Benefits of Universal Gloving on Hospital-Acquired Infections in Acute Care Pediatric Units

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ABBREVIATIONS

BSI—bloodstream infection
CI—confidence interval
CLABSI—central line–associated bloodstream infection
HAI—hospital-acquired infection
HAP—hospital-acquired pneumonia
PHGSCU—Pediatric Hematology-Oncology Special Care Unit
PBMTU—Pediatric Bone Marrow Transplant Unit
PMSMAU—Pediatric Medical/Surgical Mixed Acuity Unit
RR—relative risk
RSV—respiratory syncytial virus
UIHC—University of Iowa Hospitals and Clinics
VAP—ventilator-associated pneumonia

Ms Yin performed the statistical analysis, drafted the initial manuscript, and approved the final manuscript as submitted; Dr Schweizer conceptualized and designed the study, reviewed and revised the manuscript, and approved the final manuscript as submitted; Dr Herwaldt and Ms Pottinger provided the data, reviewed and revised the manuscript, and approved the final manuscript as submitted; and Dr Perencevich conceptualized and designed the study, coordinated data collection, reviewed and revised the manuscript, and approved the final manuscript as submitted.

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WHAT’S KNOWN ON THIS SUBJECT: Health care–associated infections cause considerable morbidity and mortality among hospitalized children. Simple barrier precautions such as universal gloving of health care workers’ hands may reduce transmission of infectious agents between patients.

WHAT THIS STUDY ADDS: Mandatory use of gloves during respiratory syncytial virus season in pediatric units prevented other health care–associated infections such as central line–associated bloodstream infections, particularly in intensive care settings. These secondary benefits suggest continuing mandatory gloving throughout the year.

METHODS: This retrospective cohort study included all patients admitted to pediatric units of a tertiary care center between 2002 and 2010. Poisson regression models were used to measure the association between mandatory gloving and HAI incidence. Autoregressive models were used to adjust for time correlation.

RESULTS: During the study period, 686 HAIs occurred during 363 782 patient-days. The risk of any HAI was 25% lower during mandatory gloving periods compared with during nongloving periods (relative risk [RR]: 0.75; 95% confidence interval [CI]: 0.69–0.93; P = .01), after adjusting for long-term trends and seasonal effect. Mandatory gloving was associated with lower risks of bloodstream infections (RR: 0.63; 95% CI: 0.49–0.81; P < .001), central line–associated bloodstream infections (RR: 0.61; 95% CI: 0.44–0.84; P = 0.003), and hospital-acquired pneumonia (RR: 0.20, 95% CI: 0.03–1.25, P = 0.09). The reduction was significant in the PICU (RR: 0.63, 95% CI: 0.42–0.93, P = 02), the NICU (RR: 0.62, 95% CI: 0.39–0.98, P = 04), and the Pediatric Bone Marrow Transplant Unit (RR: 0.52; 95% CI: 0.29–0.91, P = .02).

CONCLUSIONS: Universal gloving during RSV season was associated with significantly lower rates of bacteremia and central line–associated bloodstream infections, particularly in the ICUs and the Pediatric Bone Marrow Transplant Unit. PEDIATRICS 2013;131:e1515–e1520
Health care–associated infections (HAIs) cause considerable morbidity and mortality in the United States. Approximately 1.7 million HAIs occur in US hospitals annually, and these infections cause ∼99,000 deaths.1 Patients admitted to ICUs are more susceptible to colonization and infection due to their underlying diseases and medical conditions, use of invasive medical devices (ie, intravascular catheters), frequent contact with health care workers, prolonged length of stay, and exposure to antimicrobial agents.2 Although <10% of hospitalized patients require treatment in ICUs,3 infections acquired in ICUs accounted for >20% of all HAIs,4 and studies have documented that PICUs and NICUs have high rates of HAIs.5–7 Close physical contact between health care workers and children may increase the risk of transmission, and children whose immune systems are still immature may be more susceptible to infection than are patients whose immune systems are more mature. Pediatric units often have high rates of central line–associated bloodstream infections (CLABSIs).5–10 Simple barrier precautions such as universal gloving may reduce cross-transmission between patients via the hands of health care workers. Results from a number of studies strongly suggest that barrier precautions are beneficial in high-risk populations such as patients in an ICU or recipients of bone marrow or solid organ transplants.11–18 A study by Eber et al19 revealed that the universal use of gloves or gowns to control Acinetobacter infections was associated with reduced vancomycin-resistant Enterococcus and methicillin-resistant Staphylococcus aureus transmission. Because results of previous studies have suggested that barrier precautions substantially reduce transmission of respiratory syncytial virus (RSV),12–17 current policy requires all health care workers in the University of Iowa Hospitals and Clinics (UIHC) pediatric units to wear gloves for all patient contacts during RSV season. The objective of our study was to assess whether the requirement for gloving during the RSV season could reduce the rates of hospital-acquired pneumonia (HAP), bacteremia, and Clostridium difficile infections in a pediatric unit. If universal gloving is associated with lower rates of HAIs other than RSV, then this practice could be beneficial throughout the year.

