# Hand Hygiene Practices in a Neonatal Intensive Care Unit: A Multimodal Intervention and Impact on Nosocomial Infection

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**ABSTRACT.** *Objective.* **Health care–associated infections persist as a major problem in most neonatal intensive care units. Hand hygiene has been singled out as the most important measure in preventing hospital-acquired infection. However, hand hygiene compliance among health care workers (HCWs) remains low. The objective of this study was to assess the frequency and nature of patient contacts in neonatal intensive care units and observe the compliance and technique of hand hygiene among HCWs before and after the implementation of a multimodal intervention program.**

*Methods.* **The nature and frequency of patient contacts, the hand hygiene compliance, and hand-washing techniques of HCWs were observed unobtrusively to reflect the baseline compliance and to investigate factors for noncompliance. The intervention consisted of problem-based and task-orientated hand hygiene education, enhancement of minimal handling protocol and clustering of nursing care, liberal provision of alcohol-based hand antiseptic, improvement in hand hygiene facilities, ongoing regular hand hygiene audit, and implementation of health care–associated infection surveillance. The observational study was repeated 6 months after the completion of the intervention program, which extended over 1-year period.**

*Results.* **Overall hand hygiene compliance increased from 40% to 53% before patient contact and 39% to 59% after patient contact. More marked improvement was observed for high-risk procedures (35%–60%). The average number of patient contacts also decreased from 2.8 to 1.8 per patient per hour. There was improvement in most aspects of hand-washing technique in the postintervention stage. The health care–associated infection rate decreased from 11.3 to 6.2 per 1000 patient-days.**

*Conclusion.* **A problem-based and task-orientated education program can improve hand hygiene compliance. Enhancement of minimal handling and clustering of nursing procedures reduced the total patient contact episodes, which could help to overcome the major barrier of time constraints. A concurrent decrease in health care–associated infection rate and increase in hand hygiene compliance was observed in this study. The observational study could form part of an ongoing audit to provide regular feedback to HCWs to sustain the compliance.** *Pediatrics* **2004;114:e565–e571. URL: www.pediatrics.org/cgi/doi/10.1542/peds.2004-1107;** ***hand hygiene, education, neonatal intensive care.***

ABBREVIATIONS. NICU, neonatal intensive care unit; CDC, Centers for Disease Control and Prevention; HCW, health care worker; NNIS, National Nosocomial Infections Surveillance; BSI, blood stream infection.

Health care–associated infections persist as a major problem in most neonatal intensive care units (NICU). Neonates are susceptible to infection because their host defense mechanisms are not mature. They also occupy an environment in which frequently used antibiotics and invasive interventions often permit the invasion of common nosocomial pathogens, and the close proximity of patients in many NICUs facilitates transfer of organisms from patient to patient.

Organisms that cause nosocomial infection in NICUs are most commonly transmitted by the hands of physicians, nurses, physiotherapists, and other hospital personnel.[1–4] Hand hygiene has often been singled out as the most important procedure in preventing nosocomial infection.[5,6] The US Centers for Disease Control and Prevention (CDC) recommends hand-washing before and after contact with every patient.[7] The recommendation on hand hygiene has recently been updated, and handwashing has been replaced by hand rub as the standard of care.[8]

The importance of good hand hygiene practices in a NICU cannot be overemphasized, yet many published studies conducted in intensive care units have reported that health care workers (HCWs) failed to wash their hands more than half of the recommended times, and in many cases, the hand-washing procedure was inadequate.[9–11] Physicians in particular wash their hands significantly less frequently than nurses.[11,12]

Studies in clinical areas such as adult intensive care units, where patient contact is high, showed that strict compliance with hand hygiene occupies at least one quarter of nursing time, and implementing strict practices may affect the quality of patient care, a formidable drawback.[13] However, in NICUs, modern neonatal nursing emphasizes the concepts of minimal handling; this coupled with clustering of nursing care, the situation may become more optimistic.

