Perceived usefulness and intention to use mHealth apps’, and ‘Variations of mHealth practices—mHealth with interactivity intervention’. The landscape study using uMARS also found that the multi-functionality of App 1 is essential for providing holistic care for older adults, providing them with a more thorough understanding of their health condition regarding eight vital signs, including blood pressure, body temperature, blood oxygen level, blood sugar level, weight, heart rate, step count, and sleeping hours, than other apps.

Conclusions: Due to the human resources shortage, mHealth technology is in great demand among older adults in Hong Kong as mHealth app is believed to be effective in promoting health consciousness and self-care among older adults because of its multiple functions. However, mHealth developers and operators should address the technical and ethical issues, for example, privacy and data security, equal and fair access to mHealth technologies, and accuracy and reliability of the sources of health information used in the mHealth app, when adopting this approach in their delivery of services to older persons and their families.

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Introduction

According to the UN definition [1], Hong Kong is moving from an “aged society” to a “super-aged society” because its ageing population increased from 20.8% in mid-2022 to 25.3% in 2028 and then 35.1% in 2069 [2]. Though growing old does not necessarily result in more chronic diseases, the occurrence rate of chronic diseases in Hong Kong increased rapidly. It was estimated to have 1,799,100 persons with chronic diseases in Hong Kong, about 24.1% of the total population in 2020 compared with the 19.2% in 2013. Among these persons with chronic diseases, 67.6% were 60 years and over [3]. Research has well-documented that informal carers for older adults with chronic diseases felt stressed because of their caring responsibilities [4].

In the past decade, there has been a significant growth in health care practice, research and publications focusing on mobile health (mHealth), which can be attributed to its cost-effective as it allows individuals to access health information, assessments, and treatments for managing their health conditions and enhancing their quality of life. According to the World Health Organisation [5], eHealth (electronic health) is a cost-effective and secure way of utilising information and communication technologies in the provision of healthcare services, health surveillance, health education and health portion. For example, the Healthcare Recipient Index (HRI) and Electronic Health Records Sharing System are major applications of eHealth in Hong Kong. On the other hand, mHealth (Mobile health) is the use of wireless technologies in mobile devices, such as smartphone or tablet, to provide remote access to healthcare information and services, such as NHS app [6]. The mHealth system can store patients’ health conditions and their usage of the mHealth system for monitoring their health status on the mobile devices.

A systematic review has confirmed that mHealth effectively improves self-care management, self-efficacy, quality of sleep, diet, physical activity, mental health, medication adherence disease prevention, lifestyle change, and management of chronic diseases among older adults [7]. Given its

effectiveness and popularity of using mHealth technologies to support older adults to stay as long as possible in their home and familiar community, studies have suggested that the development of mHealth apps should adopt a user-centred, collaborative, and interdisciplinary approach to enhance its acceptability, usability, and sustainability [8].

However, the adoption rate of mHealth technologies among older adults still needs to improve despite its benefits [9]. Using the Technology Acceptance Model, Xie and Kalun Or [9] found that perceived usefulness, ease of use, and mHealth literacy were major determinants of the intention to use mHealth technologies among older adults. A recent bibliometric analysis has highlighted the research gap in mHealth research, which is about older adults' behaviours, needs, and barriers to using mHealth technologies [10]. Therefore, the current study aims to identify the benefits the current applications of mHealth technologies for older adults in Hong Kong and to explore factors that can maximise their use and positive experience of mHealth technologies.

Methods

Search strategy

Study 1. Systematic literature review

A) Methods

In mid-May 2023, researchers of the current study searched the literature from 2015 to 2023 in various databases, including Medline, Google Scholar, BMJ Journals, CINAHL Plus, and Emerald Insight. Studies were included if they met all the following inclusion criteria: they were 1) written in English or Chinese; 2) related to mobile health or eHealth (e.g., tele-health or tele-medicine); 3) empirical studies; and 4) related to older adults or community-dwelling older adults were related to Hong Kong. After examining titles and abstracts, the researchers included 11 articles in the literature review (Figure 1).

B) Data extraction and quality assessment

The researchers of the current study summarised the origin, purpose, number of participants, research design, intervention, measurement, and outcomes of the studies in Table 1. Meanwhile, the quality of those studies was evaluated with ratings of high, moderate, low, or very low using a Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach. Finally, the research team analysed themes, methodologies, and gaps in these articles.

C) Data extraction and quality assessment

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Study 2. Landscape study

In March 2023, the research team searched for mhealth apps on the Play Store using the keywords including health of older people, health, cognitive impairment, and older people. The inclusion criteria for selection are as follows: The app was designed for older adults/age-related conditions (e. g. dementia and stroke) in Hong Kong; designed for personal health management, which means helping individuals manage their health and wellbeing; in Chinese Language; free to download by the public; and compatible with Android system version 12. The application was excluded from the selection if it has yet to be updated since 2018 and refrains from accepting new registrations.

A) Apps Quality Measures

Using the Samsung Galaxy Tab S6 Lite with Android version 12 and Samsung Galaxy Note 10 Lite with Android version 12, the research team examined the basic characteristics and functionalities of the identified apps according to Song and Chen's framework [12] (Table 2). A total of 105 records were found on the Play Store, plus 15 apps suggested by frontline practitioners providing direct service to older adults in Hong Kong. The final applications identified were 121. After applying the exclusion criteria, a total of 110 apps were screened, and only 8 apps met the eligibility for evaluation in this study. Table 4 shows the basic characteristics of each app (Figure 2).