METHODS
All patients admitted between January 2002 and December 2010 to the UIHC’s pediatric units were included in the study. The pediatric units in our study were a 20-bed PICU, a 62-bed NICU, a 5-bed Pediatric Bone Marrow Transplant Unit (PBMTU), a 26-bed Pediatric Hematology-Oncology Special Care Unit (PHOSCU), and a 35-bed Pediatric Medical/Surgical Mixed Acuity Unit (PMSMAU).

The primary outcome of the study was to determine the monthly average number of HAIs (ie, bloodstream infection (BSIs), CLABSIs, ventilator-associated pneumonia (VAP), HAP, and C. difficile infections). Secondary outcomes were the rates of individual infections and the rates by unit. Infection preventionists used the National Healthcare Safety Network definitions for concurrent surveillance, and they did surveillance for HAP and VAP during part, but not all, of the study period. The infection preventionists who did surveillance on the pediatric units notified pediatric staff that RSV season had begun when the first case of RSV was diagnosed at the UIHC and that the season had ended when no more cases were diagnosed at the UIHC and no cases were reported in Iowa. Patients admitted to pediatric units with respiratory symptoms are placed on contact and droplet precautions until a respiratory panel is complete; precautions are adjusted on the basis of the results of the diagnostic tests. During RSV season, all health care workers in the pediatric units must wear a new pair of gloves every time they see a patient. They must remove the gloves and perform hand hygiene before leaving the patient’s room. Therefore, universal gloving was used during RSV season but not during non-RSV season.

The institutional review board at the University of Iowa considered this study to be non–human-subject research because aggregate data were assessed.

Statistical Methods
Poisson regression models were used to compare the difference in infection rates between the intervention and control time periods. The independent variable collected was season, which was defined as winter from January to March, spring from April to June, summer from July to September, and autumn from October to December. Season was considered to be a potential confounding factor because many infections are seasonal (eg, summer season and higher mean monthly outdoor temperature are associated with substantially increased frequency of Gram-negative BSIs). The long-term time trend was also investigated by including time as a continuous variable. The results were adjusted statistically for the effect of intermittent surveillance for HAP and VAP. Infection rates were calculated by using 1000 patient days, 1000 central line days, or 1000 ventilator days as denominators.

Primary Analysis
Poisson regression models were used to perform a time-series analysis of monthly aggregated HAI counts in the 5 pediatric units, where patient days
were taken into account as offset in the model and linear long-term time trends and seasonal effects were adjusted. Because the monthly infection data are correlated (consecutive months have stronger correlations than months separated by a longer time period), an autoregressive working correlation structure was used to model the correlation over time. The model was estimated through generalized estimating equations that assumed a Poisson distribution and log link function for the outcome. SEs were estimated with model-based variance estimation. In addition, Poisson models were used to assess the effectiveness of universal gloving for each pediatric unit (PICU, NICU, PBMTU, PHOSCU, and PMSMAU) individually. All analyses were conducted with SAS, version 9.2 (SAS Institute, Cary, NC).

