Journal Pre-proof

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PII: S2352-0132(20)30047-8

DOI: https://doi.org/10.1016/j.ijnss.2020.03.009

Reference: IJNSS 483

To appear in: *International Journal of Nursing Sciences*

Received Date: 23 March 2020

Accepted Date: 29 March 2020

Author statement:

Yan Song: Conceptualization, Methodology, Writing- Original draft preparation. **Wenhui Wang**: Data curation, Writing- Original draft preparation. **Lijun Zhang**: Writing- Original draft preparation. **Sha Li**: Writing- Original draft preparation. **Guilan Lu:** Conceptualization, Writing- Reviewing and Editing, Supervision.

Effect of Optimization of the Infusion Process on Patients with Novel Coronavirus Pneumonia ☆

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☆ This article is based on a previously published article in Chinese [Chinese Journal of Nursing, 2020, 55(3):362-7. DOI: 10.3761/j.issn.0254-1769.2020.03.009].

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Conflicts of interest

None.

Optimization of the intravenous infusion workflow in isolation ward for patients with coronavirus disease 2019

【Abstract】

Objective This study aimed to evaluate the effect of optimization of the infusion workflow in in isolation wards for patients with coronavirus disease 2019.

Methods The infusion management group optimized the infusion workflow based on Hamer's Process Reengineering Theory and applied it to the treatment of patients with coronavirus disease 2019. The infusion efficiency, patients' satisfaction and economic indicators before and after optimization were compared.

Results After the infusion workflow was optimized, average time for preparation drugs and intravenous admixture，and patients' waiting time decreased from 4.84 minutes, 4.03 minutes, and 34.33 minutes to 3.50 minutes, 2.60 minutes, and 30.87 minutes, respectively, patients' satisfaction increased from 66.7% to 93.3%, the cost of personal protective equipment (PPE) decreased from 46.67 sets and 186.6 CNY per day to 36.17 sets and 144.6 CNY, with statistical significance.

Conclusion The optimization of the intravenous infusion workflow can effectively decrease the cost of PPE while improving the efficiency of infusion and patients' satisfaction.

【Key words】

COVID-19

Drug Compounding

Intravenous Infusions

Patient Satisfaction

Personal Protective Equipment

Workflow

What is known?

- Process reengineering is a management idea put forward by Michael Hammer and Jame Champy. It has been applied to the management of various fields in China and other countries, and has achieved good results.

What is new?

- The present study finds it is effective to optimize the intravenous infusion workflow in isolation ward for patients with coronavirus disease 2019. It is helpful to increase efficiency and patient satisfaction, and reduce cost.

1. Introduction

Since December 2019, cases of coronavirus disease 2019 (COVID-19, new coronavirus pneumonia) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) have been reported [1]. The disease spreads rapidly and patients infected suffered from several complications [2,3]. The *Technical Guidelines for Prevention and Control of Novel Coronavirus Infection in Medical Institutions (First Edition)* [4] points out that when medical personnel contact patients with COVID-19, they need to take protective measures such as droplet isolation, contact isolation, and air isolation. Intravenous infusion [5] is an important treatment method in the designated hospital for this epidemic. Nurses need to wear multiple layers of personal protective equipment (PPE) in isolation wards [6], including disposable caps, protective goggles, protective face shields, N95 masks, full-body protective clothing, disposable isolation gown, two layers of shoe covers, and at least two layers of latex gloves. Compared with working in general wards, their physical and mental burdens are greater [7], as such, difficulties in nursing operation increase, the time to perform the work is longer, work efficiency decreases, and patients' satisfaction decreases due to long waiting time for treatment. Process reengineering is a management idea put forward by Michael Hammer and Jame Champy of the United States. Its purpose is to improve overall work efficiency by optimizing the process. It has been applied to the management of various fields in China and other countries, and has achieved good results [8, 9]. Its core idea is to improve work efficiency and optimize productivity by reorganizing and optimizing the organization, composition, and operation steps in enterprise processes [10]. Its main approaches include equipment renewal, material substitution, step simplification, time sequence adjustment, etc. [10]. In process optimization and implementation, continuous improvement should be made to the process in order to obtain the best results. This theory has been applied to management by enterprises and has also achieved good results in hospital management, such as surgical management [11], ward-nursing operations [12, 13], chronic-disease management [14], and others. To improve the efficiency of intravenous infusion treatment in the isolation ward, our hospital used reengineering theory to evaluate the infusion workflow, searched for the steps that could be improved, optimized the process, and achieved good results.