B) Apps Rating Using the uMARS

Five researchers from different higher education institutes in Hong Kong evaluated the apps with the User Version of the Mobile Application Rating Scale (uMARS) [13]. The uMARS consists of a 20-item measure which can be divided into five subscales: aesthetics, functionality, information quality, and engagement, as well as "app subjective quality" (Table 3). An additional subscale "perceived impact" is attached to the uMARS to evaluate how the app affects users. As the objective of the evaluation was about the quality of the apps, the "app subjective quality" subscale, and "perceived impact" subscale were not adopted in the study. Items are rated on a 5-point Likert scale, ranging from 1 (inadequate) to 5 (excellent). After the evaluation, the overall mean score for each subscale was calculated and compared.

Results

Benefits of using mHealth technologies

As reported in Kwan, Lee, and colleagues' pilot randomized controlled trial [14], the use of mHealth technologies (i.e., a smartphone-assisted programme using Samsung Health and WhatsApp in their study) could improve cognitive function and increase frailty reduction, walking time, step

count, brisk walking time, leak cadence, and moderate-to-vigorous physical activity among Chinese older adults in Hong Kong. Their follow-up studies [15] have also argued that eHealth brisk walking intervention may promote cognitive health prevention to community-dwelling among older adults. Findings of our study echo a recent systematic review on mobile health [16] that mHealth interventions can generate positive effects on the health of older adults, particularly during the COVID-19 pandemic.

To use or not to use mobile applications

Yang, Lai, and colleagues [17] have identified 14 mobile app types commonly used among older adults in Hong Kong and found that the frequently used mobile apps had basic functions such as phone and SMS etc., instant communication such as WhatsApp, information such as news or weather apps, video entertainment like YouTube, and pandemic apps such as Leave Home Safe. The frequency of using medical service/support apps like eHealth was minimal. Similarly, Cheung and colleagues [18] also found that only 23.5% of their older respondents were eHealth users compared to 76.5% of younger respondents aged below 50 who used eHealth technologies. The key factors of older adults not using mobile apps were ‘No internet’ and ‘Physical/cognitive decline or not elderly friendly’. Eye fatigue associated with the visual display was also the most prevalent reason for not using mHealth among older Chinese adults in Hong Kong.

Trust and belief in mHealth technologies

Liu and colleagues [19] found that trust is an important component of using mHealth technologies among the older Chinese population in Hong Kong. They argued that people’s belief in the capability, functions, or features of a mHealth technology to meet their healthcare needs could enhance their behavioural intention to use mHealth technologies. Kim and colleagues [20] also found that optimism, i.e., a positive view of technology and belief in the ability of technology to improve

people's control, flexibility, and efficiency, is a driving force for their perceived usefulness and perceived ease of use of mHealth technologies. Research has also suggested that the reliability of the medical information services and the promises and commitment of the mHealth technologies to satisfy their medical information needs are essential for building up perceived trust in mHealth technologies [21]. In addition to the trustworthiness of the medical information on the mHealth platform, the concern about the protection of privacy and security of sensitive health information triggers the development of a code of conduct on privacy for mHealth technologies, such as the EU's privacy code of conduct on mobile health apps [22] and the code of practice for using electronic health record for healthcare [23].

Perceived usefulness and intention to use mHealth apps

Yang, Al Mamun, and colleagues [24] found that older adults perceived the usefulness of mHealth technologies promoted their adoption of the mHealth app. In other words, users' perceived accuracy of the technology and the usefulness of the health information in reducing health risks may increase motivation for using mHealth technologies. Therefore, the design of mHealth apps should meet users' expectations and match their perceptions of organisation and content [25]. Song and Cheng's review of Chinese mobile health apps [12] argued that mHealth apps should adhere to international guidelines and regulations in designing, developing, validating, and implementing mHealth apps. In other words, a high-quality mHealth app should provide comprehensive functions, including transmitting users' data to healthcare providers and providing feedback on users' conditions, tracking health symptoms, functional ability, laboratory results, and medication management.

Variations of mHealth practices—mHealth with interactivity intervention

Wong and colleagues [26] found that community-dwelling older adults using the mHealth app

with the support of a nurse case manager and a health-social partnership team could achieve a better mean score in self-efficacy, a lower mean score in pain, a lower number of unplanned visits to government outpatient department and health service utilisation compared with the control group. Wong et al's findings [26] have confirmed that personalised support and follow-up provided by the nurse case manager could complement the mHealth technologies with in-person communications and human contacts. Lou and colleagues' mHealth-supported volunteer-assisted intervention [27] was also proven effective in enhancing older adults' meaning of life and relationship with others. Kwan, Ng, and colleagues' multi-centre cluster randomised controlled trial [15] also suggested that support from youth volunteers for older adults using information and communication technologies improve older participants' mental wellbeing. However, research has revealed that patients feared of losing a personal relationship with their healthcare providers when using mHealth technologies [28]. The lack of face-to-face interactions in mHealth apps hinders people's adoption of health technologies [29]. This reminds us that mHealth without human interactions cannot replace seeing a GP [30].

