Journal of Clinical and Nursing Research, 2023, Volume 7, Issue 4
http://ojs.bbwpublisher.com/index.php/JCNR
ISSN Online: 2208-3693
ISSN Print: 2208-3685

Construction of a New Model of Contactless Medical Services for Outpatients Based on the Project-Achieving Quality Control Circle

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Abstract: *Objective:* To carry out empirical research on the role of project-achieving quality control circle (QCC) in constructing a new model of contactless medical service for outpatients. *Methods:* A QCC, consisting of information office members from a grade A tertiary hospital in Wenzhou, was established to conduct a research project with the theme "Constructing a new model of contactless medical service based on outpatients' experience." According to the ten steps and PDCA cycle, an analysis was carried out before and after the QCC activities, focusing on improving pre-consultation services, providing steward-like services, and facilitating post-consultation management. *Results:* After the QCC activities, the mobile appointment rate, missed appointment rate, the proportion of smart check-ins, and the average check-in time were 55.68%, 4.02%, 39.75%, and 8.24 ± 3.66 min, respectively; in contrast, before the activities, they were 32.00%, 7.88%, 0.00%, and 14.96 ± 4.98 min, respectively; the difference between the two groups was statistically significant (χ^2 = 3480.112, 4994.496; Fisher's exact probability = 963788.570; t = 5.323, P < 0.001). Many experts have also visited the hospital to learn about this system, thus rendering social and economic benefits. *Conclusion:* Project-achieving QCC activities are suitable for complex situations, such as constructing a new model of contactless medical service, and can significantly improve outpatient service quality, enhance patients' experience, and improve the abilities of circle members.

Keywords: Quality control circle; Project-achieving; Outpatient; Contactless medical service; Patient experience

Online publication: July 6, 2023

1. Introduction

In 2013, Qingdao University Hospital was the first hospital in China to put forward the concept of "barrier-free access to medical care" and to launch the "barrier-free access to medical care" project. The core idea was to optimize the medical treatment process, optimize the allocation of medical resources, reduce the cost of medical treatment for patients, and improve the experience of patients [1]. The widespread use of information technology in the medical field is promoting the change in the medical service model on the one hand and the development of healthcare and medical care on the other hand [2]. In addition, information technology is transforming traditional business operation into a more efficient operation mode. The traditional outpatient model does not fully and rationally utilize modern medical resources, which may

easily lead to patient congestion and the "three long and one short" phenomenon of long waiting time for appointment, treatment, and payment, with short consultation time [3]. In addition, patients are unfamiliar with outpatient procedures and the operation of modern equipment. This presents an obstacle to convenient medical treatment. In 2020, our hospital proposed a new concept, "contactless medical service," which aims to use artificial intelligence (AI) face recognition technology, health code recognition, big data, Internet of Things, and other advanced technologies in outpatient services before, during, and after diagnosis [4], so as to save time and make it convenient for patients. From February to November 2022, our hospital developed a new model in the form of a project-achieving quality control circle (QCC) – "contactless medical service." The "project-achieving QCC" is a new model developed to achieve new goals based on solving basic problems in order to achieve better quality or to expand business [5]. The aim of this study was to build a new model of outpatient contactless medical service through the project-achieving QCC approach, actively exploring options and pathways for information technology development, and contribute to the development of medical wisdom in order to improve the outpatient experience and service quality.

2. Data and methods

2.1. General information

We included 352,455 outpatients from the hospital information system (HIS) before the implementation of "QCC" (January 2022) and 388,577 outpatients after the implementation of "QCC" (September 2022) in the control group and observation group, respectively. We compared the mobile appointment rate, missed appointment rate, percentage of smart check-ins, and average check-in time for our outpatients in January 2022 and September 2022.

2.2. Methods

2.2.1. Establishment of the quality control circle

Multiple departments and divisions were involved in the establishment of the QCC, and the principle of voluntary was adhered to in the process. Each circle consisted of 11 members. The circle leader, a senior software development engineer, was responsible for planning and coordinating the circle's activities; the circle secretary was responsible for assisting the circle leader in organizing and carrying out the activities; the roles of the Director of Information Services and the Head of Outpatient Department were assumed by two mentors who were responsible for mentoring and supporting the operation of the circle; and the other seven members were from the information department, medical department, and nursing department. The name of the circle was decided, and the circus logo was designed. We learned the characteristics of the QCC as well as the principles and methods of its activities, as directed by ten steps (theme selection, activity planning, topic clarification, goal setting, countermeasure formulation, best-fit policy pursuit, best-fit policy implementation and review, effect confirmation, standardization, as well as review and improvement).