2. Participants and Methods

2.1 Participants

The study subjects included 30 patients treated in the isolation ward of our hospital and 30 front-line nurses from January 19, 2020 to January 30, 2020. The inclusion criteria for patients were: 1) confirmed patients with COVID-19 or suspected cases according to the *Diagnosis and Treatment Plan for COVID-19 (5th Trial Version)* [3]; 2) conscious and capable of effective communication; and 3) requiring intravenous infusion therapy. The average age of patients in this study was 42.39±10.54 years, with 17 males and 13 females, 25 confirmed cases and 5 suspected cases.

There were three isolation wards in our hospital. Nurses work in 4-hour shifts. There were four nurses on duty in the morning, three in the afternoon, and two at all other times. The nurses were all women, with age of 33.25±4.38 years, median nursing experience of 10 years (range 4–29), and 27 with bachelor's degrees.

All subjects voluntarily participated in this study.

2.2 Methods

From January 19 to 24, 2020, the intravenous-infusion workflow before optimization in the isolation ward was as follows: 1) The medical personnel wearing PPE entered the isolation area; 2) Doctors entered medical orders into the computer information system after examining patients; 3) Medical-order-processing nurses checked prescriptions; 4) Medical-order-processing nurses printed intravenous infusion sheets and labels; 5) Drug-dispensing nurses double-checked and prepare drug solutions; 6) Two responsible nurses double-check and administer the intravenous infusion. All steps were carried out in the isolation area.

Process reengineering includes five main steps including establishing the process improvement team, identifying the process steps to be improved, re-optimizing the process, implementing the optimized process, and evaluating the new process. This study used this approach to optimize the intravenous infusion workflow and evaluated the optimized workflow in isolation ward for patients with COVID-19 from January 25 to 30, 2020.

2.2.1 Organizing a team to manage the intravenous infusion workflow

According to China's guidelines for outbreak control of hospital infections, prevention and control of hospital infections needs to be managed by a team of multidisciplinary experts in clinical medicine, nursing, epidemiology, management, microbiology, etc. [15, 16]. Intravenous administration management is an important treatment method in hospital, and its process optimization requires team cooperation. This research team consisted of a chief physician, a chief nurse, a head nurse of isolation ward, an infection-control expert, and two responsible nursing-team leaders. Each step of the infusion workflow was evaluated to identify if it could be improved or not. Then, the optimized design was carried out, optimized process were formulated, nurses were organized for training, the status of process-operation was recorded, and supervision and feedback were incorporated into the process implementation.

2.2.2 Formulating an optimized intravenous infusion workflow

The managing team evaluated the original intravenous-infusion workflow for patients with COVID-19, evaluated all steps and consulted relevant data, and found that there were problems with the routine workflow. Wearing goggles and face shields affected nurses' vision and hearing, causing difficulties in communication and verification [17]. Wearing a full set of PPE increased the operational difficulties. Some process could be conducted outside the isolation area, such as documentary medical-order processing, printing infusion itineration sheets and labels, drug preparation and intravenous admixture.

The managing team conducted a feasibility analysis based on the actual situation and decided the optimization strategies as follows. 1) Setting up a special, hygienic medical-order-processing and drug-dispensing area near the isolation area. 2) Relocating medical-order processing to the hygienic area outside of the isolation area, where nurses do not need to wear a full set of PPE. 3) Relocating intravenous admixture to the hygienic area outside of the isolation area. Nurses in this area do not need to wear PPE. The optimized intravenous infusion workflow is shown in Fig. 1.

2.2.3 Training of medical staff and implement the optimized infusion workflow

Strengthening training on relevant knowledge for doctors was conducted, such as updated diagnosis and treatment plan for patients with COVID-19. Doctors were requested to determine the treatment plan and entered medical orders according to standards. Front-line nurses were trained on their tasks and responsibilities in the optimized workflow. Training on knowledge and skills to use electronic products were provided to improve work efficiency.

2.2.4. Outcome measurements

We compared the following indicators before and after the optimization of the infusion workflow.

2.2.4.1. Work efficiency. The infusion efficiency data measured by working-hour is relatively accurate [18]. Time-motion was used to measure work efficiency of the optimized workflow. At the beginning of the study, the nurses participating in the study were trained on measurement methods, equipped with timers, and instructed on the correct use of timers and recording. 1) Preparation time: The time required for the medical-order-reviewing nurse to review the medical order and print the intravenous infusion sheets and infusion labels after a doctor made medical prescriptions; 2) Intravenous admixture time: The time required for verification, laying out of drugs, preparing drug-administration supplies, disinfection, reconstituting drugs, re-verification, and handling drug administration supplies; 3) Wait time for each patient: The time from verification of a medical order by the medical-order-reviewing nurse to starting of the intravenous infusion..

