Observational Study

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Research and development of safety management information system for neonatal bathroom and its clinical application

(A STROBE-compliant article)

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Abstract

We developed a bathroom safety management information system to decrease adverse nursing events, and observed the application of the self-developed safety management information system in neonatal bathroom.

A total of 3482 newborns receiving neonatal bath and rooming in between May 2015 and May 2017, were enrolled in this study. Of the 3482 newborns, 1727 that did not use the safety management information system from May 1, 2015 to May 31, 2016, were considered as control group; and other 1755 that used the safety management information system from June 1, 2016 to May 31, 2017 were entered in observation group. The accident rate of adverse nursing events, the duration to check wristbands, response time of urgency call, quantitative data recording for nursing procedures, and pregnant women's and their families' satisfaction degree were compared between the 2 groups.

The management information system possesses 4 functions including personal identification, nursing operation quantification, monitoring alarm and music function, and guidance on specialized knowledge and skills. The accident rate of adverse nursing events was significantly lower in the observation than in the control group ($P < .05$). The duration to check wristbands and the response time of urgency call were all significantly shorter in the observation group than in the control group (all $P < .05$). Quantitative data recording was significantly better in the observation than in the control group ($P < .05$). Satisfaction degree was significantly higher in the observation group (96.47%) than in the control group (89.69%) ($P < .05$). The wireless transmission information was exact and safe, and the system was sensitive and reliable.

The system not only is clinically practical but also can enhance the safety of newborns and improve pregnant women's and their families' satisfaction degree.

Keywords: clinical application, informationization, quality of nursing, safety management

1. Introduction

With the transformation of nursing pattern, bedside nursing care for mother and infant as a new nursing mode has been carried out and extended rapidly in China.[1] However, in many hospitals, the neonatal bathroom was managed in independent and closed mode. The neonatal bathroom is an important place where neonatal bath, routine treatment of umbilical cord, vaccination, disease screening, and blood collection were performed by bathrooms' nursing staffs. Therefore, adverse events may occur when the nursing staff is weak on the awareness of safety management or inexperienced in handing emergent events because young nurses account for a large proportion in clinic.[2] Based on the actual conditions, we self-designed the safety management information system for neonatal bathrooms to improve neonatal safety and avoid adverse nursing events.

2. Materials and methods

All study methods were approved by the Ethics Committee of the Second Affiliated Hospital of Nantong University. All the subjects enrolled into the study gave written formal consent to participate.

2.1. Design

The bathroom safety management information system consists of the central monitoring system, wireless network system, and bath-electronic system. Its principle is shown in Fig. 1. This system was a subsystem of rooming in safety management information system[3] which has 4 areas including personal identification recognition, nursing operation quantification, monitoring alarm and music function, and guidance on

Editor: Daryle Wane.

Funding: The project was funded by BK Application research Plan of Nantong in 2013 (No.BK2013009).

No conflict of interest to disclose.

Supplemental Digital Content is available for this article.

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Medicine (2018) 97:51(e12345)

