original article

Findings of the International Nosocomial Infection Control Consortium (INICC) Part II: Impact of a Multidimensional Strategy to Reduce Ventilator-Associated Pneumonia in Neonatal Intensive Care Units in 10 Developing Countries

Victor D. Rosenthal;[1] Maria E. Rodríguez-Calderón;[2] Marena Rodríguez-Ferrer;[3] Tanu Singhal;[4] Mandakini Pawar;[5] Martha Sobreyra-Oropeza;[6] Amina Barkat;[7] Teodora Atencio-Espinoza;[8] Regina Berba;[9] Josephine A. Navoa-Ng;[10] Lourdes Dueñas;[11] Nejla Ben-Jaballah;[12] Davut Ozdemir;[13] Gulden Ersoz;[14] Canan Aygun[15]

design. Before-after prospective surveillance study to assess the efficacy of the International Nosocomial Infection Control Consortium (INICC) multidimensional infection control program to reduce the rate of occurrence of ventilator-associated pneumonia (VAP).

setting. Neonatal intensive care units (NICUs) of INICC member hospitals from 15 cities in the following 10 developing countries: Argentina, Colombia, El Salvador, India, Mexico, Morocco, Peru, the Philippines, Tunisia, and Turkey.

patients. NICU inpatients.

methods. VAP rates were determined during a first period of active surveillance without the implementation of the multidimensional approach (phase 1) to be then compared with VAP rates after implementation of the INICC multidimensional infection control program (phase 2), which included the following practices: a bundle of infection control interventions, education, outcome surveillance, process surveillance, feedback on VAP rates, and performance feedback on infection control practices. This study was conducted by infection control professionals who applied National Health Safety Network (NHSN) definitions for healthcare-associated infections and INICC surveillance methodology.

results. During phase 1, we recorded 3,153 mechanical ventilation (MV)–days, and during phase 2, after the implementation of the bundle of interventions, we recorded 15,981 MV-days. The VAP rate was 17.8 cases per 1,000 MV-days during phase 1 and 12.0 cases per 1,000 MV-days during phase 2 (relative risk, 0.67 [95% confidence interval, 0.50–0.91]; $P = .001$), indicating a 33% reduction in VAP rate.

conclusions. Our results demonstrate that an implementation of the INICC multidimensional infection control program was associated with a significant reduction in VAP rate in NICUs in developing countries.

Infect Control Hosp Epidemiol 2012;33(7):000-000

Ventilator-associated pneumonia (VAP) is one of the most common device-associated healthcare-associated infections (DA-HAIs) in critical care settings and accounts for 6.8%–32.2% of DA-HAIs among neonates,[1-3] contributes to mortality in neonatal intensive care units (NICUs),[3] and is the leading cause of death among DA-HAIs.[4] However, within the particular context of developing countries, access to knowledge regarding VAP is scant, and there is an insufficient recognition of the importance of surveillance for measuring NICU patient infection risks, outcomes, and processes.

As part of the 5 Million Lives campaign, endorsed by leading US agencies and professional societies, the Institute of Healthcare Improvement (IHI) recommends that all ICUs implement a ventilator bundle to reduce the incidence of VAP to zero.[5] Although the guidelines developed by the Society for Healthcare Epidemiology of America (SHEA) and the

Affiliations: 1. International Nosocomial Infection Control Consortium, Buenos Aires, Argentina; 2. Hospital La Victoria, Bogota, Colombia; 3. Universidad Simón Bolívar, Barranquilla, Colombia; 4. Kokilaben Dhirubhai Ambani Hospital, Mumbai, India; 5. Pushpanjali Crosslay Hospital, Ghaziabad, India; 6. Hospital de la Mujer, Mexico City, Mexico; 7. Children Hospital of Rabat, Rabat, Morocco; 8. Hospital Regional de Pucallpa, Pucallpa, Peru; 9. Philippine General Hospital, Manila, The Philippines; 10. St. Luke's Medical Center, Quezon City, The Philippines; 11. Hospital Nacional de Niños Benjamin Bloom, San Salvador, El Salvador; 12. Hospital d'Enfants, Tunis, Tunisia; 13. Duzce University Medical School Infectious Diseases and Clinical Microbiology, Duzce, Turkey; 14. Mersin University, Faculty of Medicine, Mersin, Turkey; 15. Ondokuz Mayis University Medical School, Samsun, Turkey.

Received August 25, 2011; accepted February 3, 2012; electronically published May XX, 2012.

 0899-823X/2012/3307-00XX$15.00. DOI: 10.1086/666342

Infectious Diseases Society of America (IDSA) describe different interventions for VAP prevention in the ICU,[6] evidence to guide the choice of interventions in neonatal setting is still insufficient.[7-9] This second part of our study aims to assess the impact of the INICC multidimensional infection control program on the reduction of VAP incidence in NICUs in developing countries.

METHODS

Setting and Study Design

This before-after prospective cohort study, which was divided into 2 phases (baseline and intervention), was performed in 15 NICUs at 15 hospital members of the INICC in the following 10 developing countries: Argentina, Colombia, India, Mexico, Morocco, Peru, the Philippines, El Salvador, Tunisia, and Turkey. The institutional review boards of each hospital agreed to the study protocol, and patient confidentiality was protected by codifying the recorded information, making it identifiable only to the infection control team.

The INICC Surveillance Methodology, including statistical methods used, has been fully described in our article *Findings of the International Nosocomial Infection Control Consortium (INICC) Part I: Effectiveness of a Multidimensional Infection Control Approach on Catheter-Associated Urinary Tract Infection Rates in Pediatric Intensive Care Units of 6 Developing Countries*, published in this issue of journal. The study period was from October 2003 through October 2010 and was divided into 2 phases: phase 1 (the baseline period) was defined as the first 3 months of participation by each NICU, and phase 2 (the intervention period) included all of the following months of participation by each NICU.