The purpose of this study was to study the impact of a task-orientated hand hygiene education and in-

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tervention program, coupled with an ongoing regular hand hygiene audit on the hand hygiene compliance of HCWs. The observation study also assesses the frequency of patient contacts in the NICUs and its effect on the compliance of hand hygiene among HCWs. A nosocomial infection surveillance system was implemented to assess the impact of hand hygiene compliance on the infection rate in the NICUs.

## METHODS

### General NICU Settings

The study was conducted in the NICU of Queen Mary Hospital, The University of Hong Kong. This is a 12-bed NICU, which admits in-born and out-born infants <28 days with medical and surgical conditions. There was 1 washing basin in every cubicle, each accommodating a maximum of 6 patients. The mean distance between patient and washing basin was 3.9 ± 2.0 meters. During the second observation period, the water taps of the washing basins were modified to allow hands-free operation by fitting an infrared automatic sensor. Antiseptic alcohol-based hand rub was also made available at each incubator.

### Observation Study

The hand hygiene compliance and techniques were observed unobtrusively by the observer under the guise of medical students assigned to document NICU activity in the units. The observer underwent 1 week of training to become familiarized with NICU procedures and settings. The consistency of the observation criteria was validated by checking on selected episodes immediately after each observation period by 1 of the authors. The observation period lasted for 4 weeks and covered daytime shifts when most activity occurred. A target NICU patient was selected randomly by drawing lots before each observation period, which lasts for 8 hours. All personnel who contact the target patient, which included doctors, nurses, allied health (eg, physiotherapists, occupational therapists, radiographers), and others (eg, visitors) were observed. Types of personnel were documented, but names were not recorded. The general NICU settings and patient characteristics, including the number of indwelling devices (eg, intravenous line, umbilical arterial/venous line, long line, arterial line, endotracheal tubes, urinary catheter, chest drain) were recorded. For each observed contact with the target patient, there are 2 hand hygiene opportunities, before and after, which were recorded separately. For complex or interrupted care procedures, if the HCW contaminated her or his hands by contacting contaminated objects outside the incubator, then a separate hand hygiene opportunity was needed. Failure to do so will be counted as noncompliance. The nature of contacts was divided into low-risk and high-risk contacts—activities at high risk of contamination or transmission of large numbers of microorganisms (Table 1). Handwashing compliance was defined as hand-washing with soap and water before and after each patient contact. Episodes when washed hands were recontaminated by touching other objects (eg, patient's file, alarm button, staff own body parts) before or after actual patient contact were also counted as noncompliance. Hand hygiene was required regardless of whether gloves were used or changed. Hand decontamination with alcohol-based hand rub before patient contacts in the second phase were recorded separately. The techniques of hand-washing were recorded using a checklist on the essential steps of hand-washing (Table 2). Handwashing duration was documented from step 2 (turn on water) to step 14 (water turn off). The data were recorded by a standard computer-based data sheet.

**TABLE 1.** Nature of Patient Contacts for Hand Hygiene Opportunities

| |
|---|
| High-risk contacts |
| Invasive procedure: inserting intravenous catheter and drawing blood |
| Handle wound, mucous membrane, and body fluids |
| Change parenteral nutrition fluid |
| Administer intravenous medication |
| Care of long line |
| Endotracheal suction |
| Prolonged patient contact, eg, bathing, changing linen, change position, physiotherapy |
| Low-risk contacts |
| Take observation |
| Give oral medication |
| Tube feeding |
| Skin contact such as stimulation, padding, holding hands, touching |

### Intervention

A series of education programs targeted at nurses and doctors was developed, based on the observations and limitations identified from the first stage of the observation study and staff questionnaire study. A hand hygiene protocol was incorporated as part of the orientation program for all new staff, emphasizing the importance and the correct steps of hand-washing. An education kit was developed, and doctors and nurses attended face-to-face education seminars where solutions to overcome common constraints on correct hand hygiene were provided. A total of 2 medical and 10 nursing sessions were conducted in addition to separate orientation sessions for new staff from time to time. The coverage for nursing staff and health care assistants was 100%, whereas for doctors was 80% as a result of frequent rotation of doctors for on-call duty only. A task-orientated analysis was performed, addressing issues such as optimal time for hand hygiene during complex procedures to avoid recontamination of washed hands. Step-by-step protocols on common nursing procedures such as endotracheal suctioning and care of central line were developed and promulgated. The protocols were implemented by face-to-face training and return demonstration that were conducted at regular intervals. The minimal handling protocol and clustering of nursing care procedures was enhanced and consolidated. Pictures on steps of correct hand-washing procedures were posted at each hand-washing basin. Antiseptic alcohol-based hand rub was made readily available at each incubator, and staff were encouraged to use it as an alternative for unsoiled hands, especially in situations in which patients required urgent attendance. The intervention program was completed over 1-year period.

