Development of a Service Quality Evaluation System for Home-Based Rehabilitation Apps in Heart Failure Patients: Postprint

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Abstract

The cardiac rehabilitation process for heart failure patients has currently shifted predominantly from hospital to home settings. Mobile health applications help patients bridge the support gap during this transition from hospital to home, facilitating the home rehabilitation process. However, numerous quality issues have emerged, and the service quality urgently requires evaluation and monitoring.

To construct a service quality evaluation system for home rehabilitation APPs for heart failure patients, providing a reference for standardizing and improving the quality of mobile health APP services in China.

From July 2022 to February 2023, a service quality evaluation system for home rehabilitation APPs for heart failure patients was drafted based on literature analysis and semi-structured interviews, and two rounds of expert consultation were conducted with 18 experts. Expert engagement was represented by questionnaire response rate and opinion proposal rate, expert authority degree was represented by authority coefficient, and expert opinion coordination degree was represented by score coefficient of variation and Kendall' s coefficient of concordance. Combining expert consultation and the Analytic Hierarchy Process, the final service quality evaluation system for home rehabilitation APPs for heart failure patients was established.

The effective response rates for both rounds of expert consultation questionnaires were 100%, the expert authority coefficient was 0.867, and Kendall' s coefficients of concordance for the two rounds were 0.128-0.154 and 0.151-0.197, respectively ($P<0.001$). The final constructed service quality evaluation system for home rehabilitation APPs for heart failure patients consists of three

dimensions: software attributes, medical science, and behavioral science characteristics, comprising 7 first-level indicators, 24 second-level indicators, and 51 third-level indicators.

The constructed service quality evaluation system for home rehabilitation APPs for heart failure patients is comprehensive and scientifically sound, providing certain reference significance for evaluating the service quality of cardiac rehabilitation APPs and promoting the healthy development of similar APP services.

Full Text

Construction of a Service Quality Assessment Indicator System for Home-based Rehabilitation APP for Heart Failure Patients

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Abstract

Background: Cardiac rehabilitation for heart failure patients has largely transitioned from hospital to home settings. Mobile health applications help bridge the support gap during this transition and facilitate home-based recovery processes. However, numerous quality issues have emerged, making it imperative to establish quality control mechanisms for these services.

Objective: To construct a service quality assessment indicator system for home-based rehabilitation APP services for heart failure patients, providing a reference for standardizing and improving the quality of mobile health APP services in China.

Methods: From July 2022 to February 2023, we developed a draft quality assessment indicator system for home-based rehabilitation APP services for heart failure patients based on literature analysis and semi-structured interviews. Two rounds of expert consultations were conducted with 18 experts. Expert engagement was measured by questionnaire response rate and opinion provision rate, authority by authority coefficient, and opinion coordination by coefficient of variation and Kendall' s coefficient of concordance. The final indicator system was established through expert consultation combined with the analytic hierarchy process.

Results: Both rounds of expert consultation achieved 100% valid response rates. The expert authority coefficient was 0.867, and Kendall' s coefficients of concordance were 0.128–0.154 and 0.151–0.197 respectively (P<0.001). The final assessment indicator system comprised three dimensions: software attributes, medical science characteristics, and behavioral science characteristics, including 7 primary indicators, 24 secondary indicators, and 51 tertiary indicators.

Conclusion: The constructed service quality assessment indicator system for home-based rehabilitation APP for heart failure patients is comprehensive and scientifically sound. It provides valuable guidance for evaluating cardiac rehabilitation APP service quality and promoting the healthy development of similar APP services.

Keywords: heart failure; cardiac rehabilitation; home care services; mobile health; service quality evaluation; APP

Introduction

Cardiac rehabilitation is a multidimensional intervention model encompassing exercise, nutrition, medication, psychological support, and unhealthy behavior management. The benefits of cardiac rehabilitation for heart failure patients have been confirmed by numerous studies [**?**]. Compared with center-based or outpatient cardiac rehabilitation, home-based cardiac rehabilitation helps patients overcome various barriers such as work conflicts and transportation difficulties, demonstrating superior cost-effectiveness [**?**].

In recent years, internet technology development has driven comprehensive transformation of traditional medical models. Mobile health applications have been widely utilized in internet-enabled chronic disease management [**?**], and APP-guided home-based cardiac rehabilitation has emerged as a new pathway for patients' post-hospital recovery [**?**]. The 2022 release of the "Internet Diagnosis and Treatment Supervision Rules (Trial)" marked China' s entry into a new era of stringent regulation for internet medical services [**?**]. Under the "serious medicine" value orientation, maximizing the homogeneity between internet medical services and offline clinical services in terms of professional qualifications and quality safety has become imperative. However, current mobile health services are developing rapidly, and relevant research has revealed that the service quality of cardiac rehabilitation APPs needs improvement [**?**]. With an overwhelming number of cardiac rehabilitation APPs on the market, objective quality measurement has become a challenge.