Multi-functionality or specificity of the mHealth app

Cleland and colleagues [31] argued that home telemonitoring as a routine clinical service can enhance the efficiency of care for most medical problems. Lee and colleagues [32] suggested that the telerehabilitation group statistically significantly improved the quality of life among older adults compared to the face-to-face rehabilitation groups. Borges do Nascimento et al [33] also highlighted the negative impact of health misinformation on care recipients, including the delay of care provision, the decline of mental health, and misleading information of available evidence. While 39 features are listed in Table 5, App1 is the only app that can cover most of the functions, suggesting that the multi-functionality of the App1 is essential for providing holistic care for older adults. Moreover, the telehealth system of App1 can help users gain a more thorough understanding of their health condition regarding eight vital signs, including blood pressure, body temperature, blood

oxygen level, blood sugar level, weight, heart rate, step count, and sleeping hours, than other apps. The App1 is a telemonitoring system that allows the registered nurse to monitor the vital signs. Among these eight apps under our review, physical therapy, occupational therapy, and language therapy were only provided in the App1 Though older adults highly valued the quality of information, only three apps, including the App1, App2, and App3, that provided high quality educational information. On the other hand, as found in our systematic literature review, a large smartphone screen may enhance the acceptance of the m-health app among old adults. Using the large screen tablet in the App1 can improve the users' experience as some old adults may face age-related visual impairment, enhancing accessibility to using mHealth for self-care.

Discussion

mHealth technologies as a new source of digital inequalities

Research has argued that mHealth technologies are expanding digital divides among mHealth users and non-mHealth users, making the socially disadvantaged older adults and those people who do not have adequate financial resources with low eHealth literacy more vulnerable [34]. In addition to widening the disadvantaged groups' access to instrumental and network resources, training strategies should be developed to enhance their eHealth literacy to use the mHealth app competently. At the community level, policymakers should also promote public awareness and personal healthcare responsiveness campaigns to encourage the public to adopt the practice of self-management of their health.

An evidence-based approach to the clinical use of mHealth technologies

Though the short-term value of mHealth interventions for health education, physical health, mental wellbeing, and health behaviour change is confirmed in the literature, the long-term clinical value for users to address their chronic conditions is unclear [35]. Closer collaboration among

mHealth developers, clinical healthcare practitioners involved in monitoring the mHealth apps, and academic institutions for continuously analysing the mHealth big data to examine the trends and information of biomedical, behavioural, and lifestyle changes in mHealth users over time. Using big-data analysis of mHealth apps can empower healthcare providers to deliver more holistic and patient-centred care and lead to early identification of outbreak of disease [36].

Implications for practice and future research

Due to the human resources shortage in the Hong Kong healthcare system, telehealth services are in great demand in Hong Kong. The public healthcare system in Hong Kong is experiencing a severe human resource shortage. Research has shown an increasing trend of adopting mHealth technologies due to a high utilisation rate of ICTs and wide internet coverage in Hong Kong. The mHealth app, especially the LR System, is also believed to be effective in promoting health consciousness and self-care among older adults because of its multiple functions, such as real-time monitoring of vital signs, disease and drug management, and regular physical fitness checks. mHealth can also be used for health education and prevention for facilitative positive changes in users' health behaviours, quality of life, and wellness. mHealth technologies can also facilitate easy access to health information and resources for informal carers. Informal carers can also use the mHealth app to work with the healthcare team to remotely monitor the health and safety of the care recipients, enabling them to stay in their familiar environment as long as they want. The 24/7 real-time support from the mHealth app may also reduce caregiving demand on carers. However, mHealth developers and operators should address the technical and ethical issues, for example, privacy and data security, equal and fair access to mHealth technologies, and accuracy and reliability of the sources of health information used in the mHealth app, when adopting this approach in their delivery of services to older persons and their families.

Conclusion

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Table 1: Search terms and databases

Databases	Keywords
Medline	MHealth, ehealth, “Hong Kong”, “older adults”
Google Scholar	MHealth, ehealth, “Hong Kong”, “older adults”
BMJ Journals	MHealth, ehealth, “elders”
CINAHL Plus	MHealth, ehealth, “Hong Kong”, “older adults”
Emerald Insight	MHealth, ehealth, “Hong Kong”, “older adults”

Table 2: The basic characteristics and functionalities

Assessment measure		Description and definition
Basic characteristics		
App name		App name as shown on the Play Stores
Developer		Name of the developer
Aim		The aim that the apps are created
Target User		The specific group of users they designed the apps for
Date of update		The date to the latest update
Version		Latest update version until 18th July, 2023
Compatibility		Compatible with tablets and/or mobile phones
Healthcare provider involvement		Involvement of healthcare providers in the development and validation of the app
Star rating		Star rating score (out of 5) that users left on the Play Store
Number of reviews		Number of reviews that users left on the Play Store
Number of downloads		Number of downloads since the app released
Cost		The cost of apps
Installation		
Storage (Mobile Phone)		How many memory spaces does the application occupy in your mobile phone?
Storage (Tablet)		How many memory spaces does the application occupy in your tablet?
Privacy policy		Information on how user data are stored and shared
Functionalities		
Basic information record		Enables users to record their basic information (e.g., gender, age, and disease history)
Educational information		The information content is up-to-date, scientifically justifiable, acceptable to users, and evidence-based. The content includes disease overview, pathogenesis, treatment goals and options, exercise advice, medication, joint protection, and health advice for daily life
Communication		Facilitates patient–healthcare provider communication and patient-patient communication
Telehealth	Blood pressure	Allow users to measure and record blood pressure