### Health Care–Associated Infection Surveillance

A health care–associated infection surveillance system was piloted in the unit before the hand hygiene intervention. The definition used was similar to the standardized protocols developed by the National Nosocomial Infections Surveillance (NNIS) System.[14] The surveillance periods included all NICU admissions 6 months before and after the implementation of the hand hygiene intervention program. Infections that occurred within 48 hours after NICU discharge were also counted as NICU infections; hence, patients were followed up for 48 hours after discharge from the NICU. Infections included in the surveillance were blood stream infection (BSI), pneumonia, necrotizing enterocolitis, and central nervous system infections. Infection rates were calculated by using denominator including total patient number and patient days. Site-specific infection rates are calculated by number of patients at risk, eg, catheter-associated BSI using catheter days as denominator, ventilator-associated pneumonia divided by ventilator days. BSI, pneumonia, necrotizing enterocolitis, and central nervous system infection were diagnosed and defined by standard criteria developed by the Study Group for the Control of Infection for NICU of the Hospital Authority, Hong Kong, which was adapted with minor modification from the NNIS system.[15]

### Postintervention Observation Study

A postinterventional observation study with similar methods was conducted 6 months after completion of the intervention program.

### Statistical Analysis

The SPSS computer program was used to process the data and generate the statistics. $\chi^2$ analysis was used to compare hand hygiene compliance before and after patient contacts. Last contingency table on $\chi^2$ was used to compare the overall compliance of hand-washing techniques between stage 1 and 2 observations. Individual item of compliance on hand-washing technique was

**TABLE 2.** Step-by-Step Checklist on Hand-Washing Technique and Compliance

| Step | Technique | Preintervention, % (N = 525) | Postintervention, % (N = 355) | *P* Value, $\chi^2$ |
|---|---|---|---|---|
| | Overall compliance with checklist | | | <.0001 |
| 1 | Accessories removed | | | |
| 1.1 | No watch | 89 | 99 | <.0001 |
| 1.2 | No bracelet | 90 | 100 | <.0001 |
| 1.3 | No stone ring | 100 | 100 | NS |
| 1.4 | No ring | 98 | 92 | <.0001 |
| 2 | Turn on water, wet hands, and apply antimicrobial soap | 93 | 99 | <.0001 |
| 3 | Rubbing palm to palm | 100 | 100 | NS |
| 4 | Rubbing palm over dorsum | 96 | 98 | NS |
| 5 | Rubbing fingers interlaced | 79 | 85 | .035 |
| 6 | Rubbing back of fingers | 74 | 60 | <.0001 |
| 7 | Rotational rubbing of thumbs | 43 | 50 | .039 |
| 8 | Rubbing wrist | 42 | 59 | <.0001 |
| 9 | Rubbing forearm | 16 | 35 | <.0001 |
| 10 | Rinse under running water | 99 | 100 | NS |
| 11 | Keep hands lower than elbows while rinsing | 93 | 33 | <.0001 |
| 12 | Wipe hands dry with paper towel | 100 | 100 | NS |
| 13 | Wipe hands in fingertip to wrist direction | 8 | 27 | <.0001 |
| 14 | Turn off water without contamination | 5 | 100 | <.0001 |
| 15 | Discard used paper in a garbage bin | 100 | 100 | NS |

compared by $\chi^2$ analysis. Analysis of variance was used to compare hand-washing durations and levels of patient contact.

