Effectiveness of a multidimensional approach to reduce ventilator-associated pneumonia in pediatric intensive care units of 5 developing countries: International Nosocomial Infection Control Consortium findings

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Emerging countries
Critical care
Surveillance
Incidence density
Rate
Infection control
Bundle
Multifaceted strategy
Hand hygiene
Handwashing

Background: Ventilator-associated pneumonia (VAP) is one of the most common health care–associated infections in pediatric intensive care units (PICUs). Practice bundles have been shown to reduce VAP rates in PICUs in developed countries; however, the impact of a multidimensional approach, including a bundle, has not been analyzed in PICUs from developing countries.

Methods: This was a before-after study to determine rates of VAP during a period of active surveillance without the implementation of the multidimensional infection control program (phase 1) to be compared with rates of VAP after implementing such a program, which included the following: bundle of infection control interventions, education, outcome surveillance, process surveillance, feedback on VAP rates, and performance feedback on infection control practices (phase 2). This study was conducted by infection control professionals applying the National Health Safety Network’s definitions of health care–associated infections and the International Nosocomial Infection Control Consortium’s surveillance methodology.

Results: During the baseline period, we recorded a total of 5,212 mechanical ventilator (MV)-days, and during implementation of the intervention bundle, we recorded 9,894 MV-days. The VAP rate was 11.7 per 1,000 MV-days during the baseline period and 8.1 per 1,000 MV-days during the intervention period (relative risk, 0.69; 95% confidence interval, 0.5–0.96; \( P = 0.02 \)), demonstrating a 31% reduction in VAP rate.

Conclusions: Our results show that implementation of the International Nosocomial Infection Control Consortium’s multidimensional program was associated with a significant reduction in VAP rate in PICUs of developing countries.

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intensive care units (PICUs) has been highlighted in previous studies. VAP is one of the most common device-associated health care–associated infections (DA-HAIs) in critical care settings. VAP contributes to overall mortality in PICUs and is the leading cause of death among DA-HAIs. However, in the particular context of developing countries, knowledge regarding DA-HAIs is scant, and there is an insufficient recognition of the importance of surveillance for measuring infection risks, outcomes, and processes in PICU patients. To address this deficiency, the International Nosocomial Infection Control Consortium (INICC) has conducted an outcome and process surveillance program specifically designed for PICUs in developing countries since 2002. The INICC program has revealed 3- to 5-fold higher rates of DA-HAIs in the PICUs of hospitals in limited-resource countries compared with PICUs of hospitals in the developed world. Society for Health Care and Epidemiology of America and Infectious Diseases Society of America guidelines describe many different interventions for preventing VAP in PICUs. These interventions are categorized based on existing scientific evidence, theoretical rationale, applicability, and potential economic impact. However, there is little robust evidence to guide the choice of interventions to implement in an effort to decrease VAP rates. Studies conducted in INICC member hospitals have validated outcome and process surveillance and performance feedback of infection control practices as effective tools for reducing and controlling DA-HAIs in PICUs.

The purposes of the present study were to examine the effect of the INICC’s multidimensional infection control program—comprising a bundle of infection control interventions, education, outcome surveillance, process surveillance, feedback on VAP rates, and performance feedback on infection control practices—on reducing the incidence of VAP in the PICUs of 8 INICC member hospitals in 5 developing countries, and to advance the study of the specific impact of this preventive strategy on VAP rates in limited-resource countries.

METHODS

Setting and study design

The study was carried out in 8 PICUs of 8 INICC member hospitals in 5 developing countries: Colombia, El Salvador, India, the Philippines, and Turkey. Six of the participating hospitals were academic institutions, and 2 were private hospitals. Each hospital had been actively participating in the INICC surveillance program for at least 14 months, with an infection control team composed of a medical doctor with formal education and background in internal medicine, infectious diseases, and/or hospital epidemiology and an infection control professional. This study was performed in 2 phases: phase 1 (baseline period) and phase 2 (intervention period).

Intervention period

The intervention period was initiated after 7 months of participation in the INICC surveillance program. The multidimensional infection control program (Phase 2—Intervention period) includes the following: (1) bundle of infection control interventions, (2) education, (3) outcome surveillance, (4) process surveillance, (5) feedback of VAP rates, and (6) performance feedback of infection control practices.