2.2.2. Theme selection and activity planning

The circle members used the brainstorming method to propose three alternative themes based on the problems identified during the investigation. The themes were evaluated using the evaluation method, taking into account of certain policies, importance, urgency, and the circle's ability. The theme selected was "Constructing a new model of contactless medical service based on outpatients' experience." According to the QC-STORY judgment table (see **Table 1**), this activity was identified as a project-achieving type QCC. An activity plan was developed; the activities accorded to the PDCA cycle and strictly followed the aforementioned ten steps.

Table 1. QC-STORY judgment table

Project-achieving pattern	Degree of relationship		Problem-solving pattern
Previously inexperienced work issues	22	0	Fully experienced work issues
Substantially changing the status quo	22	11	Maintaining or enhancing the status quo
Pursuing attractive quality	22	11	Ensuring current quality
Responding to predictable issues in advance	22	11	Preventing the recurrence of resolved issues
Project-achieving through well-arranged topics	22	11	Solving issues through casual exploration
Evaluation results	110	44	Evaluation results

Degree of relationship (three-stage evaluation): strong correlation = 2; moderate correlation = 1; weak correlation = 0.

2.2.3. Topic clarification

(i) The indicators include mobile appointment rate, missed appointment rate, proportion of smart check-ins, and average check-in time. The evaluation methods were as follows: calculation of mobile appointment rate by dividing the number of patients who successfully made appointments through mobile applications, WeChat, or Alipay by the total number of appointments; calculation of missed appointment rate by dividing the number of patients who failed to show up for their appointment on the day of visit by the total number of outpatient appointments; calculation of the proportion of smart check-ins by dividing the number of smart check-ins the total number of successful check-ins on the day of the visit; verification of the average check-in time by the average time it takes for patients to successfully check in through various methods.

(ii) Based on the data of 352,455 patients who successfully scheduled appointments at our hospital in January 2022, the mobile appointment rate was 32%, the missed appointment rate was 7.88%, the proportion of smart check-ins was 0, and the average check-in time was 14.96 minutes. By analyzing the gap between the current situation and the expected values, alternative measures were formulated (**Table 2**); 12 breakthrough points were selected through evaluation and grouped under three crucial points: improve pre-consultation services, provide steward-like services, and facilitate post-consultation management.

2.2.4. Goal setting

According to the Hospital Intelligent Service Grading Assessment Standard System [7] and our hospital's quality improvement requirements for outpatient management, along with the target value, we evaluated the work and set the target values as 55.37% for mobile appointment rate, 4.10% for missed appointment rate, 42.88% for smart check-ins, and 8.66 min for the average check-in time.

2.2.5. Countermeasure formulation and best-fit policy pursuit

The QCC proposed 12 improvement measures based on the key points and selected 10 alternative measures through feasibility, economy, and circle capability evaluations. The members evaluated each alternative measure for obstacles and ramifications, as well as methods to eliminate the obstacles. Subsequently, they grouped the 10 measures into three categories: (i) improve pre-consultation services by providing smart appointment triage functions, smart parking navigation functions, and pre-consultation reminders; (ii) provide steward-like services; and (iii) facilitate post-consultation management by sending post-consultation checklists and follow-up reminders.

Table 2. Breakthrough points for building a new model of contactless medical service based on outpatient experience

Content	Item	Aspiration	Crucial point
Before consultation	Mobile intelligent triage function	Equipped with smart triage function Mobile appointment rate reached 55.37%	Improve pre-consultation services
	Reminder before treatment	Equipped with pre-consultation reminder function Cancellation rate decreased to 4.1%	
	Parking problem	Equipped with smart parking navigation	
During consultation	Barrier gate system	Associated implicit medical treatment system Smart check-ins, smart payment, medical information notification services, *etc*.	Provide steward-like services
	Time taken for check-in	Achieve automatic check-in Average check-in time decreased by 6.3 min	
	Layout of outpatient environment	Equipped with smart navigation function	
	Medical process	Generate consultation schedule	
	Outpatient camera	Add facial recognition cameras	
	Medical information notification	Deliver intelligent scene	
	Appointment for check-ups	Automatic appointment	
After consultation	Post-consultation management	Automatically deliver post-consultation checklist (drugs, expenses, education, and examination reports)	Facilitate post-consultation management
	Subsequent visits	Intelligent visit reminders	