## RESULTS

### General Intensive Care Unit Settings

The annual NICU admission was 173 and 170 during the 2 study periods, respectively. The average nurse-to-patient ratio at daytime was 0.8, which was similar at both observation periods. However, there was significant day-to-day variation as a result of fluctuations in NICU admission. The number of indwelling lines/tubes in the studied patients was also similar (mean ± standard deviation before: 1.6 ± 1.25; range: 1–5; after: 1.4 ± 1.13; range: 0–4).

### Frequency and Characteristic of Patient Contacts

During the first observation period, there were 666 patient contacts with a total of 234 patient-hours observed. The average number of contacts per patient per hour was 2.8. Of these, more were low-risk contacts (388; 58.2%) than high-risk contacts (278; 42%). Nurses had the highest number of contacts (69%) followed by doctors (24%), others who were mainly parents (3.9%), and allied health workers (2.4%), which contributed to a small percentage of total hand hygiene opportunities. During the postintervention period, average patient contact reduced significantly to 1.8 per patient per hour, indicating the enhanced concept of clustering of patient care (Table 3).

### Hand Hygiene Compliance

Compliance of HCWs for all hand hygiene opportunities before patient contact was 40% before intervention and increased significantly to 53% after intervention ($P = .0002$). Alcohol hand rub was

**TABLE 3.** Frequency and Characteristic of Patient Contacts and Duration of Hand-Washing

| | Observation Period | | *P* Value, $\chi^2$ |
|---|---|---|---|
| | Preintervention | Postintervention | |
| Observation time, patient h | 234 | 174 | |
| Patient contacts/h | 2.8 | 1.8 | |
| Total observed contacts | 666 | 317 | |
| High-risk contacts | 278 (42%) | 130 (41%) | NS* |
| Low-risk contacts | 388 (58%) | 187 (59%) | NS* |
| Type of personnel | | | |
| Nurse | 463 (69%) | 247 (78%) | .0075 |
| Doctors | 161 (24%) | 41 (13%) | <.0001 |
| Allied health | 16 (2.4%) | 10 (3.2%) | NS* |
| Visitors | 26 (3.9%) | 19 (6.0%) | NS* |
| Duration of HW, s; mean ± SD | | | |
| Overall | 12.9 ± 7.8 | 13.8 ± 4.6 | NS |
| High-risk contact | 13.5 ± 8.5 | 13.6 ± 4.0 | NS |
| Low-risk contact | 11.6 ± 7.5 | 13.1 ± 4.9 | NS |
| Type of personnel | | | |
| Nurse | 8.8 ± 4.5 | 13.1 ± 4.1 | <.05 |
| Doctors | 10.2 ± 4.8 | 13.6 ± 5.5 | NS |
| Allied health | 11.3 ± 3.2 | 12.0 ± 4.0 | NS |
| Others | 12.1 ± 6.5 | 17.7 ± 5.5 | NS |

NS indicates not significant.
* $P > .05$.

**TABLE 4.** Hand Hygiene Compliance Before and After Patient Contacts

| | Preintervention, % | Postintervention, % | *P* Value, $\chi^2$ |
|---|---|---|---|
| Before patient contacts | | | |
| Overall hand-washing compliance | 40 | 53 | .0002 |
| High-risk contact | 35 | 60 | <.0001 |
| Low-risk contact | 43 | 49 | NS* |
| Use of hand antiseptic | 0 | 4 | .0005 |
| Personnel | | | |
| Nurse | 30 | 50 | <.0001 |
| Doctor | 63 | 78 | <.0001 |
| Allied health | 50 | 40 | .0004 |
| Others | 77 | 47 | <.0001 |
| After patient contacts | | | |
| Overall hand-washing compliance | 39 | 59 | <.0001 |
| High-risk contact | 41 | 71 | <.0001 |
| Low-risk contact | 37 | 51 | <.0001 |
| Personnel | | | |
| Nurse | 36 | 61 | <.0001 |
| Doctor | 48 | 73 | <.0001 |
| Allied health | 58 | 40 | <.0001 |
| Others | 36 | 21 | <.0001 |

* $P > .05$.

practiced in another 4% of hand hygiene opportunities before patient contacts. The improvement was more prominent for high-risk procedures (before: 35%; after: 60%; $P < .0001$). Improvement in compliance was mainly among doctors and nurses, who were the main target of the education program, yet more pronounced among nurses. Significant improvement was also observed in hand hygiene compliance after patient contact (before: 39%; after: 59%; $P < .0001$). Improvement was again more marked for high-risk contacts, and again mainly among doctors and nurses. Compliance decreased among allied health workers and visitors, who contributed to only ~3% of all contacts and hence likely is subject to statistical error (Table 4).