INICC methodology

The INICC surveillance program includes 2 components: outcome surveillance (DA-HAI rates and consequences) and process surveillance (adherence to hand hygiene and other basic preventive infection control practices). At the hospitals, investigators were required to complete outcome and process surveillance forms, which were sent to the INICC headquarters office in Buenos Aires for analysis each month.

Outcome surveillance

The INICC surveillance program applies methods and definitions for DA-HAI developed by the US Centers for Disease Control and Prevention for the National Nosocomial Infection Surveillance System/National Health Safety Network program. INICC methods have been adapted to the setting of developing countries, taking into consideration these countries’ differing socioeconomic status and specific limitations.

Outcome surveillance includes rates of central line—associated bloodstream infection (CLABSI), VAP, and catheter–associated urinary tract infection (CAUTI) per 1,000 device-days; microbiogram profile; bacterial resistance; LOS; and mortality in the PICU.

Process surveillance

In INICC member hospitals, preventive strategies are based on simple, inexpensive, evidence-based measures, including education, outcome surveillance, process surveillance, feedback on DA-HAI (VAP, CLABSI, CAUTI) rates, and performance feedback. Process surveillance includes compliance rates for hand hygiene practices and specific infection control measures for the prevention of CLABSI, CAUTI, and VAP.

Process surveillance is designed to monitor compliance with easily measurable key infection control measures, such as hand hygiene. Hand hygiene compliance by health care workers (HCWs), based on the frequency of performing hand hygiene when clearly indicated, is monitored by the hospital’s infection control practitioner during randomly selected 1-hour observation periods 3 times a week. Although HCWs know that hand hygiene practices are regularly monitored, they are not actually informed of the exact moments that the observations take place.

Performance feedback

The concept of using performance feedback of outcome surveillance and process surveillance as a control measure in hospitals with limited resources is based on its proven effectiveness in previous studies within INICC. On a monthly basis, after processing the hospitals’ surveillance data, the INICC headquarters team prepares and sends to each participating hospital a report on its institutional rates of DA-HAIs, bacterial resistance, LOS, and mortality in the PICU, as well as data on compliance with hand hygiene, central line, and urinary catheter care and VAP preventive measures.

To provide feedback to PICU staff, charts providing a running tally of rates of DA-HAIs compiled by the INICC headquarters team are reviewed at monthly staff meetings and posted in a prominent location in the PICU.

Bundle components

Our bundle included the following interventions:

1. Conduction of active surveillance for VAP
2. Adherence to hand hygiene guidelines
3. Maintenance of patients in a semirecumbent position
4. Daily assessment of readiness to wean and use of weaning protocols
5. Regular oral care with an antiseptic solution
6. Use of noninvasive ventilation when possible, minimizing the duration of ventilation
7. Preference for orotracheal intubation over nasotracheal intubation
8. Maintenance of endotracheal cuff pressure of at least 20 cm H2O40
9. Removal of condensate from ventilator circuits,23 keeping the ventilator circuit closed during condensate removal41
10. Changing of the ventilator circuit only when visibly soiled or malfunctioning42
11. Avoidance of gastric overdistention43
12. Avoidance of histamine receptor 2—blocking agents and proton pump inhibitors44
13. Use of sterile water to rinse reusable respiratory equipment.23

We perform direct observation of hand hygiene compliance, duration of the ventilation, and ventilation ratio use, using a structured observation tools at regularly scheduled intervals.8

Definitions
We applied the National Health Safety Network’s definitions for VAP.23 VAP is indicated in a patient being mechanically ventilated with a chest radiograph showing new or progressive infiltrate, consolidation, cavitation, or pleural effusion. The patient also must meet at least one of the following criteria: new onset of purulent sputum or change in character of sputum, organism cultured from blood, or isolation of an etiologic agent from a specimen obtained by tracheal aspiration, bronchial brushing or bronchoalveolar lavage, or biopsy.33

Statistical methods
Patients’ characteristics in the baseline and intervention periods in each PICU were compared using Fisher’s exact test for dichotomous variables and the unmatched Student t test for continuous variables. Relative risk (RR) ratios with 95% confidence intervals (CIs) were calculated for comparison of rates at baseline and during the subsequent intervention period.