Received: 29 March 2018 / Accepted: 21 August 2018

http://dx.doi.org/10.1097/MD.0000000000012345

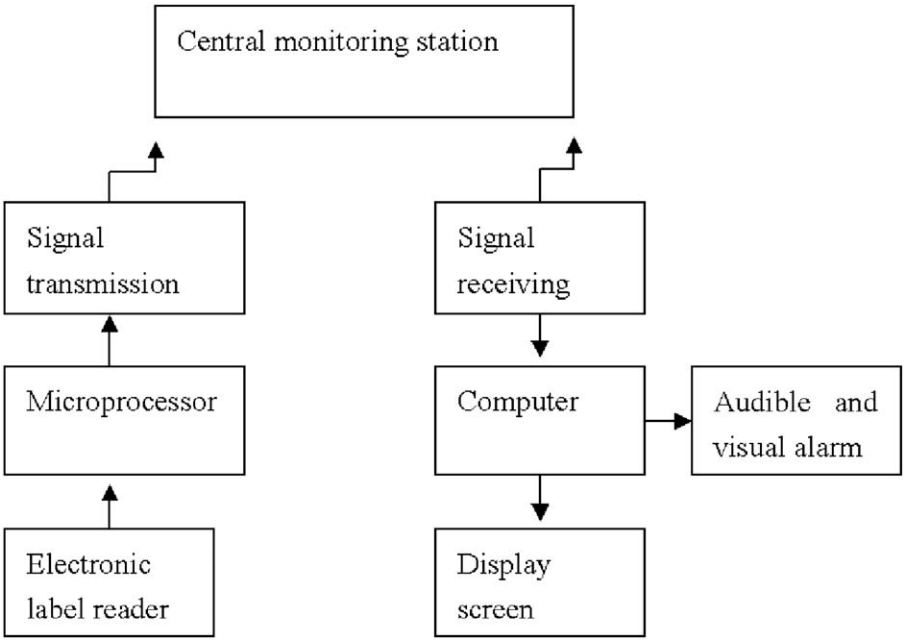

Figure 1. Block diagram showing the principle of bathroom safety management information system.

specialized knowledge and skills. Through the integration of data, information, and knowledge performed by information structure, information flow and information technology, the mobile information interaction system was established using Microsoft visual programming tools [Microsoft Inc (Redmond, Washington, USA)] and SQL 2010 SERVER VS 2005 database.

2.2. Personal identification recognition system

Neonatal wristbands, smart labels, have the functions including human identification recognition, object tracking, and information acquisition. Neonatal information was inputted into a computer by nurses, and then was written in the electronic tag on wristbands through reader-writer. The wristbands were tied around neonatal wrist joint in proper tightness. When the newborn began to take a bath, the neonatal electronic tag was scanned, and all neonatal information was automatically showed by the computer through the recognition system. After the bath, neonatal and maternal electronic tags all were scanned. If the information was consistent in neonatal and maternal electronic tags, the lamp was green; if the information was not consistent, the lamp was red with alarm which was transmitted to the nurse's central station and bedside electronic card through wireless-fidelity.

2.3. Quantitative system for nursing procedures

The nursing operation quantification system included neonatal information database, vaccination, infection control, disease screening, and so on. The neonatal information database is shown in Supplementary Table 1, http://links.lww.com/MD/C532. Each item in the supplementary Table 1, http://links.lww.com/MD/C532 was observed and timely inputted into the system. Neonatal body length was measured using automatic determinator. According to the different stages of neonatal growth, the newborn received the first kind of vaccination, including BCG and hepatitis B vaccine during the hospitalization. Infection control mainly included a variety of monitoring data, such as air monitoring in the bathroom, and bacterial number on the surfaces of objects and staff's hands, in order to ensure the number of bacterial colonies within normal range.[4] The blood collection for disease screening mainly included the time of blood collection and testing items.

2.4. Monitoring alarm system and music function

In the bathroom, 26 to 28 °C is suitable for newborns.[5] Safety management information system had the function of real-time monitoring and alarm for indoor temperature. The temperature sensor transmitted the monitored data to the computer information system through the central processing unit. When the temperature was lower or higher than the set temperature values, the system send out alarm signal to ensure the bathroom temperature within normal range. The system had the functions of emergency alarm and voice transmission. When the conditions needed medical staff to solve, you might press the alarm button and the signal was automatically transmitted. The alarm principle is shown in Fig. 2. At the same time, the information safety management system also had music function. Music could reduce the stimulation to newborns from the strange surrounding environment and shower water stream. It could reduce neonatal stress and allowed neonatal behavior to be more stable, increasing their quiet time.[6]

2.5. Guidance on specialized knowledge and skills

This system mainly included the regimen and flow sheet about bathroom, and specialized knowledge and skills which were shown by TV, video, and network. Rules and safety measures such as bathroom regimen, as well as disinfection and isolation regimen were established and improved, and some procedures