### Compliance on Checklists of Hand-Washing Techniques

During the first observation, most hand-washing techniques on the checklist were followed, except for rotational rubbing of thumb (43%), rubbing of wrist (42%), rubbing of forearm (16%), wipe hands dry in fingertip to wrist direction (8%), and turn off water without potential contamination of hands (5%). All aspects improved in the postintervention stage with the overall $P < .0001$ (Table 2). The improvement was most marked on the step of turning off water without potential contamination of hands, as a result of the installation of the automatic switch sensor on all taps. However, rubbing of forearm and wiping hands in a fingertip to wrist direction were still not consistently followed. Keeping hands lower than the elbow while rinsing decreased, which may be attributed to the change of the design of the washing basin. The mean duration of hand-washing during the first stage of study was 12.9 ± 7.8 seconds (range: 2–50 seconds), which was slightly shorter but without statistical significance compared with the postintervention period (13.8 ± 4.6 seconds). Hand-washing durations were comparable for high-risk and low-risk contacts during both stages of the study (Table 3). All values were within the minimum recommended limit of 10 seconds.

### Health Care–Associated Infection Surveillance

The health care–associated infection rate, which includes BSI, pneumonia, necrotizing enterocolitis, and central nervous system infection, decreased from 17.2 per 100 patient admissions and 11.3 per 1000 patient-days before interventions to 9.1 per 100 patient admissions and 6.2 per 1000 patient-days, respectively. The catheter-associated BSI was 6.8 per 1000 catheter days before intervention. This compared favorably with the NNIS standard (25th–50th percentile) and was further decreased to 1.2 per 1000 catheter days (<10th percentile NNIS standard). The ventilator-associated pneumonia in the unit was 16.9 per 1000 ventilator days, which was high (>90th percentile of NNIS standard). This also improved to 6.4 per 1000 ventilator days in the postintervention period (75th–90th percentile of NNIS standard)[16] (Table 5). However, the difference did not reach statistical significance, which is expected because of the low occurrence of the event and short duration of the surveillance.

## DISCUSSION

Health care–associated infections are a continuing problem in intensive care units, a serious source of morbidity, mortality, and excess health care cost.[17] Investigations of the transmission source of most health care–associated infections pointed to HCW hand-to-patient contact.[18–20] Proper hand hygiene is the single most effective means of preventing the transfer of potential pathogens from staff to patient and from patient to patient.[7,21] Officials at the CDC estimate that one third of all hospital-acquired infections are caused by a lack of adherence to established infection control practices, such as hand hygiene.[22]

The first study on hand-washing compliance by Albert et al[11] in 1981 found that hand-washing compliance in physicians was 28% in teaching hospitals

**TABLE 5.** Health Care–Associated Infection Surveillance Data 6 Months Before and After the Completion of the Intervention Program

| | Preintervention, 6 Months | NNIS Percentile† | Postintervention, 6 Months After | NNIS Percentile† | *P* Value, $\chi^2$ |
|---|---|---|---|---|---|
| Total* infection rate per 100 patients | 17.2 (20/116) | — | 9.1 (11/121) | — | .09 |
| Total* infection rate per 1000 patient-days | 11.3 (20/1764) | — | 6.2 (11/1776) | — | .14 |
| BSI per 1000 catheter days | 6.8 (6/884) | 25%–50% | 1.2 (1/815) | <10% | .16 |
| Ventilator-associated pneumonia per 1000 ventilator days | 16.9 (6/354) | >90% | 6.4 (2/312) | 75–90% | .37 |

* Total number of infections includes BSI, pneumonia, necrotizing enterocolitis, and central nervous system infection.
† NNIS percentile: NNIS 1990-1999 reported BSI (catheter associated) rate and ventilator-associated pneumonia rate.

and 14% in private hospitals. More than 20 years later, studies still find that hand-washing occurs <50% of the time between patient contact by nurses and physicians.[23,24] The hand-washing compliance of 40% in our study during the preintervention phase was considered to be relatively high when compared with these studies, especially taking into consideration our stringent criteria in defining compliance.