Secondary Analysis

The effect of universal gloving on individual HAIs (BSIs, CLABSIIs, HAP, VAP, and *C. difficile*) was investigated by using Poisson regression models with autoregressive correlation structure. The following denominators were used for these analyses: central line days for CLABSI analyses, ventilator days for VAP analyses, and patient days for all other analyses.

Sensitivity Analysis

During our study period, HAP surveillance was conducted from January 2004 to June 2006 and VAP surveillance from July 2009 to December 2010. Surveillance for HAP and VAP directly relates to the outcome, because health care–associated pneumonia would not be detected when surveillance was not conducted for HAP and VAP. For sensitivity analysis, HAP and VAP were excluded and analyses were repeated. The results were consistent with the analyses when HAP and VAP were included.

In addition, negative binomial regression and Poisson regression with adjustment for overdispersion were used to determine whether overdispersion was a problem. Given that the results of all 3 methods were very similar, Poisson regression was used to analyze the data.

RESULTS

A total of 686 HAIs were identified in the 5 pediatric units during the 9-year study period (363,782 patient-days): 362 HAIs during the standard care periods and 324 HAIs during the universal gloving periods (Table 1). During the study period, 54.2% of the months were in mandatory gloving periods and 45.8% were in standard care periods. Figure 1 presents the incidence rate trends of all HAIs in all 5 pediatric units during standard care periods and during universal gloving periods. The infection rates during universal gloving periods were lower than or similar to those during standard care periods, except for 2009 when universal glove use was extended due to the novel H1N1 pandemic. For example, HAI rates were 60.7% lower during the mandatory gloving period in 2007 than they were during the standard care period (Fig 1).

Universal gloving reduced the rates of HAIs in any pediatric unit by 25% (relative risk [RR]: 0.75; 95% confidence interval [CI]: 0.69–0.93; *P* = 0.010), after adjusting for long-term time trends, seasonality, and the effect of HAP and VAP surveillance. Glove use was associated with significantly lower HAI rates in the PICU (RR: 0.63; 95% CI: 0.42–0.93; *P* = 0.021), NICU (RR: 0.62; 95% CI: 0.39–0.98; *P* = 0.043), and PBMTU (RR: 0.52; 95% CI: 0.29–0.91; *P* = 0.022), but not in the PHOSCU (RR: 1.36; 95% CI: 0.86–2.16; *P* = 0.189) and PMSMAU (RR: 0.86; 95% CI: 0.49–1.52; *P* = 0.607) (Table 2, Fig 2).

### Table 1

Number of Events and Incidence Rates of HAIs in All Pediatric Units During Standard Care and Universal Gloving Periods

<table>
<thead>
<tr>
<th>Infection Category</th>
<th>Standard Care</th>
<th>Universal Gloving</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Events Rate</td>
<td>Events Rate</td>
</tr>
<tr>
<td>All HAIs</td>
<td>362</td>
<td>324</td>
</tr>
<tr>
<td>BSIs</td>
<td>245</td>
<td>205</td>
</tr>
<tr>
<td>CLABSIIs</td>
<td>141</td>
<td>108</td>
</tr>
<tr>
<td>HAP</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>VAP</td>
<td>32</td>
<td>1</td>
</tr>
<tr>
<td><em>C. difficile</em></td>
<td>72</td>
<td>75</td>
</tr>
</tbody>
</table>

Rates are expressed per 1000 patient-days except where noted. There were 168,660 patient days, 41,261 central line days, and 20,893 ventilator days during the standard care periods (non-RSV months). There were 195,122 patient days, 46,345 central line days, and 21,393 ventilator days during the universal gloving periods (RSV months).

* P values were computed from Wilcoxon's rank sum test on incidence rates.

* Cases per 1000 central line days.

* Cases per 1000 ventilator days.

FIGURE 1

Incidence rates of all HAIs in all pediatric units during standard care periods and universal gloving periods.
Universal gloving significantly reduced the risk of BSI (RR: 0.63; 95% CI: 0.49–0.81; \( P < .001 \)) and CLABSI (RR: 0.61; 95% CI: 0.44–0.84; \( P = .003 \)). No significance differences were found for HAP, VAP, and \( C. \) difficile infections (Tables 1 and 3).

