

Application of PDCA in improving hand hygiene compliance and nosocomial infection quality in orthopedics[†]



Original article

Ya-Ping Su^a, Rui-Ling Li^{a,*}, Yuan-Yuan Wang^b, Yu-Rui Zhang^a, Ya-Jie Ji^a

^aNursing Teaching and Research Department, School of Nursing and Health, Henan University, Kaifeng, Henan 475004, China

^bDepartment of Continuing Education, The First Affiliated Hospital of Henan University, Kaifeng, Henan 475000, China

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Abstract: **Objective:** To explore the effect of the Plan-Do-Check-Action (PDCA) cycle on hand hygiene and nosocomial infection quality of orthopedic medical staff.

Methods: The whole year of 2021 was selected to monitor the quality of hand hygiene and hospitalization. Follow-up monitoring and real-time recording during the period of morning shift and medical operation concentration time, and compare the compliance of hand hygiene before and after implementation, and evaluate the quality of nosocomial infection.

Results: The hand hygiene compliance of doctors and nurses in stage P was 82%. The compliance of medical staff in stage D was 93%. The compliance of stage C was 94% and that of stage A was 95%. The quality score of hospital self-examination nosocomial infection was also significantly increased.

Conclusions: The PDCA management cycle can effectively improve the compliance of hand hygiene and the nosocomial infection quality, which is worthy of circulatory application in orthopedic nosocomial infection quality control, especially improving the quality of hand hygiene.

Keywords: hand hygiene • quality improvement • PDCA • nosocomial infection • infection control • nursing management

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1. Introduction

On May 5, 2021, Hand Hygiene Day, the World Health Organization (WHO) called for “seconds to save lives—clean your hands,” and the 7-step hand hygiene measures are essential to prevent infection.¹ Hand hygiene compliance is closely related to the quality of hospital nosocomial infection and it is a very simple, economical, and effective measure to prevent infection.^{2,3} Improving hand hygiene compliance is significantly associated

with a reduction in hospital-acquired infections, and continuing improvement of hand hygiene compliance is a guarantee for good quality improvement.⁴ Hand hygiene compliance is related to the placement, availability, and accessibility of hand hygiene facilities in medical institutions, and the location of disinfection facilities is an important part of improving hand hygiene compliance.⁵ The infection rates of vancomycin-resistant enterococci

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*Corresponding author.

E-mail: kflrl66@163.com (R. -L. Li).

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and methicillin-resistant *Staphylococcus aureus* in the hospitals are mainly affected by crossover infection from medical workers' hands.⁶

There are many trauma patients in the orthopedic ward. Open wounds are an important reason for the high incidence of nosocomial infections. Infection not only increases the medical burden but also reduces patient satisfaction. The biggest medical hidden danger of infection is that it may cause explosive nosocomial infections. Therefore, hand hygiene monitoring and disinfection, isolation, and infection control are particularly critical. It is well known that hand hygiene facilities are insufficient. For example, the hand hygiene facilities are far away from the operation area, the hand wash pool cannot be touched, there is no hand dried-paper, and there is no alcohol-based hand sanitizer. These are the important reasons for the decline in hand hygiene compliance of medical staff, and these are the major impediments to infection control.

The problems found in the daily hand hygiene supervision of the orthopedics department are rectified into bundled intervention measures, and the application of Plan-Do-Check-Action (PDCA) cycle can effectively improve hand hygiene compliance, thereby reducing the occurrence of nosocomial infections.^{7,8} The PDCA management model has statistically significant differences in the incidence of infection in the interventional catheterization laboratory, the compliance rate of hand hygiene among medical staff, the pass rate of hand hygiene, the awareness of nursing quality control, nursing management, satisfaction and bacteriological test results, which help to improve nursing safety and improve patient satisfaction.^{9,10} The PDCA cycle management model has been widely popularized, mastered and standardized.^{11,12} Ongoing interventions would be an effective solution to maintain standard hand hygiene practices.^{13–15} Medical work is busy and handwashing is frequent. In the supervision system with the ward as a unit, to improve the overall quality of hand hygiene and hospital sense control, it is necessary to formulate rigorous and feasible operating procedures, appropriately implement reward and punishment measures, and control department costs while ensuring medical quality and safety. Based on the PDCA cycle, this study found clinical problems and found corresponding measures, which effectively improved hand hygiene compliance and hospital nosocomial quality, as detailed below.