	Body temperature	Allow users to measure and record body temperature
	Blood oxygen level	Allow users to measure and record blood oxygen level
	Blood sugar level	Allow users to measure and record blood sugar levels
	Weight	Allow users to measure and record weight
	Heart rate	Allow users to measure and record heart rate
	Step Count	Allow users to count and record their steps
	Sleeping hours	Allow users to count and record their sleeping hours
Personalised health assessments		Customise games and therapies based on the result of the health assessment
Telerehabilitation	Physical therapy	Provide physical therapy
	Occupational therapy	Provide occupational therapy
	Language therapy	Provide language therapy
	Brain training	Provide brain training games
Brain training	Reflexes	Provide games to improve users' reflexes
	Attention	Provide games to improve users' attention
	Visual ability	Provide games to improve users' visual ability
	Judgment	Provide games to improve users' judgment
	Mathematical ability	Provide games to improve users' mathematical ability
	Memory ability	Provide games to improve users' memory ability
	Executive function	Provide games to improve users' executive function
	Language ability	Provide games to improve users' language ability
	Cognitive flexibility	Provide games to maintain users' cognitive flexibility
Game difficulty levels		Provide games in different difficulty levels
Report		Generate reports after games or test
Training log		Record the times that users use the app
Multiplayer games		Allow more than one player to join a game
Medication management		Allow users to record medication name, dosage, time, and frequency
Visual analysis		Display recorded information as graphs or tables
Exercise management		Allow users to record information about exercise (e.g., frequency, time, and type)
Schedule		Allow users to organize everyday task
Reminders		Allow users to set reminders for appointments or when to take their medication
Information sharing		Allow users to share educational information and/or their disease data with healthcare providers or others
Hotline		Allow users to contact the developer when they face difficulties in using the app

Reward scheme	Reward users who use the app often
Tablet lending service	Lend tablet to the users who have economical needs

Table 3: The subscales and their description in uMARS

Subscales	Description
Engagement	Fun, interesting, customizable, interactive, has prompts (e. g. sends alerts, messages, reminders, feedback, enable sharing)
Functionality	App functioning, easy to learn, navigation, flow logic, and gestural design of app
Aesthetics	Graphic design, overall visual appeal, colour scheme, and stylistic consistency
Information	Contains high-quality information (e. g. text, feedback, measures, references) from a credible source

Table 4: The functionality table

App name		App1	App2	App3	App4	App5	App6	App7	App8
Basic information record		✓		✓	✓				
Educational information		✓	✓	✓					
Communication		✓		✓	✓	✓	✓	✓	✓
Telehealth	Blood pressure	✓		✓	✓				
	Body temperature	✓			✓				
	Blood oxygen level	✓			✓				
	Blood sugar level	✓		✓					
	Weight	✓		✓					
	Heart rate	✓							
	Step Count	✓							
	Sleeping hours	✓							
Personalized health assessments		✓				✓	✓		✓
Telerehabilitation	Physical therapy	✓							
	Occupational therapy	✓							
	Language therapy	✓							
	Brain training	✓				✓	✓	✓	✓
Brain training (n)	Reflexes	✓						N/A*	
	Attention	✓				✓	✓	N/A*	✓
	Visual ability	✓				✓		N/A*	✓
	Judgment	✓					✓	N/A*	
	Mathematical ability	✓					✓	N/A*	
	Memory ability	✓				✓	✓	N/A*	✓
	Executive function					✓		N/A*	✓
	Language ability					✓		N/A*	✓
	Cognitive flexibility							N/A*	✓
	Hand-eye coordination					✓	✓	N/A*	
Game difficulty level		✓			✓	✓	✓		✓
Report		✓	✓	✓	✓	✓			✓
Training log		✓				✓			✓
Multiplayer games						✓			
Medication management		✓		✓					
Visual analysis		✓		✓	✓	✓	✓		✓
Physical exercise management									
Schedule		✓		✓					
Reminders		✓							
Information sharing		✓		✓	✓	✓	✓		✓
Hotline		✓	✓	✓		✓		✓	✓
Reward scheme		✓					✓		
Tablet lending service		✓	N/A	N/A	N/A	N/A		N/A	N/A
	Total scores	33	3	12	9	16	12	3	15

Table 6: uMARS scores of the six apps

	App1	App2	App3	App4	App5	App6	App7	App8	Total
Engagement	3.8	3.32	2.96	2.36	4	3.68	1.88	3.52	3.19
Functionality	4.05	4.2	3.7	3.75	3.9	3.9	3.6	4.3	3.93
Aesthetics	3.93	3.67	3.07	3.2	3.8	3.8	2.27	3.53	3.41
Information	4.2	4.2	4.55	N/A	N/A	N/A	N/A	N/A	4.32
Total	4	3.85	3.57	3.1	3.9	3.79	2.58	3.78	3.57