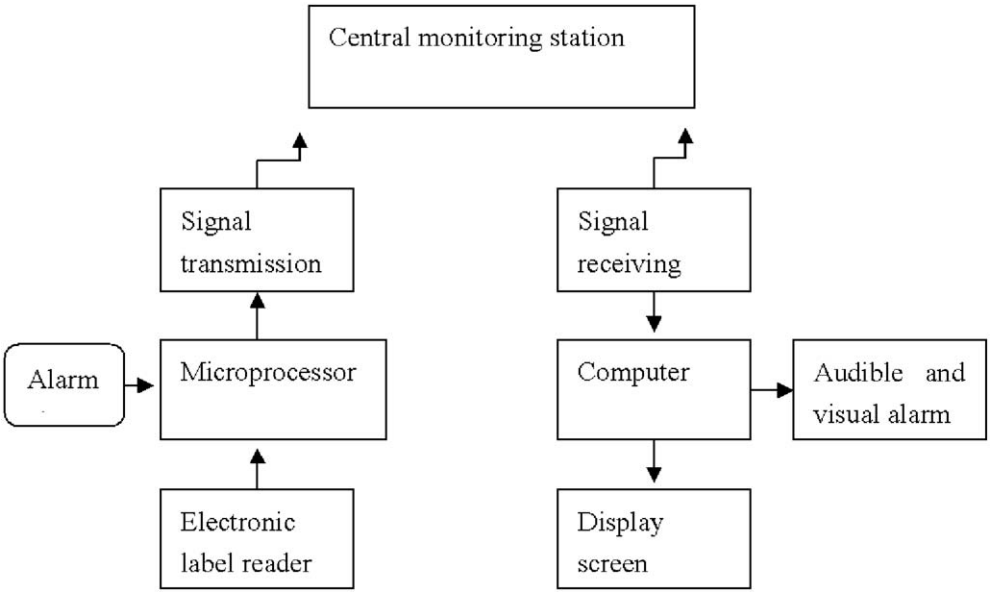

Figure 2. Block diagram showing the principle of monitoring alarm system.

about neonatal bath, vaccination, blood collection, newborn touching, and swimming were standardized using this system. Each procedure was illustrated using a program flow chart. Specialized knowledge included neonatal routine nursing, breast feeding, neonatal bath, and newborn touching during the puerperium and postpartum. Conventional techniques included isolation technology, umbilical care technology, and hip care technology. The system could show how to hold a newborn in a correct posture and how to observe a newborn. Emergency treatments included cardiopulmonary resuscitation and trachea cannula. These contents might be repeatedly shown using schematic diagram and video.

2.6. Clinical application

The inclusion criteria were body weight ≥2500 g; and Apgar score ≥8. The exclusion criteria included the neonatus requiring treatment in newborn room; the neonatus that could not undergo bath according to medical order; and the neonatus whose family member did not agree to participate in this study. Based on the above inclusion and exclusion criteria, a total of 3482 neonatus who was born between May 2015 and May 2017, were enrolled in this study. Of the 3482 neonatus, 1727 that did not use the safety management information system from May 1, 2015 to May 31, 2016, were considered as control group; and other 1755 that used the safety management information system from June 1, 2016 to May 31, 2017 were entered in observation group. The study flow design is shown in Fig. 3.

2.7. Outcome measures

Outcome measures were as follows: adverse nursing events including neonatal upper respiratory tract infection such as nasal obstruction, nasal discharge, and sneezing,[7] as well as inconsistent information between the wristband content and fact; the duration to perform identification recognition and the duration of responding to urgency call; quantitative data recording for nursing procedures including blank space without data, illegible data, and undetected error data; and pregnant women's and their families' satisfaction degree which was evaluated using a questionnaires shown in supplementary Table 2, http://links.lww.com/MD/C532. The degree of satisfaction = (very satisfactory + satisficatory)/total × 100%.

2.8. Statistical analysis

The SPSS 17.0 software was used to analysis data. The counting data were expressed as the number of cases or percentage, and group comparison was performed using chi-squared test. The measurement data were expressed as mean ± standard deviation, and group comparison was performed using t test. Statistical significance was established at $P < .05$.

3. Results

3.1. Comparison of adverse nursing events between the 2 groups

We compared adverse nursing events including neonatal upper respiratory tract infection and inconsistent information between the wristband content and fact in the 2 groups. The occurrence rate of neonatal upper respiratory tract infection and the rate of inconsistent information between the wristband content and fact all were significantly higher in the control group than in the observation group (all $P < .01$) (Table 1).

3.2. Comparison of the duration to perform identification recognition and the duration of responding to urgency call between 2 groups

We compared the duration to perform identification recognition and the duration of responding to urgency call between 2 groups. Both the duration to perform identification recognition and the duration of responding to urgency call were significantly shorter in the observation than in the control group (all $P = .000$) (Table 2).