2. Methods

2.1. Participants

From January to December 2021, a total of 27 medical staff including 19 nurses and 8 doctors in the

orthopedic ward of a tertiary hospital in Henan Province were selected. The subjects have been approved by the Ethics Committee of Henan University and its affiliated hospital (HUSOM2020-303). Through the tracking observation method, checking the hand hygiene performance of the ward medical staff during medical operations, and evaluating the self-examination effect of the hospital quality control nurses on the department's hospital infection control work every month. The timing of hand hygiene monitoring includes (i) before patient contact, (ii) before a clean or aseptic procedure, (iii) after contact with body fluid, (iv) after patient contact, and (v) after contact with the patient environment. The inclusion criteria of medical staff (i) all medical personnel registered in the hospital and (ii) continuing education and rotation of medical personnel. The exclusion criteria are interns.

2.2. Method

During the each quarter in the year 2021, implementing PDCA cycle in the affiliated tertiary hospital of Henan University according to the study design.¹⁶ Completing a research team, including researchers, tutors, managers, nurses, 4 persons in total.

2.3. Related indicators

The "Hand Hygiene Questionnaire" of the hospital was formulated using the "Hand Hygiene Standard for Medical Staff" promulgated by the government state in 2009 and the "Hand Hygiene Compliance Questionnaire" issued by WHO. According to the 5-timing hand hygiene execution table, the total execution timing and non-execution timing of doctors and nurses were monitored, and the compliance of doctors and nurses was calculated. The calculated formula is as follows:

Hand hygiene compliance

$$\frac{\begin{array}{l} \text{The actual number of hand hygiene} \\ \text{performed during the same period} \\ \text{(doctor/nurse)} \end{array}}{\begin{array}{l} \text{The number of times that hand hygiene} \\ \text{should be performed during the} \\ \text{same period (doctor/nurse)} \end{array}} \times 100\%$$

According to the National Health Commission's "Nosocomial Infection Management and Monitoring Specifications," the department's self-inspection evaluation form was carried out in the department every month in this year, and the hospital quality score of the nosocomial infection of discharge was comprehensively calculated.

2.4. Quality control

The hospital quality control nurses had 5 years of orthopedic work experience and 3 years of hospital quality control experience. The monitoring implemented the secret tracking method so that the monitored person was not informed in advance, reflecting the implementation of hand hygiene and the quality of hospital infection control by medical staff in the real working environment.

2.5. Statistical tools

IBM SPSS26.0 statistical software (IBM Corporation, Armonk, NY, United States) and Excel 2019 (Microsoft Corporation, Redmond, WA, United States) worksheet were used to analyze data. The count data were recorded by percentage and frequency, and the metering data statistics were performed by using χ^2 test and *t*-test.

3. Results

3.1. Detailed PDCA performances

3.1.1. Stage P

- (1) Identify problems, analyze causes, and formulate countermeasures.
- (2) A quality control team was established, including a hospital quality control nurse, a nurse, one hospital quality control doctor, a doctor, the department director, and the head nurse, with a total of 6 members.
- (3) At the time of bedside shifts, ward rounds, and intensive medical operations, the orthopedic ward hospital quality control nurses and their team members observe the hand hygiene implementation of each department's medical staff for 15–30 min.
- (4) Analyze the number of hand hygiene executions, as shown in Figure 1, and carry out the root cause analysis, as shown in Figure 2. Formulate corresponding countermeasures.
- (5) Improvement measures: (a) Establish the training of hospital nosocomial infection knowledge every month, and organize all members of the department to conduct closed-book assessment. (b) The medical staff of the orthopedics department are organized to carry out the practical operation of the nosocomial infection knowledge every month, and the members of the nosocomial infection team use the ending time of the month to assess each medical staff.¹⁷ (c) Track the hand hygiene