RESULTS
Throughout the study period, 4,339 patients, hospitalized for a total of 29,209 days in 8 PICUs, with a total of 15,106 mechanical ventilator (MV)-days, were enrolled in the study (Tables 1 and 2). Patient characteristics, including age, sex, underlying diseases, and previous infections, were similar in the baseline and intervention phases (Table 2). Hand hygiene compliance rates improved significantly, and MV use and the duration of MV decreased significantly (Table 3).

The VAP rate was 11.7 VAPs per 1,000 MV-days at baseline and 8.1 per 1,000 MV-days during the intervention period (RR, 0.69; 95% CI, 0.50-0.96; p = .0286). These results demonstrate a 31% reduction in VAP rate (Table 4).
The microorganism profile is shown in Table 5.

DISCUSSION
Patients undergoing MV are at considerable risk for developing a DA-HAI, particularly VAP. The occurrence of VAP is associated with increased LOS,1-4 excess health care costs,4 and increased attributable mortality.13,45 Unfortunately, many health care institutions in developing countries lack basic infection control programs, and most caregivers in these countries are unaware of their institutional rates of VAP.3,7,10-22

Reducing DA-HAIs has been identified as an important priority in many hospitals.56 The effectiveness of implementing an integrated infection control program focused on DA-HAI surveillance was demonstrated approximately 30 years ago, as demonstrated by US studies showing that the incidence of DA-HAI can be reduced by as much as 30%, and that a related reduction in health care costs is feasible as well.47

VAP is largely preventable, and researchers have documented the effectiveness of various preventive interventions, including hand hygiene,35 semirecumbent positioning,46 early endotracheal tube removal,40 and maintenance of endotracheal cuff pressure and continuous subglottic suctioning.48

The benefits of multidimensional infection control programs have been demonstrated in numerous studies that stressed educational interventions.25-31,49,50 Such positive results may be short-lived without regular reinforcement, however. Likewise, surveillance of DA-HAI rates should not be expected to lead to reduced rates of selected DA-HAIs unless the data collected are used for improving patient care practices.25-31 As a result, butressing educational efforts with regular feedback in the form of monthly incidence rates of DA-HAIs may provide the maximum benefit.25-31

Control VAP requires not just one measure, but rather a culture change involving the entire PICU team (doctors, nurses, and respiratory therapists).23 We have shown that implementation of the INICC multidimensional infection control approach—comprising an intervention bundle, education, outcome surveillance, process surveillance, feedback on VAP rates, and performance feedback—resulted in significantly reduced VAP rates over the study period. This is the first study in PICUs in developing countries to document a reduction in VAP rates in these settings, associated with the implementation of this type of infection control approach.

A weakness of this study lies in the fact that our results cannot be generalized to all PICU patients from developing countries. In addition, the higher rates of hand hygiene compliance after intervention might have been affected by the “Hawthorne effect.” Nonetheless HCW’s reactions to observations were reduced, because they were actually performed unobtrusively at randomly selected schedules. We are aware that we might not be able to sustain our current VAP rates indefinitely, but our goal is to sustain
a nearly perfect compliance with the ventilator bundle and maintain PICU team motivation for VP prevention.

The improvement shown in INICC member hospitals is motivating for HCWs, who are provided with simple and inexpensive preventive strategies. We expect that this will continue to increase the acceptance of infection control programs in all INICC member hospitals, leading to significant reductions in DA-HAI rates.

Outcome surveillance, VAP rates

<table>
<thead>
<tr>
<th>Isolated microorganisms</th>
<th>Baseline period</th>
<th>Intervention period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acinetobacter spp, n (%)</td>
<td>2 (11)</td>
<td>3 (18)</td>
</tr>
<tr>
<td>Escherichia coli, n (%)</td>
<td>1 (7)</td>
<td>2 (12)</td>
</tr>
<tr>
<td>Enterobacter spp, n (%)</td>
<td>1 (7)</td>
<td>0</td>
</tr>
<tr>
<td>Pseudomonas spp, n (%)</td>
<td>5 (42)</td>
<td>16 (165)</td>
</tr>
<tr>
<td>Staphylococcus aureus, n (%)</td>
<td>0</td>
<td>1 (9)</td>
</tr>
<tr>
<td>Stenotrophomonas spp, n (%)</td>
<td>1 (7)</td>
<td>0</td>
</tr>
</tbody>
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References:


36. Dellinger RP, Vincent JL. The Surviving Sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campaign sepsis campa


