Frontiers of Nursing • 9(3) • 2022
DOI: 10.2478/FON-2022-0029

sciendo

Frontiers of **Nursing**

Mobile medical applications' state quo and underlying barriers: review of literature†

Review

Ting-Ting Zhou, Jia-Yi Mao, Li-Ling Xie*, Qing-Hua Zhao, Yu-Lu Chen

Department of Nursing. The First Affiliated Hospital of Chongqing Medical University, Chongqing 400016, China

Received: 8 April 2022; Accepted: 17 May 2022; Published: 20 September 2022

Abstract: **Objective:** To explore the current development and challenges regarding mobile medical applications (mmAPPs), so as to provide reference for application function elevation and quality improvement.
Methods: We retrieved literature databases like Web of Science, PubMed, China National Knowledge Infrastructure, Wanfang, China Biomedical Network, time limit was from January 1, 2010 to December 31, 2021, and restricted to the Chinese or English language.
Results: This study concluded with the following six aspects: Domestic and foreign development of mmAPP, reminder function, barriers and challenges (low quality; slow update rate; lack of standard evaluation tool or criterion), privacy and safety concerns, adverse drug event report state (low report rate-related reasons, different countries' report policies), and current hindrances in the progression (economic worries; personal education level; acceptance and study of technology; rural districts, and low-income countries).
Conclusions: We should focus on the application's quality elevation rather than quantity, pay more attention to patients' adverse drug event reports, privacy and safety, and place emphasis on rural districts and low-income countries.

Keywords: *applications • chronic disease • community health service • mobile health units • review*

© Shanxi Medical Periodical Press Co., Ltd.

1. Introduction

Along with the rapid development of the Chinese aging society, the mobile and health digital market has expanded tremendously. There are numerous mobile medical applications (mmAPPs) on the Internet market that help the elderly to take medications regularly. The major functions of these applications are focused on medication reminder, self-diagnosis, wellness management, and so on.[1,2] The majority of (78%) users are chronic patients who have accompanying degenerative memory, polypharmacy, and comorbidity. Admittedly, they are a high-risk population and any medication error would lead to fragility, high re-hospitalization rate, increased economic

† This project was supported by the Joint Medical project of Chongqing Science and Technology Commission (No. 2020MSXM077) and the Nursing Development project of Chinese Medical Association (No. CMAPH-NRD2021004).

How to cite this article: Zhou TT, Mao JY, Xie LL, Zhao QH, Chen YL. Mobile medical applications' state quo and underlying barriers: review of literature. *Front Nurs*. 2022;3:241–246.

* *Corresponding author.*
E-mail: 582570124@qq.com (L. -L. Xie).

Open Access. © 2022 Zhou et al., published by Sciendo. This work is licensed under the Creative Commons Attribution 4.0 License.

cost, and even disability or death.[3–5] Recent studies have proved that the mmAPP can elevate patients' medication adherence, strengthen self-effectiveness, and improve quality of life significantly.[6] So we aim to explore the current development and challenges in mmAPP, so as to provide references for the elevation and quality improvement of the application's functions.

2. Methods

The studies enrolled in this review were retrieved from the following databases: Web of Science (13), PubMed (18), China National Knowledge Infrastructure (48), Wangfang (42), and China Biomedical Network (17). The search strategy was completed using a combination of the following search terms: *mobile medical application*, mobile health application*, smartphone application*, research progress, review.* Study was searched by "keywords" or "theme word". The search time was limited from January 1, 2010 to December 31, 2021, and was restricted to the Chinese or English language.

