

Application Progress of Smart Phone Applications in Continuous Care of Stroke Patients

Ying Yang^{1,a}, Haiyun Gai^{2,b,*}

¹Nursing Department, Shaanxi University of Chinese Medicine, Xianyang, Shaanxi, 712000, China

²School of Nursing, Health Science Center, Xi'an Jiaotong University, Xi'an, Shaanxi, 710048, China

^a250126897@qq.com, ^b1240344082@qq.com

*Corresponding author: Haiyun Gai

Abstract: With the rapid development of information technology, mobile healthcare has become a hot topic of widespread concern among scholars at home and abroad. Applying smartphone applications to the continuous care of stroke patients can improve their self-management level, significantly improve their quality of life, and also promote the effective utilization of nursing resources. This article provides a review of the demand for smartphone applications in the continuous care of stroke patients, as well as the current application status at home and abroad. By drawing on foreign research results, it analyzes the main problems currently faced in China and makes prospects for the future development of the program, with the aim of providing reference and reference for Chinese medical staff in future research and application.

Keywords: stroke; transitional care; smart phone application; review

Stroke is the second leading cause of death globally [1-2] and has become an increasingly serious global public health problem. After investigation, there are 345.1/10 million new cases of stroke in China every year [3], with about 70% of survivors remaining with varying degrees of dysfunction [4], bringing a heavy burden to families and society. Related studies have shown that stroke patients have a recovery period of 2 weeks to 6 months after onset, which is a critical period for functional rehabilitation training. However, due to limitations in medical and health resources, shortened average hospital stays, and the vast majority of patients being forced to discontinue treatment after discharge [5-7]. The American Geriatric Association defines continuing care as a series of activities designed to ensure that patients receive coordinated and continuous health care services from the hospital to their homes and different departments within the hospital [8]. Therefore, carrying out continuous care has become an inevitable trend [9-10]. In recent years, the rapid development of mobile internet technology has played an important role in solving the complexity and diversity of current medical and health problems, especially the emergence of smart phone applications (APPs), which have received widespread attention from scholars at home and abroad due to their ability to provide intelligent and personalized services, as well as advantages such as simple operation, portability, and precise positioning [11]. This study focuses on the demand, domestic and international application status, existing problems, and prospects of smartphone apps in the continuous care of stroke patients, in order to provide reference for future research.

1. The demand for smartphone apps in continuous care for stroke patients

Home-based stroke patients lack stroke knowledge and skills, which seriously affects rehabilitation outcomes. Therefore, the demand for home-based care is very urgent. Huang Tianrong et al. [12] conducted a survey on the needs of 92 stroke patients for continuous service mobile apps, and the results showed that 55.4% of patients were willing to obtain disease knowledge and remote guidance through smartphone apps. The survey results of Shen Binyan [13] on 444 stroke patients showed that the highest score for patients' demand for continuous care apps was disease health education, followed by rehabilitation guidance, complication care, and life care. The "Care for Stroke APP" developed by Sureshkumar et al. [14] found that 95% of stroke patients and all caregivers expressed complete acceptance when investigating acceptability. Meanwhile, Kamalakannan et al. [15] found that 82% of stroke patients and 92% of caregivers both expressed a significant need for stroke knowledge. In addition, a survey by Zhang Huixia et al. [16] showed that specialized care has also become an urgent need for post-stroke patients. With the rapid development of mobile internet technology, the application

of smartphone apps in the continuous care of stroke patients has become a new trend, which can overcome time and space constraints, alleviate the shortage of medical resources, and meet the diversified needs of stroke patients for remote health management services and functions. Therefore, it is imperative to promote the continuous care model of developing smart phone apps.