*The scores were correct to two decimal places

Figure 1. Selection of articles for review

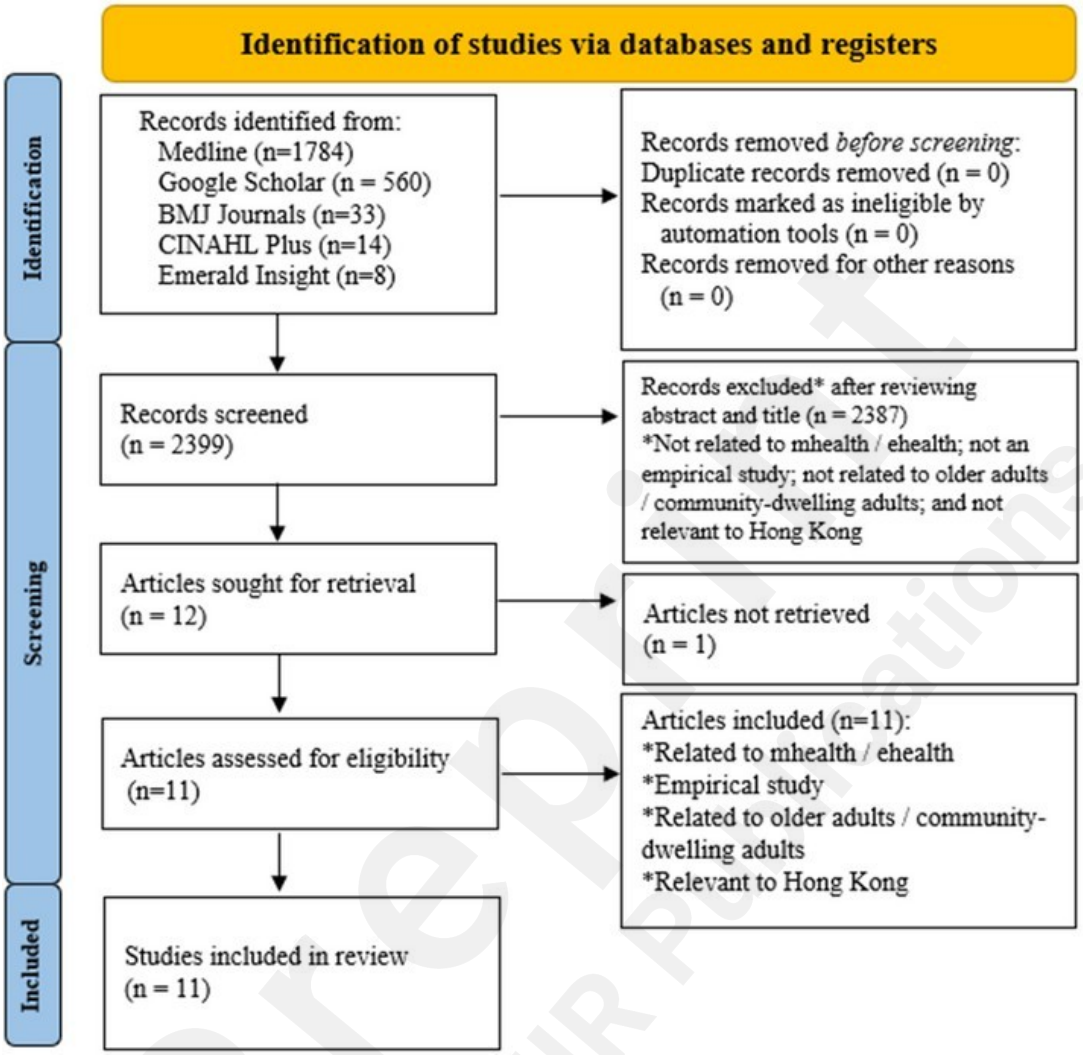
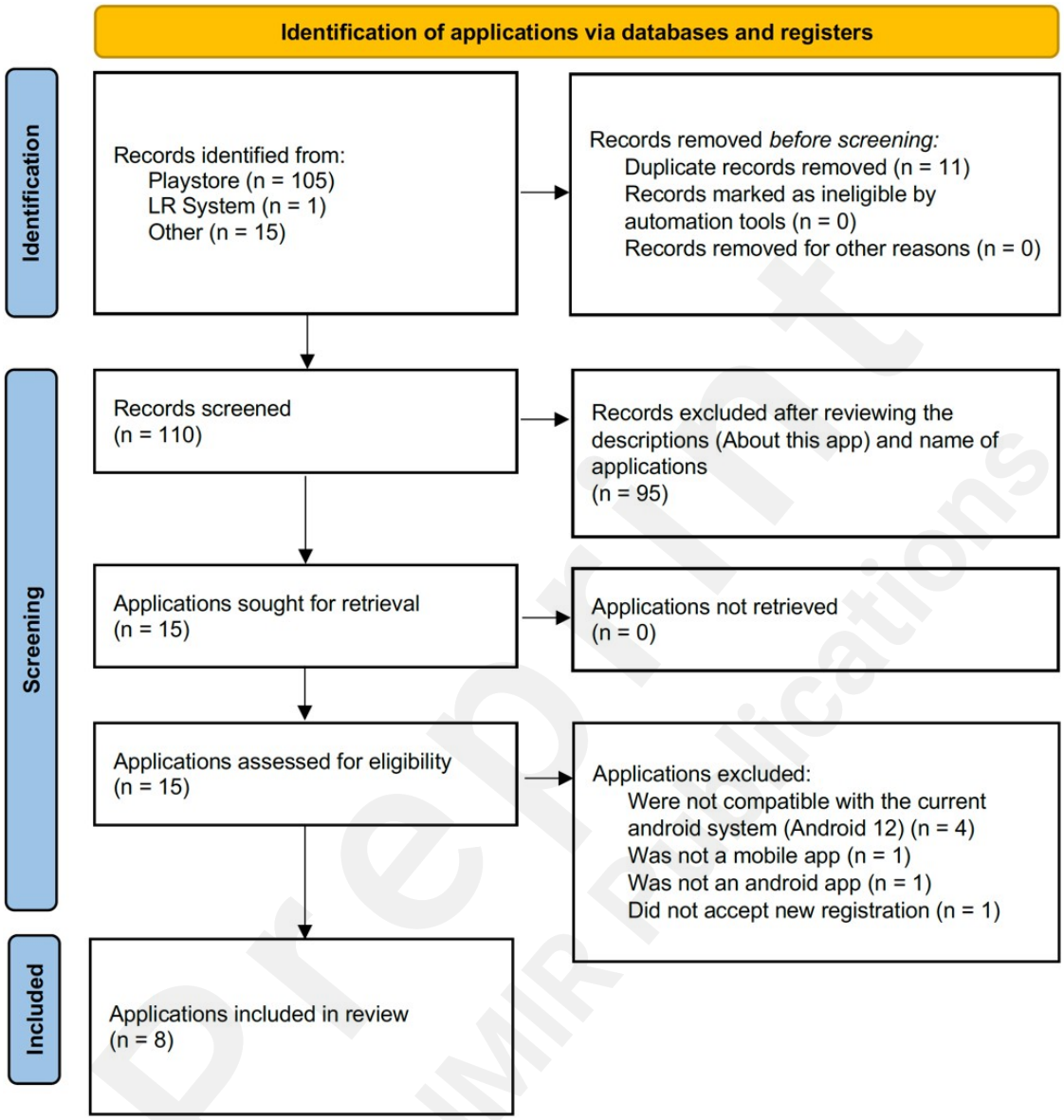