2.2.6. Best-fit policy implementation

2.2.6.1. Improve pre-consultation services: Smart triage function, smart parking navigation function, and pre-consultation reminder

By providing smart appointment triage functions on mobile applications, patients can describe their symptoms through the "Appointment Assistant," and the system will intelligently recommend the appropriate doctors. After a successful appointment, a pop-up request will appear on the mobile terminal and web terminal for smart face information collection, and patients can enjoy the contactless medical service with a single click. At the same time, the system automatically provides parking guidance. In that way, patients can check the parking location around the hospital and obtain real-time space information and navigation to help solve the issue of difficult parking. On the day before the consultation, the system automatically sends a pre-consultation and examination notification to remind the patients to attend their consultations on time. When there is insufficient balance in the card, the system will send a notification to reload.

2.2.6.2. Provide steward-like services

We addressed the problems of patients being unfamiliar with the consultation process, the lack of transparency in the process, the difficulty in finding the location, and the lack of automatic appointments for tests. We first optimized the sign-in process to enable automatic sign-in. By integrating the contactless medical service with intelligent gateways, patients can pass through the smart gates and smart cameras at the entrance of the hospital and at the main access points, respectively. The system confirms the patient's identity based on the health code information or face recognition technology and proactively helps the patient to complete the check-in. After successful check-in, a message is sent to the patient, informing him/her of the consultation location and waiting status, as well as generating a consultation schedule for

the patient. Patients can follow the schedule to organize their visits in the right order. The schedule provides navigation to specific locations, check-in, pick-up, payment, top-up, education, and other core functions that have been carefully selected for patients by the intelligent system. This reduces the learning costs and increases the ease of use. For patients who have not made any appointment, the system provides a quick access point to frequently used functions and a flowchart for patients to understand the flow of care at a glance after passing through the gates. The smart camera automatically identifies the patient and sends messages based on the scenario, filtering the functions needed for the scenario, avoiding multiple choice questions for the patient, and providing a steward-like service to the patient. After the doctor has issued a checklist, the system automatically confirms the cost, completes the merging of the application form, schedules appointment intelligently, and sends notifications through multiple channels. If patients are unable to comply with the appointment time, they can change it on their own mobile phones, thus saving them the time of queuing up for appointments and changing the appointment time.

2.2.6.3. Facilitate post-consultation management: Provide post-consultation checklist and follow-up reminders

For convenient post-consultation management, the system provides post-consultation checklists and reminders for follow-up visits to patients. The checklist includes medicines, tests, examinations, fees, and education, guiding patients on the use of medications, providing access to test reports, providing fee details and recommendations for follow-ups, as well as reminding patients about outpatient follow-ups. For patients' convenience, the system offers a quick online and offline appointment portal and recommendations for follow-ups.

2.3. Statistical analysis

Excel was used for data entry, and SPSS 21.0 was used for statistical analysis. Statistical data were compared using chi-square (χ^2) test, and *t*-test was used to compare measurement data. $P < 0.05$ indicates statistical significance.

3. Results

3.1. Tangible results

After the launched of the application, the outpatient visit data of 388,577 patients who successfully made appointments at our hospital in September 2022 were collected and analyzed. The QCC mobile appointment rate, missed appointment rate, proportion of smart check-ins, and average check-in time were significantly better compared to before the implementation of the QCC ($P < 0.001$), as shown in **Table 3**.

Table 3. Comparison of indicators before and after the implementation of quality control circle activities

Phase	Total appt.	Appt. initiated by patient	Mobile appt. rate (n, %)	Missed appt. rate (n, %)	Number of patients who checked-in	Proportion of smart check-ins (n, %)	Average check-in time (min, mean ± SD)
Before	352,455	291,593	93,310 (32.00)	27,773 (7.88)	324,682	0 (0.00)	14.96 ± 4.98
After	388,577	322,960	179,824 (55.68)	15,621 (4.02)	372,956	148,242 (39.75)	8.24 ± 3.66
Stat. value			34800.112[a]	4994.496[a]		963788.570[b]	5.323[c]
P-value			< 0.001	< 0.001		< 0.001	<0.001

Note: [a]Chi-square value; [b]Fisher's precision probability; [c]*t* value. Abbreviation: Appt., appointment; Stat. value, statistical value.