2. The Application Status of Smartphone APP in Continuous Care of Stroke Patients at Home and Abroad

2.1 Secondary prevention

It is crucial for home rehabilitation patients to master effective stroke prevention knowledge, which can reduce their readmission rate. The "Farmalarm APP" developed by Requena et al.^[17] enhances patients' disease risk awareness through functions such as medication reminder, compliance control, and exercise monitoring. After 3 months, the intervention group had a higher understanding of vascular risk factors than the control group. Research has shown that the APP can significantly improve stroke patients' understanding of vascular risk factors and treatment compliance, especially in improving their understanding of healthy lifestyle changes. The mobile health app developed by Kim et al.^[18] in South Korea provides health education programs and extensive information about stroke patients to increase their awareness of symptoms and risk factors, thereby improving drug compliance. Fruhwirth et al.^[19-20] investigated the control of secondary stroke risk factors based on mobile phone APP, and the results showed that the control of hypertension, diabetes, lack of exercise, obesity and other risk factors of patients had significantly improved. Mobile apps, due to their widespread availability, near real-time responsiveness, and relatively low cost, are feasible as a beneficial tool for patients to prevent secondary stroke.

2.2 Rehabilitation guidance

The smartphone app is a portable rehabilitation system with precise, fast, and real-time interactions that can increase user engagement and make their behavior more routine. The "mRehab APP" developed by Bhattacharjya et al.^[21], combined with 3D printing functional objects, mainly supports self-management of upper limb rehabilitation for stroke patients with sensory disorders at home. It can accurately quantify motor quality and provide feedback to enhance flexibility in rehabilitation and functional improvement. The "S3 APP" developed by Zhang et al.^[22] includes three versions: the S3 Stroke Survivor APP, the S3 Caregiver APP, and the S3 Rehabilitation APP. The characteristic of the S3 rehabilitation app is to screen suitable exercise items for patients, while using sensors to accurately record the patient's range, type, and intensity of movement, in order to develop a more reasonable rehabilitation plan for them. It can be seen that sensors based on smartphones can accurately record the range of motion, quantify the quality of motion, and improve functionality, but it is necessary to consider issues such as the patient's device function, self-condition, and safety.

2.3 Quality of Life

The loss of self-care ability in stroke patients seriously affects their exercise compliance and quality of life. The "Rehabilitation Guardian" APP developed by Zhang Weifeng et al.^[23] provides four functional modules, namely, patient diary, question consultation, health information and health reminder. After three months of implementation, patients' motor function scores and self-efficacy scores are higher than those of the control group, and the scores of various dimensions of quality of life and blood cholesterol control behavior of the intervention group are significantly better than those of the control group, with statistically significant differences. In future research, the sample size should be expanded and further attention should be paid to the long-term intervention efficacy. The study by Yao Hui et al.^[24] on improving the quality of life of stroke patients based on mobile apps showed that the self-care ability and daily living self-care ability scores of mild to moderate patients were significantly improved. This study only included mild to moderate patients and did not include severe patients. We look forward to the next step of expanding the sample size, stacking software functions, and conducting more in-depth follow-up studies to bring good results to severe stroke patients.

2.4 Information management

In home rehabilitation, it is crucial for therapists to track patients' rehabilitation needs in real-time.

The "Post Soft Care App" developed by De et al. [25] is used to manage survey questionnaires for post stroke patients, extract questionnaire information, and help therapists monitor the needs of chronic stroke patients in order to make timely treatment decisions. The results show that therapists highly recognize and evaluate their content as rich, practical, accurate, and fast, which is conducive to communication and the acquisition of big data. Reminder: The app is presented in a diverse form of content, which can save manpower and resources, be efficient and convenient, and promote research and development.

2.5 Medication monitoring and emotional management

Post stroke depression and poor medication adherence are commonly present in home rehabilitation patients. The app can monitor, remind, and provide feedback in real time to improve patients' self-management of medication and disease detection rate. The "S3-APP" developed by Zhang et al. [22] has an innovative visual tracker that can monitor medication compliance, dosage, and record international standard ratios to be monitored when using anticoagulants in real-time, and provide medication guidelines. At the same time, it can provide stroke patients with self-evaluation of daily emotions, which is used to improve the detection rate of psychological problems such as depression and inferiority after stroke, allowing patients to self-regulate their emotions and improve their emotional management ability. Although emotions and psychological states can be evaluated, there are still obstacles to conducting psychological intervention, indicating that research on psychological intervention should be strengthened in the future.