implementation status of on-the-job staff at the time of treatment and operation concentration. (d) Add a sink in the cleaning area of the dressing room. (e) The treatment room and dressing room of the ward are equipped with hand dried paper. (f) There are quick hand sanitizer facilities at the entrance of each ward in the lesion corridor. (g) Quick hand sanitizer should be provided at the bedside of patients infected with multidrug-resistant bacteria in the ward. (h) Strengthen the knowledge of hand hygiene for accompanying and visiting family members, focusing on the patients' education with multidrug-resistant bacteria infection. (i) Hand hygiene supervision nurses increase the monitoring time and monitoring intensity, and pay more attention to the hand hygiene accuracy. (j) The hospital is equipped with mini bottles of hand sanitizers, which can be carried by medical staff expediently.

3.1.2. Stage D

The intervention measures were implemented in the D phase, the hand hygiene implementation data of the same batch of people were collected, the improved hand hygiene compliance was compared with the compliance in the P phase, and statistical analysis was performed. The responsible nurse or doctor monitored by the hospital infection control team records the implementation of hand hygiene for each observation subject, and the correct operation of each hand hygiene time is marked as "yes," and the employees who have no idea of washing hands are marked as "no." All departments provide hand sanitizer with alcohol-free hand sanitizer instead of soap or running water. The latter's disinfection effect is obviously inferior to that of quick hand sanitizer. In this D stage, all the improvement measures had been completed thoroughly, and all the hand hygiene executions were supervised as the forms.

3.1.3. Stage C

In Phase C we continuously implemented improvement measures, and checked whether the problem is improved, whether new problems appear, and the effect of the improvement in clinical application. Standardize statistical data and record accurately in real time. In this stage, the correctness of the methods and methods in the previous stage of self-inspection, and in the repeated problems, the verification stage is to find out the root cause of the problem, find out countermeasures, and make adequate preparations for the next stage of cyclic quality management using PDCA management cycle. For example, if the monitoring personnel are not strict