3. Results

3.1. Domestic and foreign development of mmAPP

Studies abroad have shown that there are currently 165,000 (free and paid) health apps in 46 major apps stores around the world, categorized into Health Management apps (fitness, nutrition, weight loss, lifestyle adjustments) and Disease Management apps (diabetes, cardiovascular disease, mental health); the latter functions include self-diagnosis, medication reminder, medication therapy, and rehabilitation exercise.[1] Among them, the most popular apps are medication reminder apps, followed by medical contact apps and symptom tracking apps.[7] Domestic scholars are also focused on the emerging fields; for example, Peng et al.[8] has invented the Smart Medication Management System (including smart pill box and mini program of WeChat) based on the Internet and big data. It has been used in long-term care facilities and has shown a significant consequence on elevating the medication adherence ($Z = 2.085$, $P < 0.05$). Chen[9] designed a smart medical box based on co-design (or collaborative design), which respectively include designers, users, and other stakeholders involved in the medical box. These apps convey medical solutions based on wireless mobile networks, providing educational support, medication tracking, and remote consultation. Intelligent apps at home and abroad both empower patients and facilitate their self-management. As an auxiliary resort to doctors' intervention, they encourage more patients to participate in medical decision-making, thereby improving the disease control capability.[10] On the other side, apps increase the communication between patients and their doctors or care team, and are a relatively cheap, affordable, and apply convenient technology that relies on existing mobile networks to remotely monitor patients who are difficult to contact or require strict monitoring. Apps also have the potential to improve the control of risk factors and health conditions, especially for patients with chronic diseases such as arterial hypertension,[6] diabetes,[11] heart failure,[12] etc.

3.2. Reminder function of mmAPP

Medication noncompliance has been a common health care challenge. Poor adherence causes approximately 33%–69% of medication-related hospitalization and accounts for US$100 billion in annual health care cost.[13] The average adherence rate to chronic medication therapy is approximately 50%.[14] One of the functions of mmAPP is medication reminder; it includes 2 other functions: (1) Daily reminder, which can be paused, rescheduled, and (or) marked as "taken" or "not taken" doses; (2) Default setting, that is, periodic reminder every 10 min, up to three times; and (3) Other functions, such as medication supplement reminders, adherence statistics, export functions, and the ability to share information with others, as well as the ability to be reminded by others (e.g. family members) when participants forget to take medication. It can voice "Ding" to remind patients to take drugs by a settled down planned time. It allows patients to enter their medication list manually or by scanning the barcode on the prescription bottles, provides a visualized medication calendar, and automatically sends notification to patients when they are due for medication doses. For example, it can remind you to take medicine before lunchtime, if you take gastric mucosa protectant aluminum hydroxide. Especially for low-adherence chronic patients, it means a lot. Low adherence causes aggravated financial burden due to unsafe behavior of taking medication.[13] On average, 1 in 6 people need to be reminded of taking medication.[3] Therefore, medication reminder is in great demand. A majority of the users (68%) affirmed with the medication reminder,[15] whereas some complained that it did not work as they wished, and that the efficiency and utility needed more research. Considering users' requirement and personal preference, designers should meet their needs as closely as possible.

3.3. mmAPP barriers and challenges

By the end of 2020, there was a retrieval of 3.25 million mmAPPs in common Applications Stores (Android and

Apple); it had increased to a full 50% more than 10 years ago.[8] Data show that the customer pays more attention to acquiring and exchanging health information. Unfortunately, less than 3% of mmAPPs are invented by professional medical institutions,[7] and medical data that refer to patient safety lacks authorization and approval.[1] What is more, although mmAPP is quickly emerging, there are still some barriers including (1) Low quality of mmAPP:[16] to be more specific, low quality refers to font size that is too small to read, voice is too small to hear, and the user interface is too complicated. Morawski et al.'s[6] research represented that 65.6% patients hoped to enlarge the font, bold the font, and increase the volume. If mmAPP makes an adaptive change, it would be preferable for degenerative hearing and vision patients; (2) Slow update rate: it represented insufficient scientific data, and was deficient in rigorous calculation, especially lack of high-quality best practice based on evidence.[17] So far, the most significant and active evidence are focused only on type 2 diabetes, cardiovascular system, and obesity. Nowadays, we have not retrieved any clinical practical study above intelligent mmAPP, it does not produce any available clinical data yet.[17] Therefore, we suggest adding more high-quality evidence on the application to enrich the content. However, there is a giant challenge that the high-quality evidence needs at least 3–5 years' clinical randomized control trial, which is far behind the APP's update rate. How to make high-quality evidence at the same pace as the APP update rate is a critical problem waiting to be solved urgently; (3) Lack of a standard evaluation tool or criterion:[18] early in 2016, the U.S. Food Drug Administration (FDA)[19] authorized a company named Social Wealth to proceed with certification approval and a quality control of 328 mmAPPs. Even today, a number of countries and regions still have not build a general, standard criterion for mmAPPs. Thus, we hope that the government departments, third-party entrepreneurs, and professional groups should construct a standard and systematic method to evaluate the APP's utility and effectiveness.

