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## Major article

# Sequential hand hygiene promotion contributes to a reduced nosocomial bloodstream infection rate among very low-birth weight infants: An interrupted time series over a 10-year period



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## Key Words:

Hand disinfection  
 Infant  
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**Background:** Sustained high compliance with hand hygiene (HH) is needed to reduce nosocomial bloodstream infections (NBSIs). However, over time, a wash out effect often occurs. We studied the long-term effect of sequential HH-promoting interventions.

**Methods:** An observational study with an interrupted time series analysis of the occurrence of NBSI was performed in very low-birth weight (VLBW) infants. Interventions consisted of an education program, gain-framed screen saver messages, and an infection prevention week with an introduction on consistent glove use.

**Results:** A total of 1,964 VLBW infants admitted between January 1, 2002, and December 31, 2011, were studied. The proportion of infants with  $\geq 1$  NBSI decreased from 47.6%-21.2% ( $P < .01$ ); the number of NBSIs per 1,000 patient days decreased from 16.8-8.9 ( $P < .01$ ). Preintervention, the number of NBSIs per 1,000 patient days significantly increased by 0.74 per quartile (95% confidence interval [CI], 0.27-1.22). The first intervention was followed by a significantly declining trend in NBSIs of -1.27 per quartile (95% CI, -2.04 to -0.49). The next interventions were followed by a neutral trend change. The relative contributions of coagulase-negative staphylococci and *Staphylococcus aureus* as causative pathogens decreased significantly over time.

**Conclusions:** Sequential HH promotion seems to contribute to a sustained low NBSI rate.

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Microorganisms carried by health care workers or that present on surfaces and equipment around patients are a source of nosocomial infections. The Centers for Disease Control and Prevention (CDC) singled out hand hygiene (HH) by means of alcohol hand rub as the most effective measure to prevent pathogens from spreading.<sup>1</sup> However, compliance with HH protocols is generally <50%.

Very low-birth weight (VLBW) infants (<1,500 g) receiving intensive care are at high risk for nosocomial bloodstream

infections (NBSIs). They often receive medication and parenteral nutrition through a central venous catheter (CVC), which forms an entry point for bacteria and, therefore, raises the risk of NBSI. In this patient group, the incidence of NBSIs ranges from 13%-53%; the number of NBSIs per 1,000 patient days ranges from 6-15.<sup>2-4</sup> NBSIs are associated with higher mortality and morbidity, prolonged hospitalization, and greater hospital costs.

Previously, we established a 44% incidence of NBSIs among VLBW infants in our neonatal intensive care unit (NICU),<sup>5</sup> which prompted us to develop preventive interventions. The available evidence suggested that improved HH compliance would be most effective. Therefore, and bearing in mind that successful implementation of an intervention often requires a sequential approach, which spotlights the challenge from different perspectives,<sup>6</sup> we

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introduced a multifaceted HH education program for our NICU staff, which reduced NBSI rates in the long term.

The aim of this study was to evaluate the effects of combined HH-promoting interventions on the occurrence of NBSIs and to determine a possible change in distribution of causative pathogens among VLBW infants over a 10-year period.

## MATERIALS AND METHODS

### Study design

This combined retrospective and prospective observational study had an interrupted time series (ITS) design. Data from 2002-2004 were collected retrospectively; more recent data were collected prospectively. Three time periods were distinguished: (1) baseline, prior to any intervention (January 1, 2002-June 31, 2005); (2) intervention phase 1, starting with a 1-month multifaceted HH education program (July 1, 2005-April 1, 2008); and (3) intervention phase 2, with the introduction of gain-framed screen saver messages, an infection prevention week, and promotion of the consistent use of gloves during dirty body site care (April 1, 2008-December 31, 2011).

The Erasmus MC Institutional Review Board approved the individual studies.

### Setting and patients

This study was conducted in a 27-bed, level IIID NICU in a teaching hospital and included all VLBW infants admitted >72 hours. The antibiotic therapy protocol remained the same over the study period.

### Interventions

During the baseline period, no additional efforts were undertaken to influence compliance with HH and reduce NBSIs.