2.2.4.2. Patient satisfaction. On the last day of the two study periods, i.e., January 24 and 30, 2020, a questionnaire was completed using a self-made electronic questionnaire on the satisfaction of patients with novel coronavirus infection with the nursing care that they received. The questionnaire was based on the Inpatient Satisfaction and Experience Monitoring Scale [19] and the Press Ganey Patient Satisfaction Survey [20], with a total of 15 queries. The Likert scoring method was used. Scores of 1 to 4 points indicate “very dissatisfied,” “dissatisfied,” “satisfied,” and “very satisfied,” with a total score of 60 points. In this study, a total score ≥40 points was regarded as satisfied and <40 points as dissatisfied.

2.2.4.3. Cost of protective materials. The direct observation method was used to record the numbers of PPE consumed (including protective clothing, gloves, caps, goggles, N95 masks, shoe covers, and face shields) and their disposal cost for 5 days during the two study periods, the average values were compared.

2. 3. Statistical methods

Statistical analyses were done using the SPSS software, version 20.0. The work efficiency and cost of PPE were expressed with mean and standard deviation (*SD*), and a *t*-test was used to compare the data obtained before and after optimization of the workflow. Patient satisfaction was measured by enumeration data and chi-square test was used to compare satisfaction before and after optimization of the workflow. $P < 0.05$ was considered to be statistically significant.

3. Results

3.1. Comparison of work efficiency before and after optimization of the workflow (Table 1)

Table 1. Comparison of work efficiency before and after optimizing the intravenous infusion workflow (*minute*, *Mean±SD*)

Time	*n*	Preparation time	Intravenous admixture time	Wait time for each patient
Before	30	4.84±0.55	4.03±0.50	34.33±9.55
After	30	3.50±0.68	2.60±0.36	30.87±5.53
t		9.010	14.61	2.686
P		<0.001	<0.001	0.012

3.2. Comparison of patient satisfaction before and after optimization of the workflow（Table 2）

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Table 2. Comparison of patient satisfaction before and after optimization of the intr avenous infusion workflow [*n*(%)]

Time	*n*	Satisfied	Dissatisfied
Before	30	20 (66.7)	10 (33.3)
After	30	28 (93.3)	2 (6.7)

Note: $\chi^2 = 6.667$, $P = 0.011$.

3.3. Comparison of cost of PPE before and after optimization of the workflow（Table 3）

The PPE used in out hospital including protective clothing, isolation gowns, shoe covers, protective goggles, protective face shields, N95 masks, disposable caps gloves were calculated.

Table 3. Comparison of cost of PPE per day before and after optimizing the intravenous infusion workflow (*Mean±SD*)

Time	PPE (set)	Cost of disposal PPE (CNY)
Before	46.67±1.63	186.6±6.53
After	36.17±0.75	144.6±3.01
t	18.66	18.659
P	<0.001	<0.001

4. Discussion

During major public-health emergencies, PPE often becomes scarce resource. Once PPE is no longer available, it becomes extremely difficult to carry out rescue work [21]. Given the shortage in PPE, the managing team of intravenous infusion workflow optimization conducted a feasibility analysis based on the current situation and optimized the whole workflow, by which not only the work efficacy and patients satisfaction were improved, but also the cost of PPE was reduced.

Infusion treatment is a key index for evaluating nursing quality, safety, and efficiency [22, 23], that takes up a lot of time of nursing in China. In 2016, China issued the *Planning Outline of Healthy China 2030*, which raises the improvement of nursing efficiency and service quality to the height of national strategic management [24]. In this study, the transfusion process was modified according to process reengineering theory, which improved infusion efficiency. The core idea of this theory is to reorganize and optimize the organization, composition, and operation of the existing process, and to improve the overall work efficiency and increase income by means of equipment renewal, process simplification, and timing adjustment [10]. In this study, the medical-order processing and intravenous admixture were not performed in the isolation area, and personal digital assistants (PDAs) were provided to nurses, thus shortening the infusion working time and improving the overall infusion efficiency. The results showed that after optimization, the preparation time before intravenous admixture was shortened from 4.84 minutes to 3.50 minutes; the intravenous admixture time, from 4.03 minutes to 2.60 minutes; and the waiting time for each patient shortened. The possible reason was that when providing infusion treatment to patients with COVID-19, the nurses involved in the medical order processing step and intravenous admixture step after optimization did not need to wear heavy PPE; therefore, the influence on vision and hearing were reduced, and the degree of difficulty encountered was lesser than that noted previously. On the premise of ensuring the safety of patients, the overall drug preparation time was effectively shortened, patients were treated in time, and their satisfaction was also improved.