3.4. Privacy and safety concern

Sunyaev et al.[20] have shown that among the 600 most used applications, only 183 (30.5%) made a privacy protect policy, while two-thirds of the applications did not specially design a privacy protect policy. Bitglass[21] (a technology company to provide safety service) medical safety report claims that in 2016, in the United States, over 111 million of personal data were lost due to hacker attacks or other reasons. Each lost or stolen medical record resulted in an average loss of US$ 363. The National Health Service (NHS)[22] randomly examined 79 mmAPPs and found that none of them stored personal information on mobile devices in an encrypted way. As high as 66% of applications failed to protect and encrypt users' data. In my perspective, it is a tremendous potential threat for digital data safety and privacy based on the Web and Internet methods. Several studies and reports[20] have shown that the majority of mmAPP developers currently fail to provide privacy policies for their applications. Users have expressed concern and worry about the safety and effectiveness of mmAPP. More than 50% of users choose to unload or uninstall applications for fear security of their personal information,[7] and call for stricter scrutiny on the privacy and security of mmAPP. Consequently, we suggest strengthening the protection of users' personal information and privacy guidance. We call for relevant departments to implement the privacy protection policies of mmAPP for users' personal information, and impose certain economic penalties on applications that illegally embezzle personal information. Application developers should guarantee the security of applications, and ensure rigorous testing prior to releasing, in order to reduce the underlying system vulnerability such as data storage, information encryption, and identification verification.

3.5. Adverse drug events report current state

3.5.1. Low report rate-related reasons

Chronic disease patients due to accompanying polypharmacy and comorbidity are a high-risk population of adverse drug event (ADE). The specific association of ADE is over-dosage, under-dosage, missed dosage, and wrong dosage. When ADE happens, it would worsen the patient's original disease condition, decrease lifespan expectancy, aggravate medical cost, and cause potential damage to the body.[18,23] Thus, attaching more importance to the ADE report is extremely important; however, currently the ADE report is mainly focused on medical staff and less than 3% of ADE is reported by the patient.[24] Lower ADE report on willing patients may be due to the following: (1) Less communication between doctors and patients;[25] patients are afraid of bothering doctors or are blamed when they encounter professional terminology, and do not know how to answer; patients' low willing report is usually influenced by the doctor's negative attitude. (2) Attach less importance to ADE; patients usually think that it does not exert any influence, whether they report or not. Medical staff always ignores and does not take it seriously. (3) Processing result is not ideal; patients hope to obtain some feedback when they submit the ADE report, such as submitting successfully or not, how many people submit the same question, and the processed consequence feedback.[26] We hope to find the root reasons that lead

to low report, making some rules or measures from the aspects of spiritual encouragement and material reward to elevate patient report enthusiasm.

3.5.2. Different countries' report policies

Reporting ADE and "Near Miss" events were seen as important measures to prevent medication errors. These events usually include valuable information that can be used to prevent ADE from happening. The Organization for Economic Co-operation and Development (OECD)[27] has suggested that the ADE report should be transferred from medical staff to patients; patients are located at the priority of the pyramid when making sure of medication safety. Encouraging patient-reported ADE does not need enormous financial cost and human resource; at the same time, it represents excellent value orientation. If it works well, it can greatly reduce 15% of the harm and economic burden, saving millions of dollars each year.[28] Japan Medical and Device Administration (JMDA)[29] built a spontaneous report system, called the Japan Adverse Drug Event Report (JADER). It is a database to evaluate the potential adverse effects of medication. In 2015, the United Kingdom[27] implemented online reports in primary health care units. Adopting the anonymous report method by medical staff and patients, over 36 million adverse events were counseled each year. The community has the responsibility to report ADE, and necessarily conduct a compulsory report for severe ADE. Mexico's[30] ADE is moving forward to a National Systematic Registry. Elevating the ADE report system made it more intelligent and informational. Sweden[31] has mainly concentrated on long-care facilities to conduct the ADE report, which has transferred from the hospital and asylum for lunatics to the home and community gradually. In conclusion, worldwide, the ADE report performed an uprising trend; China should take the step forward and discard the dregs, building a systematic ADE report database that is patient-oriented.