Figure 2. Selection of mHealth apps for review



Appendix 1. List of empirical studies included for literature review

1. Kwan, R. Y., Lee, D., Lee, P. H., Tse, M., Cheung, D. S., Thiamwong, L., & Choi, K. S. (2020). Effects of an mHealth brisk walking intervention on increasing physical activity in older people with cognitive frailty: pilot randomized controlled trial. JMIR mHealth and uHealth, 8(7), e16596.
2. Liu, J. Y. W., Sorwar, G., Rahman, M. S., & Hoque, M. R. (2023). The role of trust and habit in the adoption of mHealth by older adults in Hong Kong: a healthcare technology service acceptance (HTSA) model. BMC Geriatrics, 23(1), 73.
3. Kim, S., Chow, B. C., Park, S., & Liu, H. (2023). The Usage of Digital Health Technology among Older Adults in Hong Kong and the Role of Technology Readiness and eHealth Literacy: Path Analysis. Journal of Medical Internet Research, 25, e41915–e41915.
4. Wong, A. K. C., Wong, F. K. Y., Chow, K. K. S., Wong, S. M., Bayuo, J., & Ho, A. K. Y. (2022). Effect of a Mobile Health Application with Nurse Support on Quality of Life among Community-Dwelling Older Adults in Hong Kong: A Randomized Clinical Trial. JAMA Network Open, 5(11), E2241137–e2241137.
5. Kwan, R.Y.C., Ng, F., Lai, M. et al. (2023). The effects of Digital Buddy programme on older adults' mental well-being: study protocol for a multi- centre, cluster randomized controlled trial. Trials, 24 (95). https://doi.org/10.1186/s13063-023-07130-5
6. Wong, A. K. C., Bayuo, J., Wong, F. K. Y., Chow, K. K. S., Wong, S. M., & Lau, A. C. K. (2023). The Synergistic Effect of Nurse Proactive Phone Calls With an mHealth App Program on Sustaining App Usage: 3-Arm Randomized Controlled Trial. Journal of Medical Internet Research, 25, e43678–e43678.
7. Yang, C., Lai, D. W. L., Sun, Y., Ma, C.Y., & Chau, A. K. C. (2022). Mobile Application Use and Loneliness among Older Adults in the Digital Age: Insights from a Survey in Hong Kong during the COVID-19 Pandemic. International Journal of Environmental Research and Public Health, 19(13), 7656.
8. Lou, V. W., Cheng, C. Y., Ng, D. K., Chan, F. H., Mo, S. S., Kung, E. K., & Luk, J. K. (2023). A mHealth-Supported Volunteer-Assisted Spiritual Well-Being Intervention for Discharged Older Patients: A Tripartite Collaboration. Journal of Gerontological Social Work, 66(2), 189–207. https://doi-org.ezproxy.herts.ac.uk/10.1080/01634372.2022.2068722
9. Cheung, D. S. T., Or, C. K., So, M. K. P., Ho, K., & Tiwari, A. (2019). The Use of eHealth Applications in Hong Kong: Results of a Random-Digit Dialing Survey. Journal of Medical Systems, 43(9), 293. https://doi-org.ezproxy.herts.ac.uk/10.1007/s10916-019-1422-2
10. Song, Y., & Chen, H. (2021). Evaluating Chinese Mobile Health Apps for Ankylosing Spondylitis Management: Systematic App Search. JMIR MHealth and UHealth, 9(7), e27234. https://doi- org.ezproxy.herts.ac.uk/10.2196/27234
11. Yang, Q., Al Mamun, A., Hayat, N., Md Salleh, M. F., Salameh, A. A., & Makhbul, Z. K. M. (2022). Predicting the Mass Adoption of eDoctor Apps During COVID-19 in China Using Hybrid SEM-Neural Network Analysis. Frontiers in Public Health, 10, 88

Appendix 2. PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	p.1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	p.1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	p.3-4
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	p.4
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	p.4
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	p.4
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	N/A
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	p.5
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	p.5-6
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	p.5-6
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	p.5-6
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	p.5-6
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	N/A
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	p.5-6
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary	p.5-6