Effective measures to improve compliance with hand hygiene are vital to improve patient care and save health care funds. Numerous strategies to increase the frequency and effectiveness of hand hygiene indicate that education in combination with performance feedback is the most successful approach.[25] A study by Conly et al[26] showed that hand-washing compliance rose from 28% to 81% after the introduction of an education program. This was associated with a significant drop in the nosocomial infection rate. However, after 3 years, the nosocomial infection rates rose again, and a repeated survey showed deterioration in hand-washing compliance. Another controlled study by Mayer et al[27] in an intensive care unit showed improved compliance by providing performance feedback in the form of a daily memo to staff on hand-washing frequency. Again, follow-up observation after 6 months showed a washout effect, indicating the need to repeat the program. Hence, to modify human behavior such as hand hygiene habit, intervention must be more specific and ongoing at regular intervals. Apart from providing general principles and guidance on hand hygiene, the education program devised by us provided staff with practical solutions to overcome common constraints on exercising proper hand hygiene, especially during complex and interrupted patient contacts.

Our first observation study noted that HCWs had a tendency to recontaminate their washed hands during interrupted patient care by touching inanimate objects such as medication dispensers, computer mouses, patient records, alarm buttons, and writing pens before actual patient care. Furthermore, after patient care procedures, staff at times had a tendency to touch their body parts or other fomites before washing their hands. A study by Pittet et al[28] demonstrated a similar problem of frequent contamination of HCWs' hands during interrupted patient care. Therefore, focused education is necessary to increase HCW awareness during the sequence of patient care. For addressing this problem, a task-orientated analysis was performed, focusing on the critical time point for hand hygiene during some commonly performed complex procedures, such as endotracheal suctioning. A step-by-step protocol was developed to organize the procedures around the concept of infection control. The protocols were implemented by face-to-face training and return demonstration, which were conducted at regular intervals.

Our intervention program also promoted the modern NICU nursing concept of minimal-handling protocol and clustering of nursing care. Study by Pittet et al[29] showed that high demand for hand hygiene combined with high workload are the most significant risk factors for noncompliance. The average number of patient contacts in our first phase of study was already low at 2.8 per patient per hour. Multiple or interrupted nursing procedures were streamlined and clustered to reduce the need for hand contamination between contacts with the same patient. This reduced the patient contact to 1.8 per patient per hour and hence the total time spent on hand hygiene, which is a major hindrance during stressful times of increased activity amid manpower shortages. Nurses had the highest number of patient contacts (65%). On the basis of the average nurse-to-patient ratio of 0.8, the total number of hand hygiene episodes before and after each patient contact was reduced to 2.9 episodes per staff per hour. Hence, the total time required for hand-washing was not that formidable, as previously shown in other intensive care settings. This is encouraging information for staff to sustain their efforts.

Instruction on the correct and judicious use of alcohol-based hand rub during emergency situations or as an adjunct for washed but potentially recontaminated hands also helped to alleviate this problem. Our intervention program was launched before the CDC released a new guideline on hand hygiene last year.[9] Before this, the efficacy of alcohol-based hand rub was not fully established. Hence, in our intervention program, it was recommended only as an alternative to decontaminate unsoiled hands before patient contact during an emergency situation. Hand hygiene with soap and water was required after all patient contacts. This explained that alcohol-based hand rub was used in only 4% of all hand hygiene opportunities before patient contact. The most radical change in the new CDC guideline is the recommendation to use alcohol-based hand rubs rather than soap and water as the primary agent for hand hygiene. The advantages are time, hand health, and effectiveness in achieving higher compliance in hand decontamination. Alcohol-based hand rub