4. Discussion

Although mmAPP has developed very well and almost 50% of smart phone users download at least 1 mmAPP, there are still some hinders to block mmAPP generalization.[8] (1) Economic worries: although 75% mmAPP are free to users, only a proportion of extra functions need to be paid for, such as more advanced consulting and better services.[32] In some areas of the world, the burden ability of mobile Internet technology is still one of the greatest hinders for consumers. (2) Personal education level: different education levels determine different acceptance and using frequency. Studies have shown that persons with higher education prefer to use mobile applications than those less educated. However, on average 80% of users' education level is below middle school.[33] (3) Acceptance and study of technology: owing to users' average age being over 70 years, applying smart phone and applications may be a little difficult for them, and it is also difficult for them to adopt and use it frequently like the younger generation.[34] (4) Rural districts and low-income countries: although the popular coverage of 4G technology increased from 75% to 95% recently, it is still limited in rural areas and remote regions. Especially in low-income countries and rural areas, due to lack of acquiring and using capability of technology, some proportion of the population still cannot connect with the Internet; content distribution and the service visit has always been restricted due to language barriers, therefore some applications and content are only shown in the local languages. From a researcher's point of view, mmApp has met with an era of high-speed development, but also filled with potential barriers and challenges. Only if the underlying hinders can be swept out, can mmApp realize large-scale coverage.

5. Conclusions

The literature review of the mmAPP and its current state and challenges have been analyzed from the following 6 aspects: domestic and foreign development of mmAPP, reminder function, barriers and challenges, privacy and safety concerns, ADE report, and mmAPP's hinders in progression. There is still plenty of room for improvement and we should focus on quality elevation rather than quantity. What is more, we should pay more attention to patient-reported ADEs, privacy, and safety and place emphasis on rural areas and low-income countries, which still confront with difficulties in applying the mmAPP.

Acknowledgement

Thanks are given to Prof. XIE's assistance and guidance, and to Nurse Li and Nurse MAO's help during data collection. The authors also grateful to Mrs. HE and other medical staff in the community health care center.

Ethical approval

This study was approved by the ethics committee of the First Affiliated Hospital of Chongqing Medical University (IRB approval number: 2020-837).

Conflicts of interest

All contributing authors declare no conflicts of interest.

References

1. Kao CK, Liebovitz DM. Consumer mobile health apps: Current state, barriers, and future directions. *PM R*. 2017;9:S106–S115.
2. Daifi C, Bahrami S, Kaakeh R, Kaakeh Y. Evolving frontier: A review of the role of mobile medical application prescribing. *J Pharm Technol*. 2016;32:91–97.
3. Panozzo G. An intervention to reduce medication noncompliance and hospitalizations. *Home Healthc Now.* 2018;36:34–42.
4. Zelko E, Klemenc-Ketis Z, Tusek-Bunc K. Medication adherence in elderly with polypharmacy living at home: A systematic review of existing studies. *Mater Sociomed.* 2016;28:129–132.
5. Bieri M, del Río Carral M, Santiago-Delefosse M, et al. Beliefs about polypharmacy among home-dwelling older adults living with multiple chronic conditions, informal caregivers and healthcare professionals: A qualitative study. *Healthcare (Basel)*. 2021;9:1204.
6. Morawski K, Ghazinouri R, Krumme A, et al. Association of a smartphone application with medication adherence and blood pressure control: The MedISAFE-BP randomized clinical trial. *JAMA Intern Med*. 2018;178:802–809.
7. Tabi K, Randhawa AS, Choi F, et al. Mobile apps for medication management: Review and analysis. *JMIR Mhealth Uhealth*. 2019;7:e13608.
8. Peng YH, Xie LL, Liang Y, et al. Application of intelligent drug management system in elderly care institutions. *Chin J Nurs.* 2021;56:680–686 (in Chinese).
9. Chen RB. *Design and Development of Elderly Intelligent Medicine Box based on Co-design*. Beijing: Beijing University of Posts and Telecommunications; 2019. (in Chinese).
10. Omboni S. Connected health in hypertension management. *Front Cardiovasc Med*. 2019;6:76.
11. Agarwal P, Mukerji G, Desveaux L, et al. Mobile app for improved self-management of type 2 diabetes: Multicenter pragmatic randomized controlled trial. *JMIR Mhealth Uhealth*. 2019;7:e10321.
12. Santo K, Kirkendall S, Laba TL, et al. Interventions to improve medication adherence in coronary disease patients: A systematic review and meta-analysis of randomised controlled trials. *Eur J Prev Cardiol.* 2016;23:1065–1076.
13. Haase J, Farris KB, Dorsch MP. Mobile applications to improve medication adherence. *Telemed J E Health*. 2017;23:75–79.
14. Murray MD, Kroenke K. Polypharmacy and medication adherence: Small steps on a long road. *J Gen Intern Med.* 2001;16:137–139.
15. Patton DE, Hughes CM, Cadogan CA, Ryan CA. Theory-based interventions to improve medication adherence in older adults prescribed polypharmacy: A systematic review. *Drugs Aging.* 2017;34: 97–113.
16. Santo K, Singleton A, Rogers K, et al. Medication reminder applications to improve adherence in coronary heart disease: A randomised clinical trial. *Heart*. 2019;105:323–329.
17. Patient Adoption of mHealth. IMS Health. http://www.imshealth.com/en/thought-leadership/ims-institute/reports/patient-adoption-of-mhealth. Published August 23, 2016. Accessed September 25, 2020.
18. Fallah M, Yasini M. A medication reminder mobile app: Does it work for different age ranges. *Stud Health Technol Inform*. 2017;235:68–72.
19. Mobile Medical Applications Guidance for Industry and Food and Drug Administration Staff. http://www.fda.gov/downloads/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/UCM263366.pdf. Accessed October 9, 2020.
20. Sunyaev A, Dehling T, Taylor PL, Mandl KD. Availability and quality of mobile health app privacy policies. *J Am Med Inform Assoc*. 2015;22:e28–e33.
21. Bitglass Healthcare Breach Report 2016. https://pages.bitglass.com/Healthcare-Breach-Report-2016.html. Accessed December 21, 2020.
22. NHS Health Apps Library Closing Amid Questions about App Security & Quality. October 2015. http://www.imedicalapps.com/2015/10/nhs-health-apps-library-closing-commentary/. Accessed October 10, 2020.
23. Foreman KJ, Marquez N, Dolgert A, et al. Forecasting life expectancy, years of life lost, and all-cause and causespecific mortality for 250 causes of death: Reference and alternative scenarios for 2016-40 for 195 countries and territories. *Lancet*. 2018;392:2052–2090.
24. Abe J, Umetsu R, Uranishi H, et al. Analysis of polypharmacy effects in older patients using Japanese adverse drug event report database. *PLoS One*. 2017;12:e0190102.
25. Al Dweik R, Yaya S, Stacey D, Kohen D. Patients' experiences on adverse drug reactions