Due to time and manpower constraints, this study only completed a 12-day survey in 30 patients and 30 nurses. This is the limitation of this study.

5 Conclusion

The COVID-19 epidemic is a relatively serious, complicated, and widespread public health concern in the world. The rapid progression of the epidemic poses many challenges to the relevant administrative authorities and medical institutions, including challenges in manpower and material resources. Optimizing workflow based on process reengineering theory provided a potential way to improve work efficiency and reduce PPE consumption during the epidemic.

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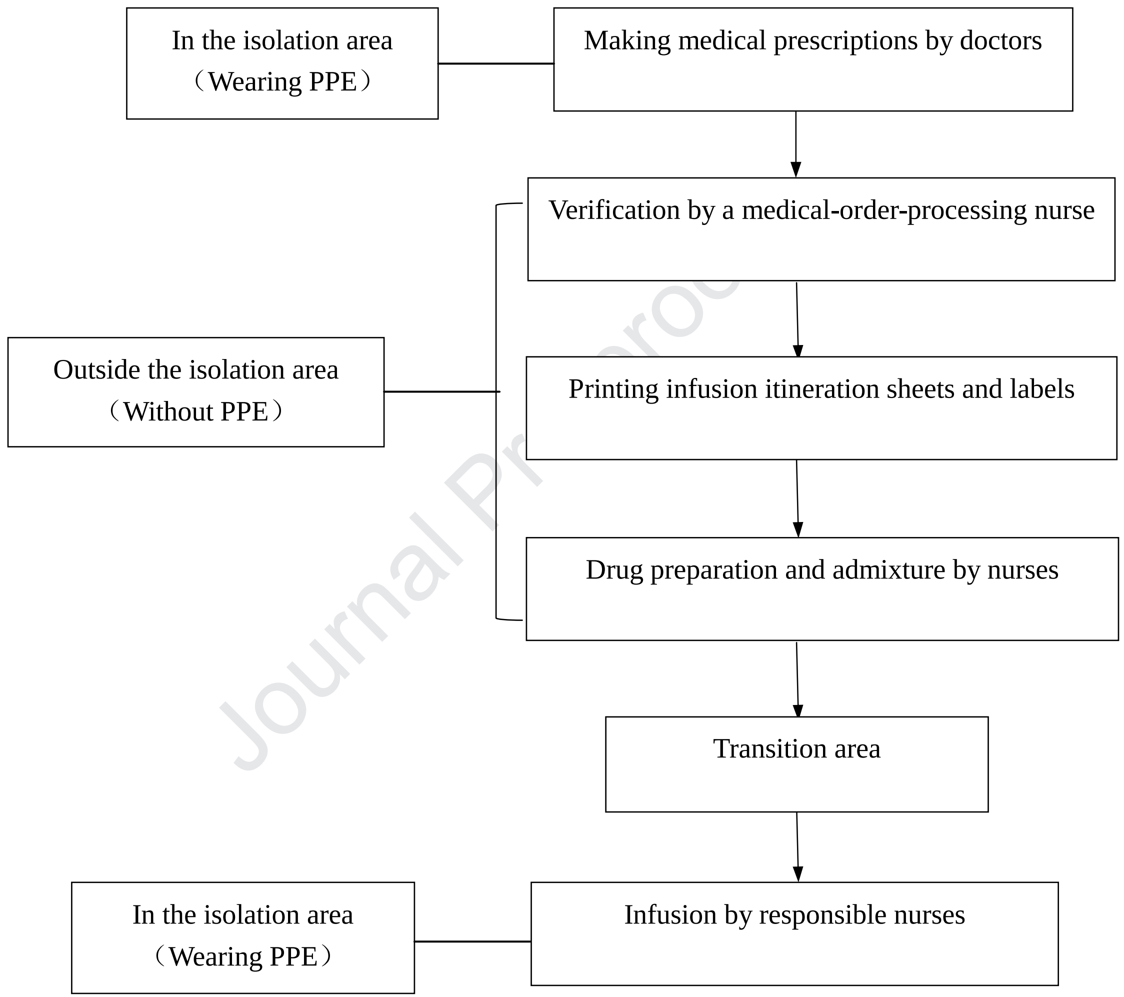

Fig.1. Flowchart showing the optimized intravenous infusion workflow in isolation ward