Section and Topic	Item #	Checklist item	Location where item is reported
		statistics, or data conversions.	
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	p.5-6
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	p.5-6
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	p.5-6
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	p.5-6
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	p.5-6
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	N/A
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	p.7-11
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	p.7-11
Study characteristics	17	Cite each included study and present its characteristics.	Table 2 & 4
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Table 6
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Appendix 3
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	p.7-11
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	p.7-11
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	p.7-11
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	Figure 2
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	N/A
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	p.11-12
	23b	Discuss any limitations of the evidence included in the review.	p.12-13
	23c	Discuss any limitations of the review processes used.	p.12-13
	23d	Discuss implications of the results for practice, policy, and future research.	p.12

Section and Topic	Item #	Checklist item	Location where item is reported
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	N/A
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	N/A
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Title page
Competing interests	26	Declare any competing interests of review authors.	Title page
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	N/A

Appendix 3. Summary of the key findings of the selected articles

No	Intext Citation	Origin	Purpose	Population and no. of participants	Research design	Intervention	Measurement	Outcomes
1	Kwan et al., 2020	Hong Kong	To identify the issues related to the feasibility of an mHealth intervention and the trial (ie, recruitment, retention, participation, and compliance) and to examine the effects of the intervention on cognitive function, physical frailty, walking time, and Moderate-to-vigorous physical activity (MVPA).	33 older adults were randomised into either the intervention group (n=16) or the control (n=17) group	Pilot Randomised Controlled Trial	Intervention group received both conventional behavior change intervention and mHealth (ie, smartphone-assisted program using Samsung Health and WhatsApp) interventions.	Cognitive Function: Montreal Cognitive Assessment (MoCA); Frailty was measured using the Fried Frailty Index (FFI); Walking was measured using a wrist-worn ActiGraph GT3X+; Physical activity was also measured using a wrist-worn ActiGraph GT3X+	After the interventions, cognitive function improvement was significant in both the intervention and the control groups. The increase in frailty reduction, walking time, step count, brisk walking time, peak cadence, and MVPA time were significant only in the intervention group.

2	Liu et al., 2023	Hong Kong	This study aims to understand key factors influencing mHealth use intention among the older Chinese population in Hong Kong	201 participants aged 65 or above	Survey	NA	Constructs include Performance Expectancy, Effort Expectancy , Facilitating Conditions, Hedonic Motivation, Social Influence, Price Value, Habit , Behavioral Intention, Service Quality, Trust	The findings show that trust is an important component of technology service acceptance intention behavior. Several antecedent factors (i.e., social influence, government policy, and service quality) are critical in forming technology trust beliefs

3	Kim et al., 2023	Hong Kong	The study aimed (1) to assess the current usage of digital health technologies (DHT) among older adults in Hong Kong and (2) to examine how high and low levels of eHealth literacy in this group affects the relationship between the Technology Readiness and Acceptance Model (TRAM) and attitudes and intention toward DHT	A total of 306 adults over 60 years of age in Hong Kong	Survey	N.A.	eHealth literacy scale; The technology readiness (TR) (eg, optimism, innovativeness, discomfort, and insecurity) scale; PU, PEU, and attitude toward using digital health technology (ATDHT)	Optimism was significantly related to perceived usefulness, while optimism, innovativeness, and discomfort were significantly associated with perceived ease of use. Both perceived usefulness and perceived ease of use were significantly linked to attitude toward the use of DHTs. Meanwhile, attitude significantly predicted usage intention. eHealth literacy encouraged older adults to use DHT and obtain health benefits from it

4	Wong, Wong, Chow, Wong et al., 2022	Hong Kong	To evaluate the effects of an interactive mHealth program supported by a health-social partnership team on quality of life (QOL) among community-dwelling older adults in Hong Kong	72 participants per group, ie, a total of 216 participants recruited from five community centre for older adults	A single-blinded, 3-group randomised clinical trial design	Participants in the mHealth+I group received the mHealth app and nurse case management supported by a health-social partnership team. The mHealth group received the mHealth app only. The control group received no mHealth app or health-social care services.	The 12-item Short Form Health Survey version 2–Chinese (HK) version; GeneralSelf-efficacy Scale; blood pressure; pain score; Geriatric Depression Scale; Health service utilization	At 3 months after the intervention and compared with the intervention group, there were no statistically significant differences in QoL scores Only self-efficacy, systolic blood pressure, pain levels and health services utilisation improved in the mHealth+1 group compared with the control group
5	Kwan, Ng, Lai, Wong, & Chan, 2023	Hong Kong	This study aims to evaluate the effectiveness of a Digital Buddy programme on the mental well-being, depressive symptoms, health-related quality of life, self-efficacy, and social support of older adults	292 older participants	A multi-centre, cluster-randomized, two-parallel-group, noninferiority , controlled trial design	A series of training sessions for a minimum of 23 h for older adults. The Digital Buddy will lead older adults to complete activity-based ICT tasks on their	The World Health Organization Five Well-being Index ; The 9-item Patient Health Questionnaire (PHQ-9); The 12-item Short Form Health Survey Version 2 (SF-12v2) ; The 10-item General Self-Efficacy Scale (GSES-10) ; The 12-item Multidimensional	Older people’s mental well-being may be improved through new components (i.e. promoting ICT skills and intergeneration mentorship)

						smartphones and answer questions they may have about smartphone usage.	Scale of Perceived Social Support (MSPSS-12) (WHO-5)	

6	Wong et al., 2023	Hong Kong	The study aimed to use a case management approach led by a nurse and supported by a health-social partnership team with the aim of sustaining app usage among community-dwelling older adults and evaluated the outcome differences (i.e, self-ef icacy, levels of depression, and total health service usages) between those who continued to use the app.	221 older adults	A 3-arm randomized controlled trial	mHealth (n=71), mHealth with interactivity (ie, received 8 proactive calls in 3 months from a nurse) (mHealth+I; n=74), and the control (n=76)	Chinese version of the General Self-Ef icacy Scale (GSES); Chinese version of the Geriatric Depression Scale; Total health service usages were evaluated using the participants' self-reports of the number of times in previous 3 months they had attended a general practitioner's clinic	The difference in app usage across the mHealth group and mHealth+1 groups between T2 and T3 was signiicant. Improvements in self-efficacy and depression levels from T1 to T3 were observed in the mHealth group participants who continued using the app.