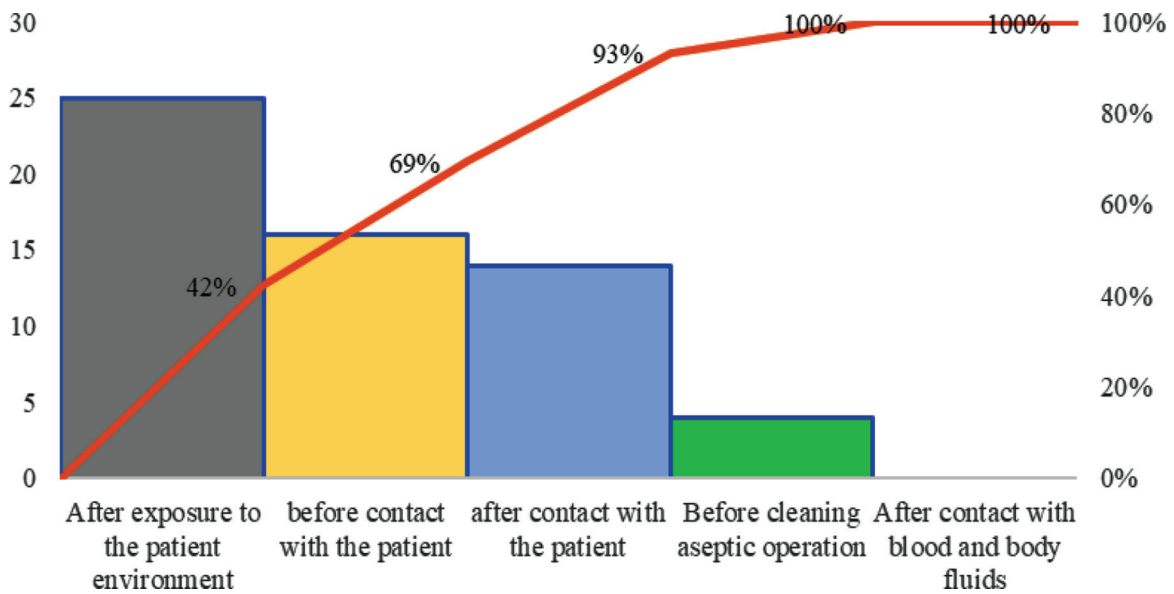


Figure 1. Unexecuted timing of hand hygiene in the first quarter Plato.

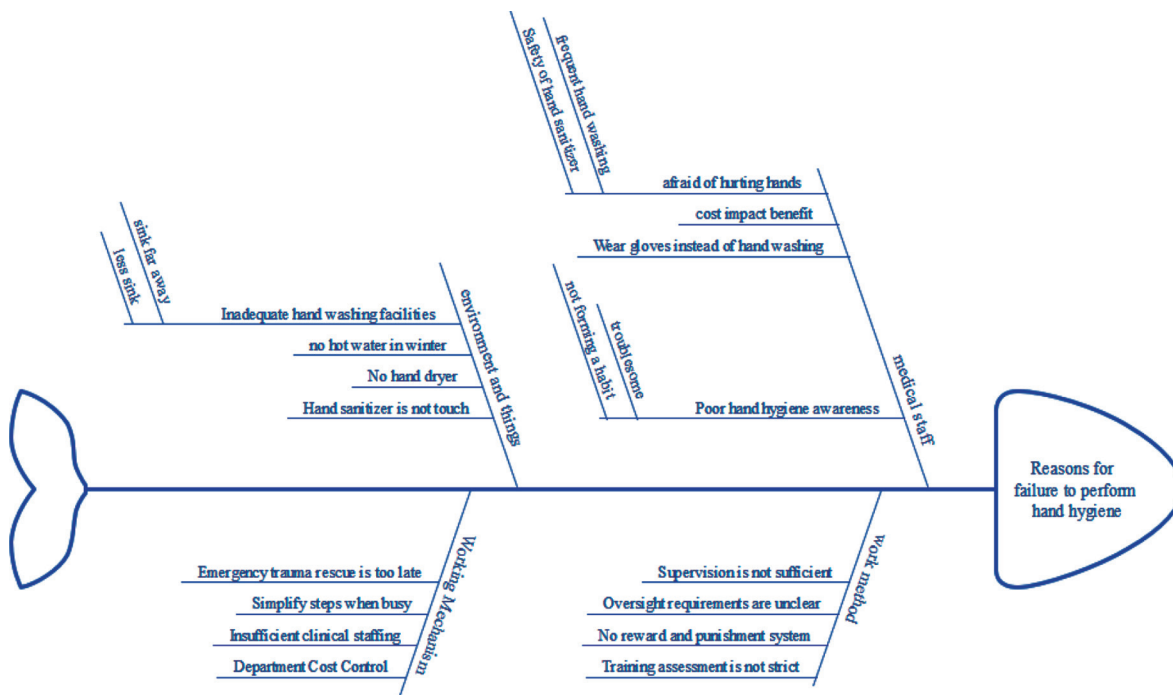


Figure 2. The reason why the timing of hand hygiene was not carried out in fishbone chart analysis.

Medical staff	Total monitoring time	Actual execution time	Compliance	χ^2 value	P-value
Physician	125	102	82%	17.308	<0.001
Nurse	200	164	82%		

Table 1. Comparison of hand hygiene compliance of orthopedic medical staff in the first quarter.

enough, it can be done by strengthening the testing frequency of quality control personnel and strictly following the standard. It is well known whether the timing of hand hygiene is correct or not advocated by the WHO. Due to the insufficient handwashing facilities, we had set up sufficient numbers and touch-enabled devices within the correct standards of the disinfection and isolation system.