2.6 Symptom management

Stroke patients often suffer from complications such as swallowing and cognitive impairment, which seriously affect their physiological and social functions. The symptom management APP developed by Liu Huahua et al. [26] is used to manage symptoms such as dysphagia, deep vein thrombosis and urinary incontinence after stroke. First, risk assessment of signs is carried out, and then linked to the corresponding relevant nursing courses to guide learning. Nurses answer questions online in real time. The results showed that the patients' swallowing function was improved, the incidence of deep vein thrombosis was significantly reduced, and the urinary incontinence score was lower than that at admission. The cognitive function rehabilitation training app developed by Yao Ti et al. [27] showed a statistically significant difference ($P < 0.05$) in the scores of the Mini Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA) between the two groups of patients after 3 and 12 months of intervention. Over time, the observation group showed a significant upward trend compared to the control group. From the above, it can be seen that the application of APP can significantly improve the concurrent symptoms after stroke. However, there is currently relatively little research on related applications, so it is advocated to vigorously promote research and development.

3. The problems of smartphone apps in continuous care of stroke patients

3.1 Insufficient download volume

The majority of stroke patients are middle-aged and elderly, with poor acceptance and awareness rates. Studies have shown that 62.5% of app downloads are less than 1000 times, and 32.45% of the population have not heard of or used related apps [28-30]. In addition, due to the limitations of patient devices or physical conditions on the application of smartphones [31], the above will affect the use and promotion of the APP.

3.2 Lack of involvement of medical institutions in software development

The participation of medical institutions in the development and design of APP will directly affect the popularity, reliability, and patient satisfaction of the application. Research has found [32] that only 21.3% of stroke related apps interact online with health professionals, 23% of mobile health markets are non-healthcare institutions, and only 47.3% of stroke related apps developed by health professionals. So it is necessary for health professionals to participate in the development and design of the app.

3.3 Single functional design

Although the number of apps developed in China is gradually increasing, their functions are limited and limited, only limited to light functions such as health education, SMS reminders, symptom management, and rehabilitation guidance. However, the functional needs of online interaction, voice assistance, and psychological intervention urgently need to be met^[31,33].

3.4 Lack of authoritative quality evaluation tools

At present, most evaluation tools are mostly concentrated in foreign countries^[34-35], lacking targeted and localized quality evaluation tools for stroke continuing care apps. In order to better evaluate the quality of the stroke continuity care app and promote its vigorous promotion, it is necessary to construct an authoritative and objective APP quality evaluation tool suitable for home rehabilitation patients in China.

3.5 There are safety hazards

As an important carrier of healthcare, smartphone apps carry the privacy of tens of thousands of users, and relevant policies and regulations still need to be improved. Therefore, in order to strengthen user trust, mobile health management service providers should regulate the collection and use of information, develop and implement strict privacy protection mechanisms, and minimize user privacy concerns to the greatest extent^[36].

4. Look into the distance

With the rapid development of mobile health technology, smartphone apps, as a tool for continuous care of stroke patients, have shown positive effects in symptom management, health education, disease monitoring, and improving quality of life. They also have important economic value and social significance in stroke disease management. However, its development is still slow and has not been widely promoted and applied. It is recommended to expand the scope of application in future research, add online interactive functions, voice reading and voice input functions, and carry out online psychological intervention and develop APP quality evaluation tools to better serve the field of stroke continuous care through smartphone apps.