3.2. Intangible results

When comparing the overall scores of the circle members in terms of ability, there was improvement in the abilities of the members in all areas to varying degrees after the implementation compared to those before the implementation. Details are shown in **Table 4** and **Figure 1**.

Table 4. Comparison of scores before and after the implementation of quality control circle activities

Component	Before improvement		After improvement		Activity growth
QCC technique application	39	3.5	81	7.4	3.9
Team spirit	62	5.6	89	8.1	2.5
Brain development	54	4.9	76	6.9	2.0
Communication and coordination	56	5.1	82	7.5	2.4
Confidence	45	4.1	79	7.2	3.1
Responsibility and honor	63	5.7	90	8.2	2.5
Problem-solving skill	59	5.4	89	8.1	2.7

Note: Rated by 11 members, with a maximum score of 10 points per person and a minimum score of 1 point per person for each component (total score = 110 points). Abbreviation: QCC, quality control circle.

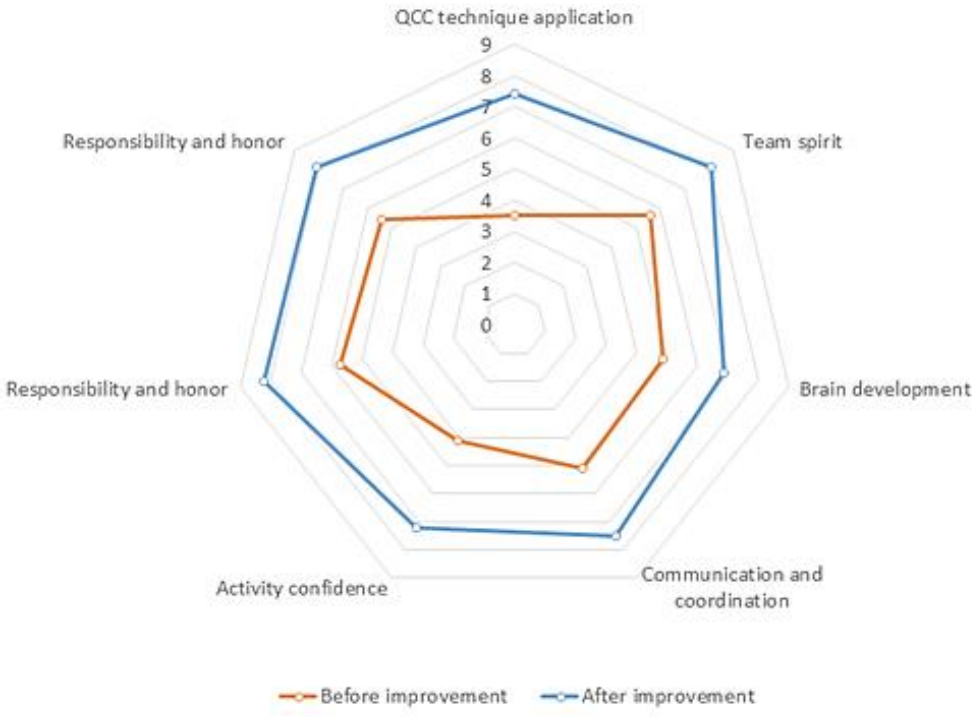

Figure 1. Radar diagram of the abilities of quality control circle members before and after the implementation

4. Discussion

4.1. The new model of contactless medical service for outpatients based on the project-achieving quality control circle changes the traditional process and improves patient experience

The rapid development of information technology has led to profound changes in the way patients access medical care [8]. Devices such as cell phone or offline self-service devices are now used to make online appointments, pay fees, view medical reports, and access other traditional offline outpatient services [9]. However, the existing digital applications and modern devices have complicated interfaces, and patients

lack familiarity with the outpatient consultation process, resulting in repeated appointments and prolonged waiting time for consultation. The members of the QCC should look from the patient's perspective, identify the pain points and difficulties of medical treatment, emphasize on being patient-centered, attempt to improve patient experience, change the traditional consultation process, and use face recognition technology to achieve "smart check-in." Through digitalization, smart appointments for physical examinations can be made, which saves time and effort, as well as provides peace of mind. In order to help patients understand the process and achieve integration and simplification of operations, the system generates a schedule automatically, offers guidance throughout the entire process, and provides clear instructions to patients about the next steps and operations, thus achieving a "one-stop" service. After the implementation of QCC activities, the mobile appointment rate increased from 32% to 55.68%, the missed appointment rate decreased from 7.88% to 4.02%, and the proportion of smart check-ins reached 39.75%. On average, it saves patients' time up to 14.96 min per visit.