3.1.4. Stage A

Stage A is the continuous implementation of the improvement measures in the previous stage. Once again, there are also new problems and unresolved problems. It is the concern that needs to be improved in the next stage of the hand hygiene PDCA cycle. At the same time, it also shows that the policy of hospital quality control needs to be monitored and implemented repeatedly. The time after contacting with the patient environment and before the contact with the patient is the lowest hand hygiene compliance stage of medical staff, and

the most non-implementation time. In the next PDCA cycle, concentrated measures to improve hand hygiene can achieve the purpose of continuous improvement and improve orthopedics quality of nosocomial control in wards. It makes the hand hygiene monitoring program a big loop and a small loop, and the PDCA cycle spirals upwards, which continuously improves hand hygiene compliance. PDCA management cycle is an efficient model to improve the medical operation quality, and in this study, it plays a critical role in increasing the executions of orthopedics staff.

3.2. PDCA intervention outcomes

The hand hygiene compliance of doctors and nurses in the orthopedic ward was both 82% in the first quarter, and the difference was statistically significant, as shown in Table 1. After the root cause analysis of PDCA, in the second quarter of the implementation of the rectification measures, the compliance of hand hygiene in the ward was improved. In 2021, when PDCA was

Medical staff	Total monitoring time	Actual execution time	Compliance	<i>t</i> value	<i>P</i> -value
Before implementation	325	266	82%	4.070	0.000
After implementation	440	407	93%		

Table 2. Comparison of hand hygiene compliance in the first and second quarters.

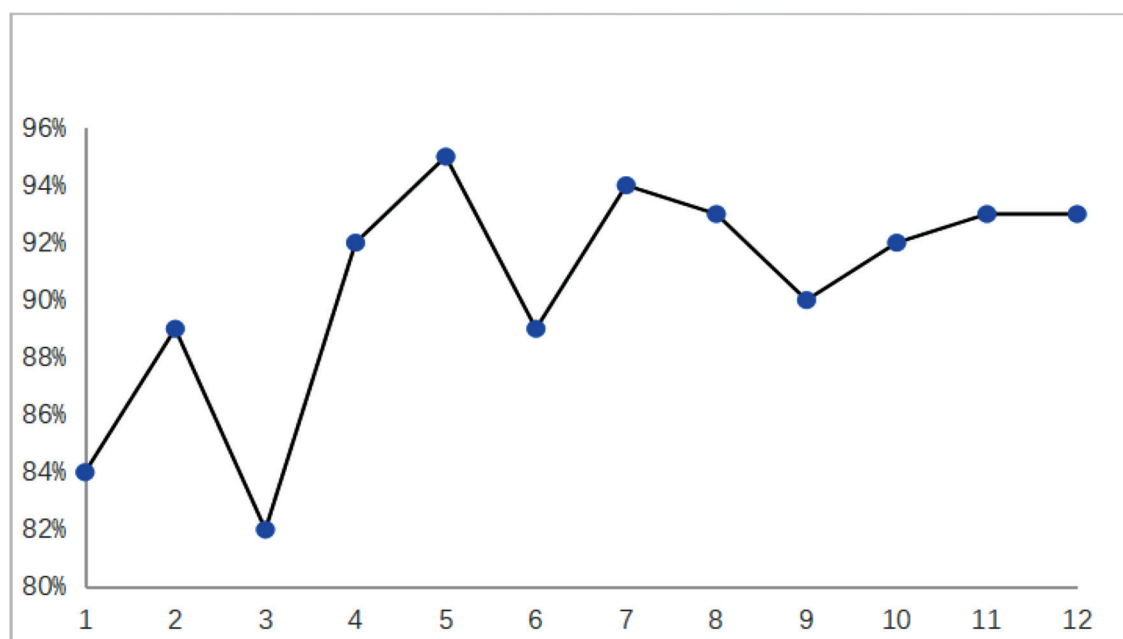


Figure 3. Nosocomial infection score of orthopedic self-examination in 2021.