saves time going to and from the sink and adjusting the water temperature, etc, which may add another 10 to 20 seconds to the time spent in actual hand hygiene. A study by Voss et al[13] showed that the use of alcohol-based hand rub dramatically cut hand hygiene time to <70%. Another study by Pittet et al[30] on the impact of hand hygiene programs emphasizing use of bedside, alcohol-based hand disinfection showed that compliance improved from 48% to 66% and was associated with a significant fall in the nosocomial infection rate from 16.9% to 9.9%. The methicillin-resistant *Staphylococcus aureus* transmission rate also decreased from 2.16 to 0.93 incidents per 10000 patient-days. Brown et al[31] showed that a switch from soap and water to alcohol for hand hygiene in the NICU improved hand hygiene compliance and was associated with decreased cross-transmission of *Klebsiella*. These studies suggest that hand hygiene with alcohol hand rub can reduce the nosocomial infection rate and seems to be more acceptable to HCWs.[32] Greater availability of modern alcohol-based hand rubs, especially those that contain emollient, which are less irritating and drying to the skin than traditional hand-washing with soap or antiseptic, may also potentially reduce resistance against hand hygiene from those who cite poor skin condition. However, in promoting alcohol-based hand rub, it is important that proper techniques of using it are emphasized, including the application of sufficient amounts to cover all parts of the hands and fingers and adequate rubbing until it is completely dry.

Most studies on hand-washing intervention programs demonstrated that improvement was usually short term, and without ongoing audit, compliance tends to return to the baseline over a period of time.[23,33] Poor compliance on hand hygiene is probably related to lack of accountability and a belief in the security of potent antibiotics. Unfortunately, in most situations, the occurrence of infection is multifactorial and cannot be traced to a specific individual. To sustain the improvement, regular evaluation of hand hygiene behavior and compliance with performance feedback to all staff are helpful. A study by Avila-Agnaro et al[34] in a pediatric hospital showed that performance feedback increased hand hygiene compliance to 56%, and with additional motivation, the compliance increased further to 74%. The positive aspects of creating change to improve hand hygiene and reduce infection must be stressed. Regular nosocomial infection surveillance data to demonstrate the correlation of hand hygiene compliance and low nosocomial infection rate is another positive feedback, encouraging staff to improve their accountability. Our health care–associated infection surveillance data demonstrated improvement in overall infection rate, as well as BSI and ventilator-associated pneumonia in the postintervention phase. However, it is acknowledged that more data over a longer period of surveillance are necessary to document a definite impact.

According to the recommendation of the CDC guidelines for hand-washing and hospital environmental control, initial hand-washing before entering the NICU area should be aseptic. Personnel should scrub their hands and arms thoroughly with an antiseptic soap to a point above the elbow. After vigorous washing, the hands should be rinsed thoroughly and dried with a paper towel.[7] The hand-washing duration in this study was between 12.9 ± 7.8 seconds and 13.8 ± 4.6 seconds, which just falls within the recommended time limit. It is important to emphasize the correct technique in addition to the actual time spent on hand-washing. Proper design and convenient location of hand-washing facilities is another important factor.

One limitation of this study was associated with the method used to collect the data. There was a concern that some staff members may have "guessed" the real reason for the sudden, frequent appearances of an observer not previously known by NICU personnel. However, this factor should have had a similar effect for both stages of observation. Furthermore, as a result of regular staff exchanges between clinical areas, it was not possible to ascertain changes contributed by staff change. However, the second observation was performed after the implementation of the program, and >90% of nursing staff during the second phase had been exposed to the education program.

## CONCLUSION

This study suggests that an effective education program can improve hand hygiene compliance. The importance of hand hygiene and correct hand hygiene habits should be incorporated as part of orientation programs for all staff before working in neonatal units. Such programs should be task orientated and continuously reinforced to achieve optimal compliance. Similar observation study could form part of an ongoing infection control audit program providing regular feedback to staff to sustain compliance. The provision and promotion of the proper use of hand decontamination agents such as alcohol-based hand rub may further help to solve common problems associated with hand-washing. Staff in critical health care settings must come to realize that their compliance with proper hand hygiene protocols is essential to lower nosocomial infection rates and thus improve patient care, promote timely discharge, and contain health care costs.

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