7	Yang, Lai, Sun, Ma et al., 2022	Hong Kong	This paper examines the relationship between mobile app use and loneliness among Hong Kong's older adults during the pandemic	364 older adults	A questionnaire survey to assess the use frequency and duration of 14 mobile app types and levels of emotional and social loneliness	N.A.	The six-item De Jong Gierveld Loneliness Scale; frequency and duration were measured in using 14 types of mobile apps	The most frequently used apps included basic functions, instant communication, and information apps. Attitudinal factors, including the willingness to try and interest in new things, constitute an important aspect driving the intense use of mobile apps. In terms of use duration, video entertainment and instant communication ranked the top two. Instant communication apps are used for maintaining or expanding the contact with distanced relation. Physical barriers and competency factors (e.g., ICT self-efficacy) could be discouraging them from using mobile apps. ICT use is related to older adults' wellbeing and loneliness

8	Lou et al., 2023	Hong Kong	The present study aims to investigate the impact of an mVS intervention using a medical-social-academia tripartite collaboration on the spiritual well-being of discharged older patients.	137 older people	Quasi-experienmental design (2017-19)	theory-driven mobile health-supported volunteer-assisted self-help (mVS) intervention; volunteers assistant; mobile application Fu Le Man Xin □□ □□	Spiritual Scale for Chinese Elders (SSCE); Spiritual Enhancement Group for Chinese Elders (SEGCE)	Repeated measures ANOVA showed mVS inter- vention significantly enhanced two domains of SSCE: meaning of life ($F(1, 64) = 4.029$, $p = .049$) and relationship with others ($F(1, 57) = 6.428$, $p = .014$).

9	Cheung et al., 2019	Hong Kong	To explore the characteristics of eHealth applications in Hong Kong information and communication technology (ICT) users, their attitudes towards eHealth, and their reasons for not using eHealth applications	495 ICT users (163 of them aged 18-29 years, 190 of them aged 30-49 years, 142 of them aged 50+ years)	Cross-sectional telephone survey using random-digit dialing	NA	A 20-item questionnaire that covered three domains (characteristics of eHealth applications, attitudes towards eHealth, and sociodemographic characteristics)	A smartphone was the most frequent way of performing eHealth activities, followed by a computer and then a table. The most prevalent eHealth activity was reading about health/illness. eHealth applications could improve their understanding of health care issues. More than 65% of users indicated that they intended and planned to conduct eHealth activities. Eye fatigue associated with visual displays being the most prevalent reaon for not using eHealth application

10	Song & Cheng, 2021	China	The aim of this study was to identify existing, publicly available Chinese mHealth apps for ankylosing spondylitis (AS) management and to evaluate their features and quality.	354 mHealth apps screened on the Apple and Huawei App stores	Systematically searched potential mHealth apps	NA	NA	Of the 5 apps, 1 (20%) involved medical professionals in the development process, 2 (40%) were developed by companies, and 2 (40%) were developed by medical institutions. All apps provided educational information about AS. Around half of the apps had functions like a basic information record (ie, users can input gender, age, disease history, etc) (n=3, 60%), patient–health care provider (and patient-patient) communication (n=2, 40%), symptom tracking (n=2, 40%), and information sharing (n=3, 60%). Only 1 (20%) app provided comprehensive functions that adhered to international guidelines for AS management and mHealth apps. The overall uMARS scores ranged from 2.7 to 4.2; only 1 app, with an overall Mobile App Rating Scale (uMARS) score of 4.2, was considered as a high-quality app.
11	Yang,		this study aimed to	961 Chinese	Survey	NA	46 measurement items	The results revealed the

	Al Mamun, Hayat, Md Salleh et al., 2022		examine the effects of health consciousness (HCS), health motivation (HMO), perceived compatibility (PCT), perceived critical mass (PCM), perceived usefulness (PUS), perceived technology accuracy (PTA), and perceived privacy protection (PPP) on users' intention to use eDoctor apps (ITU) and adoption of eDoctor apps (ADT)	older adults: 69.4% of the total respondents were between 20 and 30 years old, followed by the age groups of 31–40 years old (20%), 41–50 years old (5.3%), and 51–60 years old (4.3%). The other 1.0% of the total respondents were above 60 years old			measuring HCS, HMO (55, 56), PCT (57), PCM (57),PUS, PTA, PPP, PPV, ITU, and ADT	significant influence of eDoctor apps in terms of usefulness, compatibility, accuracy, and privacy on users' intention to use eDoctor apps. Intention and product value were also found to suggestively promote the adoption of eDoctor apps. Developers of eHealth apps need to make every attempt of informing and building awareness to nurture users' intention and usage of healthcare technology. Users' weak health consciousness and motivation are notable barriers that restrict their intention and adoption of the apps