reporting: A qualitative study. *Eur J Clin Pharmacol*. 2020;76:1723–1730.
26. de Vries ST, Wong L, Sutcliffe A, et al. Factors influencing the use of a mobile app for reporting adverse drug reactions and receiving safety information: A qualitative study. *Drug Saf.* 2017;40:443–455.
27. Organisation for Economic Co-operation and Development. The economics of patient safety in primary and ambulatory care: Flying blind; 2018. http://www.oecd.org/els/health-systems/health-working-papers.htm. Accessed October 10, 2020.
28. Kim JM, Suarez-Cuervo C, Berger Z, et al. Evaluation of patient and family engagement strategies to improve medication safety. *Patient*. 2018;11:193–206.
29. Chisaki Y, Aoji S, Yano Y. Analysis of adverse drug reaction risk in elderly patients using the Japanese Adverse Drug Event Report (JADER) Database. *Biol Pharm Bull*. 2017;40:824–829.
30. Terblanche A, Meyer JC, Godman B, Summers RS. Knowledge, attitudes and perspective on adverse drug reaction reporting in a public sector hospital in South Africa: Baseline analysis. *Hosp Pract* (1995). 2017;45:238–245.
31. Noguchi Y, Ueno A, Otsubo M, et al. A simple method for exploring adverse drug events in patients with different primary diseases using spontaneous reporting system. *BMC Bioinformatics.* 2018;19:124.
32. Shade M, Boron J, Manley N, Kupzyk K, Pullen C. Ease of use and usefulness of medication reminder apps among rural aging adults. *J Community Health Nurs.* 2019;36:105–114.
33. Khafagy R, Gibson P, Reniers D, Patel S. Assessing parents' needs in using phone applications to improve medication adherence in an outpatient pediatric oncology clinic. *J Pediatr Hematol Oncol*. 2020;42:e277–e280.
34. Liu JF, Lee JM, Strock E, et al. Technology applications: Use of digital health technology to enable drug development. *JCO Clin Cancer Inform*. 2018;2:1–12.