4.2. The new model of contactless medical service for outpatients based on the project-achieving quality control circle optimizes the medical environment, improves hospital governance, and expands the hospital's influence

After the launched of the application, the hospital's medical treatment process improved significantly. Through background service data, the reasonable allocation of various medical resources was enhanced. Ever since the launch, 758,500 people have signed up for the contactless medical service, providing non-contact check-ins for 910,000 patients, facial recognition for 6,842,800 people, and 12.82 million notifications. Seven triage windows were cancelled, 14 guide personnel were saved, and labor costs were reduced by approximately 2 million yuan per year. The outpatient satisfaction rate increased from 90.01% to 92.31%, and our hospital's "Contactless medical service" was listed in the "Typical Artificial Intelligence Application Scenarios and Excellent Solutions (Products) in Zhejiang Province." Our contactless medical service outpatient system won the "Excellent Award" in the first "Chuangqingchun" National Health Industry Youth Innovation Competition and made to the list of the top 100 exceptional cases in the first Internet Hospital Practice. In addition, our circle was invited to conduct special lectures in Zhejiang Province and throughout China, attracting many experts in the industry to visit our hospital and learn. Our hospital's medical informatization construction has been highly praised, and our project has been reported in XueXiQiangGuo, Today's Headlines, and Wenzhou News Network, gaining recognition by the society and expanding the hospital's influence.

4.3. The project-achieving quality control circle mobilizes circle members and improve their overall ability and teamwork

This project is the first attempt of the project-achieving QCC in Information Service. The new model of contactless medical service in our hospital is also a brand-new attempt. The circle members gave full play to their initiative in improving patient experience and solved the problems encountered in medical treatment by brainstorming, clarifying the themes, exploring the breakthrough points, and formulating countermeasures. Although the members of Information Division are all from science and engineering backgrounds, they showed motivation in participating in the activities. Moreover, the activities mobilized their motivation to work, markedly increased their awareness of active service, and encouraged them to think innovatively, communicate and cooperate with other departments, as well as solve the problems in the process. This reflects the advantages of the project-achieving QCC. The ability of the circle members in operating QCC methods, their teamwork, confidence, responsibility, honor, and problem-solving skills had significantly improved. The project-achieving QCC effectively utilizes teamwork to enhance individual achievement and teamwork, as well as to improve hospital management.

4.4. Limitations and future direction

Although there is significant improvement in patient experience through project-achieving QCC activities, there are still some problems. First, the service targets are mainly young and middle-aged people who can use smartphones; elderly patients with low literacy or who do not know how to use smartphones might find it difficult to use. This is also one of the main reasons the percentage of smart check-ins has not reached the expected target. Our future research direction is to help them narrow the digital gap and make aging-friendly modifications to create more convenient contactless medical services for the elderly. The next step is to expand the application scenarios of smart medical consultation, such as smart examination, smart test, smart physical examination, *etc*. The scope of application shall be expanded, covering 350,000 square meters in each hospital area, so that more patients can benefit from the convenience brought by contactless medical services.

5. Conclusion

In recent years, QCC activities have been rapidly developed in local medical institutions, greatly contributing to the improvement of medical quality [10-12]. Project-achieving QCC activities are suitable for more complex topics, such as process reengineering [13]. The new model of contactless medical service can enhance the intelligent, humanized, and senseless medical experience in all aspects of outpatient consultation, bringing efficient and convenient changes to the cumbersome medical process. It plays a positive role in alleviating the "three long and one short" phenomenon in hospitals, bringing greater convenience to people and enhancing patients' satisfaction in all aspects of medical treatment. QCC activities allow circle members to grow in the activities through a relaxed and pleasant management style, which improves the enthusiasm of circle members, enhances their responsibility, and encourages them to participate more actively and voluntarily in hospital information technology construction.

Disclosure statement

The authors declare no conflict of interest.

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