**DISCUSSION**

Infection prevention and control staff often focus on actively detecting colonized or infected patients and placing these patients in isolation to prevent transmission of infectious pathogens among hospitalized patients, including those in ICUs. Currently, some investigators have questioned whether this approach is effective or necessary.\(^{20,21,22,23} \)

Leclaire et al\(^{12} \) previously found that an intervention to improve use of gowns and gloves for all contact with patients known or suspected to have RSV was associated with a substantially lower rate of RSV transmission. We found that a mandatory universal gloving policy for RSV has an important secondary benefit in a pediatric population, in that this practice was associated with a significantly lower risk of HAIs, particularly BSIs and CLABSIs, in the NICU, PICU, and PBMTU. These findings suggest a potential clinical benefit for extending a universal gloving policy beyond RSV season and provide evidence to support using universal gloving throughout the year in acute care pediatric units.

Several studies have revealed that gloves prevent contamination of healthcare workers’ hands.\(^{25,26} \) And universal gloving has helped control outbreaks in ICUs where vancomycin-resistant *Enterococcus* or methicillin-resistant *Staphylococcus aureus* were epidemic.\(^{27} \) Two previous studies revealed that use of gloves and gowns was associated with reduced HAI incidence rates among pediatric patients.\(^{3,13} \) However, these studies evaluated specific patient populations: children who required mechanical ventilation\(^{5} \) and children with solid organ transplants.\(^{13} \)

Our study is the first to our knowledge to evaluate the benefit of glove use in all pediatric inpatient units, including a general pediatric ward.

The primary weaknesses of this study are the use of a quasi-experimental design and the inclusion of a single center, which could limit the validity of the findings. Randomized trials are needed to evaluate the efficacy of universal gloving as an infection prevention measure in pediatric settings. However, it could be considered to be unethical to conduct a randomized trial of glove use in pediatric units given the apparent effectiveness of universal gloving for preventing RSV and the potential complications in hospitalized children who acquire RSV. This limitation may have been offset by our study design. We evaluated time-series data over 9 years and we used segmented regression analysis, which together are considered the highest quality quasi-experimental methods with the strongest internal validity.\(^{29,30} \) An additional limitation is that the study did not include patient-level data such as patient demographic characteristics and antibiotic use; thus, residual confounding may have affected our analysis. Finally, because we did not monitor glove use,
we do not know if health care workers changed gloves appropriately to ensure that they did not transmit organisms from patient to patient when implementing universal gloving. Inappropriate glove use was shown to increase the risk of methicillin-resistant transmission during the SARS (severe acute respiratory syndrome) outbreak and may have accounted for the higher HAI rate during the extended period of universal glove use in 2009. These limitations may have prevented us from detecting the true differences in HAI rates between the RSV season and non-RSV seasons.

Although significant decreases in HAI were observed for BSIs and CLABSIs during the universal gloving periods compared with the standard care periods, the rates of HAP, VAP, and C. difficile were not significantly different. We believe that many issues may play a role in the differential findings, such as limited power to detect significant differences for HAP, VAP, or C. difficile given the low rates even in standard care periods. Thus, a longer observation period might be needed to detect the effect of universal gloving in preventing HAP, VAP, and C. difficile. Also, the discontinuity of the surveillance for HAP and VAP may have contributed to the insufficient power in our study. In addition, the diagnosis and detection of HAP and VAP are subject to interpretation. It is known that imprecise measurement of the outcomes, particularly nondifferential misclassification, could bias our findings for VAP and HAP to the null in measures of association with universal gloving periods. In addition, we observed a significant reduction in infection in the intensive care settings such as in the NICU, PICU, and PBMTU, but not in the general pediatric units. It is possible that the higher level of acuity in ICUs with differential frequency or duration of patient to health care worker contact could explain these differences.

CONCLUSIONS

Universal gloving is a simple, practical, and feasible prevention strategy that requires minimal time and economic resources. In our study, the routine use of gloves to prevent spread of RSV in pediatric units also prevented other HAIs, such as BSIs and CLABSIs. These secondary benefits support the continuation of universal gloving throughout the year in high-acuity PICUs.

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