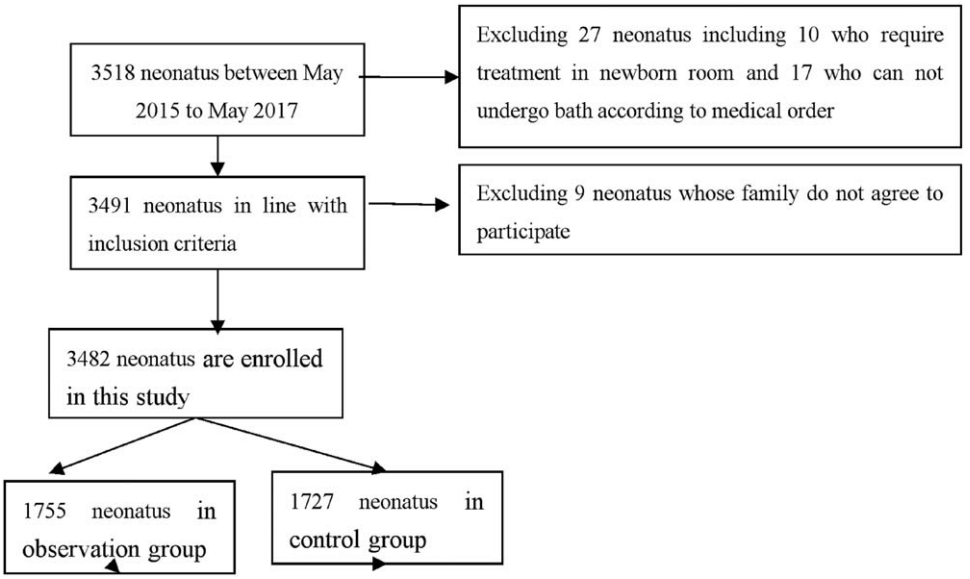

Figure 3. The study flow design.

3.3. Comparing of quantitative data recording for nursing procedures between the 2 groups

The quantitative data recording for nursing procedures was compared between 2 groups. The blank space without data, illegible data, and undetected error data were all significantly less in the observation group than in the control group (all $P = .000$) (Table 3).

3.4. Comparison of pregnant women's and their families' satisfaction degree between the 2 groups

We compared the pregnant women's and their families' satisfaction degree between the 2 groups in health education, neonatal safety measures, and neonatal identification. The satisfaction rate was significantly higher in the observation than in the control group ($P = .000$) (Table 4).

4. Discussions

4.1. Personal identification

If neonatal wristbands were exfoliated or confused, newborns are likely to be mistakenly brought to other parents or abducted by burglars.[8] Therefore, to avoid this adverse event, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) has established a good practice guideline to ensure newborn safety during hospitalization.[9] Moreover, China National Health Planning Committee also annunciated Neonatal Safety Management Regime in Medical Institutions in 2015, which required medical institutions to improve the vulnerabilities in newborn safety management including neonatal wristbands for effective personal identification. Our self-developed system can rapidly and automatically recognize neonatal identification, which avoids the mistakes made by nurses during reading, writing, and taking wristbands. When newborns were brought to undergo physical examination or had a bath, if neonatal identification was not consistent with their mother, this system would automatically alarm with sound and light, which avoided the conditions that newborns are mistakenly brought to other parents or stolen by robbers. This system improved the pregnant women's and their families' satisfaction degree for neonatal safety measures.

4.2. Hidden safety danger decreased by quantitative data recording and dynamic management

It is common that some nurses sometimes forget to observe a few items due to inexperience. In the quantitative data recording area of this system, the data on neonatal conditions are comprehensive. Besides routine monitoring items, the items easily ignored such as limb activity, defect of body surface, cyanosis, and macula also have been included in the quantitative data recording area. Neonatal conditions may be recorded in the electronic tables at any time. Abnormal data are shown in red words which can be

Table 1

Comparison of adverse nursing events between the 2 groups (n [%]).

Items	Control group (n = 1727)	Observation group (n = 1755)	χ^2	*P*
NURTI	13 (0.75)	2 (0.11)	8.281	.004
IIWCF	16 (0.93)	0 (0.00)	16.335	.000

IIWCF = inconsistent information between the wristband content and fact, NURTI = neonatal upper respiratory tract infection.

Table 2

Comparison of the duration to perform identification recognition and the duration of responding to urgency call between the 2 groups (second/$\bar{x} \pm s$).

Items	Control group (n = 1727)	Observation group (n = 1755)	*t*	*P*
DPIR	49.12 ± 5.24	6.84 ± 2.47	305.304	.000
DRUC	15.35 ± 3.27	3.21 ± 1.57	14.375	.000

DPIR = duration to perform identification recognition, DREC = duration of responding to urgency call.

Table 3

Comparison of quantitative data recording for nursing procedures between the 2 groups (n[%]).