#### Phase 1: HH education program

In intervention phase 1, a compulsory multifaceted education program was offered to all NICU staff throughout June 2005.<sup>5</sup> Groups of 3 health care workers received information on the high NBSI rate among VLBW infants and high rate of noncompliance with HH (40%) at the NICU to create a sense of urgency for behavioral change toward improved HH compliance. Performance feedback on personal HH practices was part of the program. Furthermore, senior nursing and medical staff were encouraged to serve as role models.

#### Phase 2: Screen savers and infection prevention week, including consistent glove use

Screen savers may serve to disseminate motivational messages and have been shown to be effective in changing behavior because they promote the desired behavior. As reported previously, from April 2008-May 2008,<sup>7</sup> we presented the so-called gain-framed screen saver messages showing the advantages of HH on 6 computer screens at the 3 units.<sup>7</sup>

In September 2008, an infection prevention week kept attention focused on infection prevention aims. It was organized in collaboration with the institutional infection control practitioners. We first showed a self-produced movie featuring 6 common situations where infection prevention is an issue. Twenty hygienic errors were introduced for this purpose. Colleagues were asked to identify and document these errors by way of a contest. We also distributed mugs, toilet paper, and posters with poignant messages concerning HH. Each of the 5 days had a special theme: general hygienic precautions, pathogens at the NICU, HH, invasive procedures, and

**Table 1**  
Clinical characteristics of the included infants

Characteristics	Baseline (n = 530)	Phase 1 (n = 523)	Phase 2 (n = 911)
Gestational age (wk)	28.6 (27.3-30.1)	28.7 (27-30.3)	28.6 (26.7-30.3)
Birth weight (g)	1,045 (863-1,260)	1,040 (865-1,240)	1,050 (830-1,265)
Admission (d)	20 (10-43)	18 (9-35)	17 (9-37)
Patient days (d)	16,810	14,083	22,922
Infection rate, % (n)	42.6 (226)	31.7 (166)	23.1 (210)
NBSI/1,000 patient days	16.8	14.2	8.9
Onset first NBSI (d)	8 (5-11)	9 (6-12)	9 (6-14)

NOTE. Data are expressed as median (IQR) unless specified otherwise.

recapitulation, including an award ceremony for the best identified errors. In addition, during the first 3 days, all staff were encouraged to culture surfaces. The infection control practitioners commented on the findings from the cultures. Physicians were offered CVC insertion classes; nurse assistants attended classes about hygienic handling of formula and breast milk.

The next step was promotion of the consistent use of nonsterile gloves during dirty body site care. Wearing gloves is indicated when contact with infants' secretions is likely, but it does not replace the need for appropriate HH because self-contamination could occur when gloves are taken off. A professionally designed leaflet encouraging glove use, and including photo portraits of key players' and catchy one-liners from these key players on the need to wear gloves, was distributed throughout the NICU.

### Outcomes

The primary outcome was incidence of NBSI. The secondary outcomes were the number of NBSIs per 1,000 patient days and change in distribution of the most frequent causative pathogens. An NBSI was defined as an infection occurring >72 hours after admission with at least 1 positive blood culture and an elevated C-reactive protein (CRP) concentration (>10 mg/L).<sup>4</sup>

### Sample size

Based on the knowledge that approximately 45% of VLBW infants will develop an NBSI, a sample size of approximately 180 per period would be required to detect a 30% reduction in the incidence of NBSIs (80% power with 5% 2-sided significance).

### Statistical methods

Effects of the interventions were analyzed by an ITS, which is the preferred presentation of results according to the Outbreak Reports and Intervention Studies Of Nosocomial infection (ORION) statement.<sup>8</sup> Longitudinal effects of the interventions were determined through an ITS, with a segmented linear regression analysis of NBSIs per 1,000 patient days. Observations were based on large numbers; therefore, we applied the rate as a continuous outcome. The number of NBSIs was aggregated over 3-month periods. Three study periods were distinguished: baseline, phase 1, and phase 2. The slope of the segments indicates the rate of change in the time of the interventions. An abrupt change in the level at the time of the implementation indicates an immediate effect.<sup>8</sup> Data are expressed as median and interquartile range (IQR) unless indicated otherwise. SPSS version 17 (SPSS Inc, Chicago, IL) was used.

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