Literature review shows that existing studies mostly conduct quality control of cardiac rehabilitation APPs based on superficial features without evaluating their potential effectiveness in real-world application contexts, resulting in incomplete assessments [**?**, **?**]. Meanwhile, China lacks a service quality evaluation system specifically for home-based cardiac rehabilitation APPs, with inadequate supervision of functional content and unguaranteed service quality. This dilemma urgently needs to be addressed. Heart failure patients represent the

primary target population for cardiac rehabilitation APPs, and service quality is a critical factor ensuring user benefits. Therefore, this study focuses on heart failure patients in the home-based cardiac rehabilitation context, constructs a service quality assessment indicator system based on the effective integration of mobile health applications and home healthcare, and provides references for evaluating and measuring APP service quality and guiding related APP development.

1.1 Research Team Formation

The research team comprised eight members, including one nursing professor, three cardiac rehabilitation specialist nurses, and four master' s degree students, all with research experience in mobile health. The team' s main tasks included: (1) conducting qualitative interviews to formulate evaluation dimensions and build the indicator system framework; (2) searching and summarizing literature to extract evaluation indicators and refine their connotations; and (3) conducting expert consultations to verify the comprehensiveness and rationality of the indicator system. This study was approved by the hospital ethics committee (2021-SR-142).

1.2.1 Mobile Health APP Service Quality

This study defines "mobile health APP service" as a service model that uses mobile applications as a medium to deliver health information and provide health guidance for health promotion purposes. "Service quality" refers to the degree to which APP services in this model align with current user needs and scientific requirements in terms of content presentation and implementation.

1.2.2 Home-based Rehabilitation APP Service Quality for Heart Failure Patients

This study limited the evaluated APPs to those primarily serving heart failure patients and providing cardiac rehabilitation guidance in home settings. Focusing on the health context of "home-based cardiac rehabilitation for heart failure patients," we constructed a service quality assessment system to explore the effective integration of cardiac rehabilitation APPs with home healthcare.

1.3.1 Semi-structured Interviews

We used qualitative interviews to explore heart failure patients' attitudes toward and needs for cardiac rehabilitation APPs, aiming to clarify the role positioning of these APPs in patients' home rehabilitation and analyze the connotation of service quality. Using purposive sampling, we selected 17 heart failure patients from the Cardiology Department of the First Affiliated Hospital of Nanjing Medical University between July and August 2022. Based on literature review and the Chinese patient context, we developed an interview guide with four questions: (1) What mobile health services have you encountered for disease

management? (2) How do you think such platforms can help your home-based cardiac rehabilitation? (3) What functions do you expect such platforms to provide? (4) What factors do you consider when choosing such platforms? Based on interview results and current mobile health APP quality evaluation perspectives [**?**], we preliminarily formulated three evaluation dimensions— "software attributes," "medical science," and "behavioral science" —to build the structural framework of the assessment system. Dimension descriptions are provided in Table 1 .

1.3.2 Literature Search

We systematically reviewed studies on mobile health APP service quality evaluation, organized and summarized evaluation content, and extracted assessment indicators to provide evidence-based support for the system. Using search terms including "APP*,*"" *mobile health,*"" *quality,*"" *evaluat*," "criteri*," "rating," "移动健康,""移动医疗,""质量,""评价,""标准,"and "原则,"we searched Cochrane Library, Web of Science, Scopus, CINAHL, PsyINFO, CNKI, and Wanfang databases from January 2008 to September 2022. We included 72 articles, extracted mobile health APP service quality evaluation indicators, and categorized them according to the three dimensions of "software attributes," "medical science," and "behavioral science." The research team then integrated these indicators with domestic home-based cardiac rehabilitation guidelines [**?**, **?**, **?**, **?**, **?**, **?**] and qualitative interview results to draft the service quality assessment system for home-based rehabilitation APP for heart failure patients, comprising 8 primary indicators, 26 secondary indicators, and 65 tertiary indicators.

1.4.1 Development of Expert Consultation Questionnaire

Through literature review and team discussion, we developed an expert consultation questionnaire consisting of four parts: (1) research background, (2) overview and dimension description of the indicator system, (3) assessment indicator system consultation, and (4) expert information registration form. Part 3 was the main body, presenting titles and connotations of all evaluation indicators and inviting experts to score each indicator on a 5-point scale from "very important" to "not important at all," with space for modification suggestions.