Items	Control group (n = 1727)	Observation group (n = 1755)	χ^2	P
Blank space without data	57 (3.30)	5 (0.28)	45.262	.000
Illegible data	79 (4.57)	0 (0.00)	82.145	.000
Undetected error data	17 (0.98)	0 (0.00)	17.360	.000

transmitted to doctor's computer in order to make a treatment protocols in time. No illegible data and undetected error data occurred in this system (in Table 3), suggesting that this intelligent system can effectively avoid artificial error rate. However, there were blank spaces without data in 5 newborns of the observation group although the blank space without data was significantly less in the observation group than in the control group ($P = .000$). Therefore, it is necessary to add a reminder function before preserving data. The data in the infection control area are continuous and dynamic, and this system has a continuous improvement table about infection control quality, which is conducive to analyze causes and make proper measures, decreasing nosocomial infection. The blood collection for disease screening should be performed at 72 hours after the newborn was born and when the newborn had taken milk 6 times or more. The neonatal birth time was inputted into this system, and then the blood collection time might be automatically shown, avoiding false negative or positive results in screening diseases. This system has many functions such as data storage, query, transmission, and trend graph display, which not only decreases human resources, but also provides strong evidence for medical dispute.

4.3. Reliable monitoring and timely alarm system

The room temperature and water temperature should be constant in the neonatal bathroom.[10] The low temperature for a long time may cause neonatal cold injury syndrome, even pneumonia or pulmonary hemorrhage.[11] At present, the temperature is monitored using wall thermometers in most Chinese hospitals. Staffs neglect the changes in the neonatal bathroom temperature sometimes when they have heavy workload, which readily leads to adverse events. This self-developed system can show real-time temperature on the display screen, and send out an alarm signal to remind staffs when the temperature was higher or lower than setting range, ensuring the neonatal bathroom temperature within the normal range. Therefore, the occurrence rate of neonatal upper respiratory tract infection and other accident rates of adverse events were significantly decreased in the observation group as compared with the control group in this study. It is common for a newborn to spit up milk during bath, which may lead to asphyxia, even death. The bathroom was far from the nursing work station. In the past, once adverse events occurred, nurses called for doctors only by telephone. If the line is engaged, it will be difficult for doctors to arrive in time, losing the best time to treat the adverse events. Since the safe information system was applied in the neonatal bathroom, nurses simply press the alarm button, the emergency signal can be sent to the nurse's central station directly, ensuring that medical stuffs arrive in time for treating adverse events. In this study, the duration of responding to urgency call was significantly shorter in the observation group than in the control group, decreasing the accident rate of adverse events.

Table 4

Comparison of pregnant women's and their families' satisfaction degree between the 2 groups.

Groups	N	Satisfactory	Dissatisfied	Satisfactory rate (%)	χ^2	P
Control group	1727	1549	178	89.69	62.242	.000
Observation group	1755	1693	62	96.47		

4.4. Improving efficiency of health education and extending nursing service

Obstetric nursing service is very important and is more difficult than that in other departments. Health education is a key in the clinical nursing service. In the past, we handed out handbooks in a one-on-one to carry out health education, which consumed a lot of manpower and material resources. Therefore, TV images used in propaganda and education are increasing in recent years.[12,13] The guidance system on specialized knowledge and skills, an open education mode, is used to carry out health education not only by TV images, but also by WeChat and network station which can form readable information platforms.[14] This decreases the expense of health education and provides professional help and healthy inquiry platform both inside and outside the hospital. This system provides much help for the 2 groups including young nurses who need improvement in professional knowledge and skills, as well as pregnant women and their family who need some convenient services such as individual guidance and operative skill video both inside and outside the hospital. This system plays a role in the extension of nursing service. In this study, the satisfaction rate was significantly higher in the observation group (96.47%) than in the control group (89.69%). However, there still were 62 pregnant women who were no satisfied with our health education. This may be that pregnant women did not accept electronic education due to their lower educational level, or the health education time was inappropriate when pregnant women were in pain and poor mood. These remain to be further improved in the application of this system.

4.5. Limitation

In this study, there may be sampling bias due the data from single center. Therefore, multi-center large sample randomized controlled studies will be needed to confirm it.

Author contributions

Conceptualization: Jian-rong Chen.
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Formal analysis: Si-yu Zhang.
Methodology: Man-hua Liu.
Software: Jian Wang.
Writing – original draft: Fang Wang.

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