References

- [1] Benjamin Ej, Blaha Mj, Chiuvse Se, et al. Heart Disease and Stroke Statistics-2017 Update: A Report From the American Heart Association[J]. *Circulation*, 2017, 135(10):e146.
- [2] Hu Shengshou, Gao Runlin, Liu Lisheng, et al. Summary of China Cardiovascular Disease Report 2018 [J]. *Chinese Journal of Circulation*, 2019, 34 (03): 209
- [3] Wang W, Jiang B, Sun H, et al. Prevalence, Incidence, and Mortality of Stroke in China: Results from a Nationwide Population-Based Survey of 480 687 Adults[J]. *Circulation*, 2017, 135(8): 759.
- [4] Feigin VI, Forouzanfar Mh, Krishnamurthi R, et al. Global and regional burden of stroke during 1990-2010: findings from the Global Burden of Disease Study 2010[J]. *Lancet*, 2014, 383(9913): 245.
- [5] Gao Changyu, Wu Chenghan, Zhao Jianguo, et al. Guidelines for the Diagnosis and Treatment of Cerebral Infarction in China (2017) [J]. *Chinese Journal of Integrated Traditional and Western Medicine*, 2018, 38 (02): 136
- [6] Hayward Ks, Kramer Sf, Thijs V, et al. A systematic review protocol of timing, efficacy and cost effectiveness of upper limb therapy for motor recovery post-stroke[J]. *Syst Rev*, 2019, 8(1):187.
- [7] Li Jian, Cai Chunyan. Testing the threshold effect of average hospitalization days on average hospitalization expenses for stroke patients [J]. *Chinese Medical Record*, 2016, 17 (07): 37
- [8] Buchanan Im, Besdine Rw. A systematic review of curricular interventions teaching transitional care to physicians-in-training and physicians[J]. *Acad Med*, 2011, 86(5):628.
- [9] Tang Shan, Li Li, Yan Caixia, et al. A survey on the needs for continued care of stroke patients [J]. *Nursing Research*, 2018, 32 (19): 3103
- [10] Wei Yuanyuan, Ni Chunping, Wang Xianni, etc. A qualitative study on the demand for continuing care after discharge of stroke patients [J]. *Journal of Nurse Continuing Education*, 2018, 33 (04): 365
- [11] Wang Ying, Xu Wenkui, Yang Lei, et al. Research progress on smartphone applications in continuing care for chronic disease patients [J]. *Chinese Journal of Health Management*, 2020, 14 (03): 295
- [12] Huang Tianrong, Zeng Ying, Yang Canhong, et al. Survey and analysis of the current demand for