1.4.2 Selection of Expert Consultants

Expert inclusion criteria included: (1) being a nursing management, clinical practice, or research expert in health management, clinical nursing, or mobile health; (2) holding a bachelor' s degree or above with senior professional title, or a master' s degree with intermediate or higher title, or a doctoral degree with relevant research experience in mobile health and patient rehabilitation; and (3) being able to actively complete questionnaires and participate in multiple consultation rounds. Ultimately, 18 experts completed two rounds of consultation, including 2 males (11.1%) and 16 females (88.9%); aged 30–57 years, mean (43.1$±7.9)$years; work experience$1–37$ years, mean$(19.4±$10.4)

years; 16 (88.9%) held associate senior or higher titles; 16 (88.9%) had master' s degrees or above; and all experts' research fields (mobile health, public health, health management) were relevant to this study.

1.5 Statistical Methods

We used Excel 2019, SPSS 26.0, and yaahp 10.3 for statistical analysis. Categorical data were expressed as frequencies and percentages; measurement data were expressed as (mean±SD). Expert engagement was measured by questionnaire response rate and opinion provision rate; authority by authority coefficient (Cr); opinion coordination by coefficient of variation and Kendall' s coefficient of concordance; and opinion concentration by mean importance score and full-score ratio. Additionally, the analytic hierarchy process was combined with Satty' s 1–9 scaling method to assign values to differences in mean importance scores and calculate indicator weights. $P<0.05$ was considered statistically significant.

Results

2.1.1 Expert Engagement and Authority

Both rounds of expert consultation achieved 100% valid response rates. In the first round, 15 experts (83%) provided 111 modification suggestions, while in the second round, 11 experts (61%) provided 41 suggestions. The overall expert authority coefficient (Cr) was 0.867, indicating high expert engagement and authority, and thus reliable consultation results.

2.1.2 Expert Opinion Coordination

In the first round, the coefficient of variation for indicator scores ranged from 0 to 0.246, with Kendall' s coefficient of concordance at 0.128–0.154 ($P<0.001$). In the second round, the coefficient of variation was 0–0.183, and Kendall' s coefficient of concordance was 0.151–0.197 ($P<0.001$). These results indicate relatively high consistency and coordination among experts after two rounds, yielding reliable consultation outcomes.

2.1.3 Expert Opinion Concentration

In the first round, mean importance scores for 99 indicators ranged from 3.94 to 5.00, with 91 indicators (92%) scoring $ $4.5. Full-score ratios ranged from 27% to 100%. In the second round, mean importance scores for the revised 88 indicators ranged from 4.38 to 5.00, with 86 indicators (98%) scoring $ $4.5. Except for one indicator with a full-score ratio of 44%, all others exceeded 60%. These results demonstrate converging expert agreement on indicator content.

2.2.1 First Round of Expert Consultation

Based on expert feedback, the research team revised indicators as follows: (1) deleted eight indicators including "development quality," "multilingual support,"

and "scientific testing" ; (2) merged three tertiary indicators, such as incorporating "development background" into "development information transparency" ; (3) adjusted the position of nine indicators, such as moving the tertiary indicator "health reminders" under the secondary indicator "essential functions" ; and (4) revised the names of 16 indicators and connotations of 37 indicators, such as changing "gamification settings" to "fun settings."

2.2.2 Second Round of Expert Consultation

Incorporating expert feedback from the second round, we made the following revisions: (1) deleted two indicators ("information interaction" and "interface compatibility"); (2) merged four indicators, such as incorporating "fault tolerance" into "system self-check, update, and error handling" ; and (3) revised the names of five indicators and connotations of 26 indicators, such as changing "aesthetics" to "visual appeal." The final service quality assessment system for home-based rehabilitation APP for heart failure patients included 7 primary indicators, 24 secondary indicators, and 51 tertiary indicators (Table 2). Key evaluation points for selected indicators are presented in Table 3 .

Discussion

3.1 Scientific Analysis of the Evaluation System

This study first used qualitative interviews to explore heart failure patient needs, clarify the connotation of APP service quality, and build the evaluation framework. Second, literature analysis was employed to search relevant studies and guidelines, integrating and summarizing evaluation content to provide evidence-based support. Finally, expert consultation combined with analytic hierarchy process established the final assessment system. This construction process demonstrated clear thinking and rigorous logic, showing a progressive development from structural framework to content building. During indicator revision, 18 experts participated in the consultation, meeting scientific requirements. Their work fields were all relevant to this study, with high-level knowledge structures and rich clinical experience, and high engagement. After two rounds, all indicators had coefficients of variation <0.25, and Kendall' s coefficients of concordance at all levels were statistically significant ($P<0.001$). Additionally, hierarchy analysis confirmed no internal logical errors across all indicator levels, meeting consistency requirements and ensuring objective weight results. Therefore, the constructed service quality assessment system demonstrates good reliability and scientific validity.