not implemented in the orthopedic ward, the timing of hand hygiene was monitored 325 times, among which hand hygiene operations were performed. The number of times was 266, and the compliance was 82%. After implementing PDCA cycle management, a total of 440 hand hygiene timings were monitored, 407 times were performed, and the compliance was 93%, as shown in Table 2. During 2021, the quality of hospital infection control in orthopedic wards has also improved, as shown in Figure 3. Through this round of PDCA quality management of hand hygiene, the scores of self-examination of hospital infection were also significantly improved.

4. Discussion

The first quarter, there were 325 times of hand hygiene monitoring and 266 times of execution time for orthopedic medical staff. There was a significant difference between physicians and nurses in the implementation of hand hygiene. Considering that nurses are mostly workers, they are busy and they wash their hands frequently. It can be seen from Figure 1 that hand hygiene was not performed the most times after contacting with the patient's environment. Hand hygiene compliance at the 3 timings after contacting with the patient's environment, before contacting with the patient, after contacting with the patient, and these 3 times are key links in the improvement of hand hygiene quality. Therefore, members of the hospital infection control team brainstormed to find out the reasons why hand hygiene was not implemented and the main measures for quality improvement. During the implementation stage, when the hospital quality control nurses were tracked in real time, and when there was a total of 440 times where hand hygiene was to be performed, it was actually performed 407 times, it was not performed 33 times, and the hand hygiene compliance was 93%. Taking the second quarter compared with the first quarter as an example, comparing the hand hygiene compliance before and after the implementation, there is a significant statistic difference, proving that the PDCA cycle is beneficial to improving hand hygiene compliance. Hand hygiene compliance was 94% in the third quarter and 95% in the fourth quarter, showing the continuous improvement of the PDCA cycle. Considering the actual situation of the medical environment and the hand hygiene compliance of medical institutions reported in the literature, the hand hygiene compliance of this project is relatively high. Considering the large impact of the Hawthorne effect, the sample size and monitoring time will be increased in the next quality improvement

cycle. Fixed monitoring personnel conducted year-on-year and month-on-month difference analysis of hand hygiene compliance across years. The availability and accessibility of hand hygiene facilities and nosocomial infection monitoring procedures influence hand hygiene compliance.¹⁷ By increasing handwashing facilities in wards and corridors, and training on-the-job medical staff and related medical practitioners, the project not only benefits patients but also reduces the incidence of hospital-acquired infections, hospital costs, and medical healthcare system burdens.¹⁸ The study is consistent with its findings. This project does not combine the results of the hospital-level quality control of the department's quality of life, and the effect is somewhat high. In the future, it will be considered to combine the hospital-level supervision results and the laboratory air culture results of the ward to ultimately prove the effectiveness and feasibility of continuous quality improvement measures.

WHO hand hygiene strategy includes 5 aspects: providing alcohol-based hand sanitizers, systematic training and education, monitoring and feedback on implementation, visual reminders to medical staff, and adhering to the concept of patient safety.¹⁹ Hand hygiene compliance is affected by objective conditions such as medical staff's professional knowledge, values, work attitude, hospital working environment, stress coping style, bed-to-care ratio, and bed occupancy rate.^{20,21} Mastering and improving hand hygiene measures can improve hand hygiene compliance and quality of hospital nosocomial infection.²² Department phones, computer keyboards, and doorknobs are the most polluted but most easily overlooked places, and the monitoring of such equipment should be strengthened. The American intensive care unit installs electronic display screens in the middle of the beds, which improves hand hygiene compliance, but the remote monitoring equipment cannot judge the quality of the operation and needs to be further improved.²³ WHO claims that the observational method to solve poor hand hygiene level has a certain exaggerated effect, and it can be combined with professional hand hygiene testing tools to more truly reflect the actual implementation rate of hand hygiene.²⁴ The actual data observed in the medical scene cannot reflect the situation in the real work time,²⁵ these data have little effect on the improvement measures in the later stage, and even have an affection on the improvement effect.²⁶ Compared with traditional observational methods for monitoring hand hygiene compliance and self-inspection checklists, the improved hand hygiene quality control tool includes several practical questions,²⁷ whether all employees are subject to comprehensive hand hygiene for up to