- mobile apps for stroke continuity services based on the integration of medical and nursing technology [J]. *Chinese Clinical New Medicine*, 2018, 11 (06): 611
- [13] Shen Binyan. Analysis of the demand for continuous care apps for stroke patients and their influencing factors [D]. Guangzhou: Guangdong Pharmaceutical University, 2020:17
- [14] Sureshkumar K, Murthy G, Kuper H. Protocol for a randomised controlled trial to evaluate the effectiveness of the 'Care for Stroke' intervention in India: a smartphone-enabled, carer-supported, educational intervention for management of disabilities following stroke[J]. *BMJ Open*, 2018, 8(5):e020098.
- [15] Kamalakannan S, Gudlavalleti Venkata M, Prost A, et al. Rehabilitation Needs of Stroke Survivors After Discharge From Hospital in India [J]. *Arch Phys Med Rehabil*, 2016, 97(9): 1526.
- [16] Zhang Huixia, Lin Beilei, Mei Yongxia, et al. Development and application of a professional care app for stroke patients at home [J]. *Chinese Rehabilitation Theory and Practice*, 2019, 25 (10): 1214
- [17] Requena M, Montiel E, Baladas M, et al. Farmalarm[J]. *Stroke*, 2019, 50(7):1819.
- [18] Kim Dy, Kwon H, Nam Kw, et al. Remote Management of Poststroke Patients With a Smartphone-Based Management System Integrated in Clinical Care: Prospective, Nonrandomized, Interventional Study[J]. *J Med Internet Res*, 2020, 22(2):e15377.
- [19] Fruhwirth V, Enzinger C, WEISS E, et al. [Use of smartphone apps in secondary stroke prevention] [J]. *Wien Med Wochenschr*, 2020, 170(1-2):41.
- [20] Sarfo F, Treiber F, Gebregziabher M, et al. PINGS (Phone-Based Intervention Under Nurse Guidance After Stroke): Interim Results of a Pilot Randomized Controlled Trial[J]. *Stroke*, 2018, 49(1): 236.
- [21] Bhattacharjya S, Stafford Mc, Cavuoto La, et al. Harnessing smartphone technology and three dimensional printing to create a mobile rehabilitation system, mRehab: assessment of usability and consistency in measurement [J]. *J Neuroeng Rehabil*, 2019, 16(1):127.
- [22] Zhang Mw, Yeo Ll, Ho Rc. Harnessing smartphone technologies for stroke care, rehabilitation and beyond [J]. *BMJ Innov*, 2015, 1(4):145.
- [23] Zhang Weifeng, Chen Lina. The application effect of continuous care based on mobile app in community stroke patients [J]. *Chinese Journal of Modern Nursing*, 2018, 24 (02): 190
- [24] Yao Hui, Chang Hong, Wang Xiaojuan, et al. A study on the application of mobile app intervention to improve the quality of life in patients with mild to moderate stroke [J]. *China Nursing Management*, 2017, 17 (01): 103
- [25] De Bartolo D, Morone G, Lupo A, et al. From paper to informatics: the Post Soft Care-App, an easy-to-use and fast tool to help therapists identify unmet needs in stroke patients[J]. *Funct Neurol*, 2018, 33(4):200.
- [26] Liu Huahua, Jiang Hong, Shi Yu, et al. The establishment and application of a symptom management app for stroke patients [J]. *Journal of nursing*, 2018, 33 (01): 8
- [27] Yao Di, Wang Yi, Chen Fei. The application of a nursing centered mobile app in rehabilitation training for patients with cognitive impairment after stroke [J]. *Chinese Journal of Modern Nursing*, 2018, 24 (05): 548
- [28] Sun L, Jiao C, Wang Y, et al. A Survey on the Willingness to Use Physical Activity Smartphone Applications (Apps) in Patients with Chronic Diseases[J]. *Stud Health Technol Inform*, 2016, 225: 1032.
- [29] Liu Yang, Yang Tiantian, Mao Min, et al. Survey on the current situation of mobile medical apps in China [J]. *Journal of Medical Informatics*, 2018, 39 (10): 7
- [30] Zhang Huixia, Zhang Yongchao, Zhang Ning, et al. A systematic review of stroke related smartphone applications in China [J]. *China Digital Medicine*, 2020, 15 (01): 76
- [31] Henriquez-Camacho C, Losa J, Miranda Jj, et al. Addressing healthy aging populations in developing countries: unlocking the opportunity of eHealth and mHealth[J]. *Emerg Themes Epidemiol*, 2014, 11(1):136.
- [32] Zhang H, Wang T, Zhang Z, et al. The current status of stroke-related smartphone applications available to adopt in China: A systematic review study[J]. *Medicine (Baltimore)*, 2020, 99(27): e20656.
- [33] Zhang Huixia. Development and application of a professional care smartphone application for stroke patients at home [D]. Henan: Zhengzhou University, 2019: 52
- [34] Stoyanov Sr, Hides L, Kavanagh Dj, et al. Mobile app rating scale: a new tool for assessing the quality of health mobile apps[J]. *JMIR Mhealth Uhealth*, 2015, 3(1):e27
- [35] Stoyanov Sr, Hides L, Kavanagh Dj, et al. Development and Validation of the User Version of the Mobile Application Rating Scale (uMARS)[J]. *JMIR Mhealth Uhealth*, 2016, 4(2):e72
- [36] Zhao Dongxiang A study on the influencing factors of willingness to use mobile health management services - based on the perspective of innovation diffusion [J] *Intelligence Journal*, 2017, 36 (11): 120