3.2 Professional Analysis of the Evaluation System

Our results show that "functional support" and "information content" had the highest and equal weights among primary indicators, consistent with patient needs identified in our qualitative interviews. As a tool to assist heart failure patients with home-based cardiac rehabilitation, functional services and health

information support are the fundamental reasons patients use cardiac rehabilitation APPs, making them key quality indicators. This suggests that user needs should guide APP development, and future efforts should further focus on target population needs to comprehensively improve APP service quality. Among secondary indicators, "essential functions" had the highest combined weight, followed by "privacy security," aligning with our initial logic. "Essential functions" were designed around scientific requirements for home-based cardiac rehabilitation in heart failure patients, consistent with current domestic guidelines and representing the core of high-quality cardiac rehabilitation APP services that warrant sufficient attention. The high weight for "privacy security" aligns with Jin et al.' s findings [**?**] that privacy protection is a major user concern directly affecting willingness to use mobile health services. Compared with other primary indicators, indicators under "behavioral strategies" had relatively lower weights, consistent with the current development status of cardiac rehabilitation APPs [**?**]. While simple, direct knowledge dissemination functions are common, features promoting active health behaviors such as health planning and reward systems remain rare. Expert feedback suggested this may be because integration of health behavior promotion strategies with APP functions is still in its early exploratory stage, with actual effectiveness yet to be verified. Therefore, "behavioral strategies" and its sub-indicators did not receive excessive weight. However, this does not diminish the importance of behavioral strategies in APP services, as generating and maintaining health behaviors is the ultimate goal of cardiac rehabilitation APPs. Future indicator development and weight distribution should follow relevant research developments and timely update and adjust the system based on evidence and latest concepts.

3.3 Innovative Analysis of the Evaluation System

Rooted in China' s "serious medicine" context, this study focused on heart failure patients in the home-based cardiac rehabilitation setting and constructed a service quality assessment system using multiple methods. This system overcomes limitations of current evaluation tools that only measure superficial APP features, have single evaluation dimensions, and lack specificity [**?**]. It represents a scientific exploration of effective integration between mobile health and home-based cardiac rehabilitation, filling a research gap in this field in China. Beyond universal APP evaluation indicators, the system adds specific requirements for cardiac rehabilitation APP functions, aligns with home rehabilitation contexts, follows current cardiac rehabilitation guidelines, and comprehensively presents cardiac rehabilitation characteristics with more concrete evaluation points. Innovatively, from the multiple positioning of cardiac rehabilitation APP service quality connotation, we identified three evaluation dimensions—software attributes, medical science, and behavioral science characteristics—from the perspectives of mobile technology, health information dissemination, and health behavior promotion. The resulting evaluation framework for home-based rehabilitation APP service quality for heart failure patients is more comprehensive and multidimensional. Furthermore, the system emphasizes detailed APP ser-

vice design and control over service implementation methods, representing a theoretical exploration of cardiac rehabilitation APP service settings that can guide the healthy development of similar services.

Conclusion and Future Directions

This study constructed a scientific and reliable service quality assessment indicator system for home-based rehabilitation APP for heart failure patients using qualitative interviews, literature analysis, expert consultation, and analytic hierarchy process. From the three levels of mobile technology, health information dissemination, and health behavior promotion, we identified three evaluation dimensions—software attributes, medical science characteristics, and behavioral science characteristics—providing guidance for evaluating cardiac rehabilitation APP service quality and promoting healthy service development. China' s mobile health field remains in its exploratory stage, and this study' s exploration of user needs may have limitations. The system content and patient needs, such as APP aging-friendly modifications for elderly patients, require further refinement and optimization. Future research could employ field studies to enter real home-based cardiac rehabilitation APP service settings, deeply understand heart failure patients' rehabilitation environments and experiences, and more precisely identify APP service quality control points. As mobile health stands at the intersection of multiple fields, future work could incorporate more professional perspectives such as rehabilitation medicine and home nursing to further revise the system' s connotation. Additionally, systematic searches of domestic cardiac rehabilitation APPs could summarize their functions and features, and quality evaluation using this assessment system could reveal improvement opportunities for China' s cardiac rehabilitation APP services based on real-world evidence.

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Note: Figure translations are in progress. See original paper for figures.