2 years. Hospital sense knowledge training? Are all handwashing facilities properly designed? The quality control in the form of question and answer not only inspected the basic knowledge of hospital sense but also improved the hand hygiene awareness of medical staff. Improving hand hygiene observation methods and monitoring facilities can not only reduce the impact of the Hawthorne effect but also stimulate the awareness of hand hygiene among medical staff.

Surgical perioperative hand hygiene compliance was the worst, with improvement programs led by physicians, anesthesiologists, nurses, and sensory control specialists, including education, reminders, and feedback, hand hygiene compliance increased from 68% before intervention to 79% after intervention, and the program can constitute an infinite loop to continuously improve hand hygiene compliance.²⁸ Multidisciplinary collaboration combined with quality control at the hospital and department levels plays an important role in reducing multidrug-resistant bacterial infections, and the improvement of hospital nosocomial infection quality is significantly related to the improvement of hand hygiene quality.²⁹ Open wounds are a good host for bacteria and viruses, therefore, quality control of hand hygiene in orthopedic wards is crucial; medical staff do not wear jewelry, and proper hand hygiene and hand disinfection are performed to protect the health of hands and skin, which can reduce surgical site infections rate to ensure the safety of surgery.³⁰ Incorporating visitors into the quality control object and controlling the number and time of visitors is the guarantee for the wound healing of patients.³¹ The 5 timing interventions for hand hygiene implemented in Haiti's neonatal intensive care unit have achieved significant results in both medical staff and children's parents as monitoring objects, with significant statistical differences. The most important link is that the subjects do not know the monitoring hands and the observer role of hygiene enforcement reduces the impact of the Hawthorne effect.³² The PDCA cycle helps hospital infection monitoring personnel in medical institutions to quickly find out the reasons for poor hand hygiene compliance, grasp the current situation of hand hygiene implementation in departments and hospitals, and help formulate continuous improvement measures. This quality control measure has been implemented and confirmed in many places and centers.^{12,33,34} PDCA management of hand hygiene, knowledge assessment, and patient satisfaction have achieved excellent results. It is a feasible quality management theory and is worthy of clinical promotion.³⁵ Rectification measures from methods, training, and feedback can effectively improve hand hygiene and quality of hospital nosocomial infection.³⁶

5. Conclusions

Improving hand hygiene monitoring tools and collecting the implementation status of individual medical staff in real time can significantly improve the implementation status of nosocomial infection and hand hygiene. At the same time, it can also collect other relevant data during medical operations, providing strong and credible evidence for the improvement of medical quality. Improving relevant systems, improving relevant facilities, improving one's own professional knowledge, and strictly implementing aseptic operation and disinfection and isolation systems are the primary measures to ensure medical safety. Hand hygiene is an important part of standard prevention and the top priority of nosocomial infection prevention and control. To sum up, there may be a positive correlation between the quality improvement of hand hygiene and the quality of nosocomial infection. The 2 measurements link each other and are an important guarantee for nosocomial infection control.

Innovation and limitation

It is good to use PDCA cycle management model in the nursing process and medical events. Our study is useful for other nursing management interventions during the deep research in the future.

We have not recorded the timings by interns, which is rigorous for the data due to students' performing blindness, and we have not compared the data in different years because of some objective limitations.

Author contributions

RL conceived and designed the study. YS performed the majority of this manuscript. All the authors contributed to the article and approved the submitted version of this manuscript.

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Ethical approval

This study was approved by the ethics committee of School of Nursing and Health of Henan University (IRB approval number: HUSOM2020-303).

Conflicts of interest

All contributing authors declare no conflicts of interest.

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