Intervention Period

The intervention period was initiated after 3 months of participation in the INICC Surveillance Program. The mean duration ($\pm$ standard deviation) of the intervention period was 15.1 $\pm$ 9.1 months (range, 3–35 months).

Bundle Components for VAP Prevention

Our bundle included the following interventions:

1. Active surveillance for VAP.[10]
2. Adherence to hand hygiene guidelines.[11]
3. Performance of daily assessments of readiness to wean and use of weaning protocols.[12]
4. Performance of regular oral care with an antiseptic solution.[13]

TABLE 1. Classification of Participating Neonatal Intensive Care Units (NICUs) by Country, Number of Patients, and Hospital Type

Data	No. (%) of NICUs (n = 15)	No. (%) of NICU patients (n = 6,829)	Period
Country			
Argentina	1	235	Aug 2005–May 2008
Colombia			
Overall	2	230	
NICU A		158	May 2004–Mar 2006
NICU B		72	Dec 2008–Dec 2009
India			
Overall	2	527	
NICU A		217	Jan 2010–Jul 2010
NICU B		310	Feb 2009–Oct 2010
Mexico	1	515	Oct 2003–Jun 2005
Morocco	1	368	Aug 2008–Sep 2010
Peru	1	51	Aug 2005–Oct 2007
Philippines			
Overall	2	1,813	
NICU A		1,596	Sep 2007–Aug 2008
NICU B		217	Jan 2006–Dec 2009
Salvador	1	1,270	Jan 2007–Aug 2009
Tunisia	1	191	Oct 2008–May 2009
Turkey	3	1,629	
NICU A		1,141	Jan 2004–Jun 2007
NICU B		130	Sep 2005–Dec 2006
NICU C		358	Oct 2008–Oct 2009
Type of hospital			
Academic teaching	9 (60)	3,964 (58)	...
Public hospital	3 (20)	724 (11)	...
Private community	3 (20)	2,141 (31)	...

NOTE. NICU, neonatal intensive care unit.

TABLE 2. Characteristics of Patients, Hand Hygiene (HH) Improvement, and Ventilator-Associated Pneumonia (VAP) Rates in Patients Hospitalized in Neonatal Intensive Care Units in Phase 1 (Baseline Period) and Phase 2 (Intervention Period)

Variable	Baseline period	Intervention period	Rate ratio	95% CI	*P*
Patient characteristic					
Study period, mean months ± SD (range)	3	15.1 ± 9.1 (3–35)			
No. of patients	1,237	5,592			
Duration of MV, mean days ± SD	2.55 ± 7.3	2.85 ± 6.6			.144
No. of bed days	16,733	73,700			
Sex, no. (%) of patients					
Male	59 (731)	58 (3,261)	0.99	0.91–1.07	.7456
Female	41 (506)	42 (2329)			
Weight, mean kg ± SD	2.43 ± 1.14	2.36 ± 0.87			.094
HH improvement					
No. of HH observations	1,608	4,888			
HH compliance, % (no. of observations)	62 (1,004)	81 (3,947)	1.29[a]	1.21–1.39	.0001
VAP					
No. of cases of VAP	56	191			
No. of MV days	3,153	15,981			
MV use ratio, mean value (95% CI)	0.19 (0.18 – 0.20)	0.22 (0.21 – 0.23)	1.15	1.11–1.20	.0001
VAP rate per 1,000 MV-days	17.8	12.0	0.67	0.50–0.91	.0009

NOTE. CI, confidence interval; MV, mechanical ventilation; SD, standard deviation.
[a] For HH, relative risk, rather than rate ratio, is calculated.

5. Use of noninvasive ventilation whenever possible and minimization of the duration of ventilation.[6]
6. Preferable use of orotracheal instead of nasotracheal intubation.[14]
7. Removal of the condensate from ventilator circuits and keeping the ventilator circuit closed during condensate removal.[6]
8. Change of the ventilator circuit only when visibly soiled or malfunctioning.[15]
9. Avoidance of gastric overdistention.[16]
10. Avoidance of histamine receptor 2–blocking agents and proton pump inhibitors.[17]
11. Use of sterile water to rinse reusable respiratory equipment.[6]

We performed direct observation of hand hygiene compliance, duration of the ventilation, and ventilation use ratio using a structured observation tools at regularly scheduled intervals.[18] It is to be noted that, because there are few studies that have evaluated the prevention of VAP in children, the majority of the items included in our bundle are based on studies that involved adults.[6]

Definitions

We applied NHSN definitions for VAP.[19] VAP is indicated in a patient receiving mechanical ventilation who has chest radiograph findings that show new or progressive infiltrates, 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 aspirate, bronchial brushing or bronchoalveolar lavage, or biopsy.[19]

Statistical Methods

Patient characteristics during the baseline and intervention periods in each NICU were compared using Fisher exact test for dichotomous variables and an unmatched Student *t* test for continuous variables. The 95% confidence intervals (CIs) were calculated using VCStat (Castiglia). Relative risk (RR) ratios with 95% CIs were calculated for comparisons of rates of central line–associated bloodstream infection using EPI Info, version 6. *P* values <.05 by 2-sided tests were considered significant. In addition, we explored the change in VAP rate after an ICU joined INICC by looking at the follow-up period stratified by 3-month periods over the first year, 6-month periods over the second and third years of follow-up, and then yearly (to allow somewhat for fewer subjects in ICUs with longer periods of follow-up). We calculated crude stratified rates and, using random-effects Poisson regression to allow for clustering by ICU, we calculated IRR for each time period, compared with the baseline 3 months. Device days were included in the model as an offset with the coefficient constrained to be 0 (patients without mechanical ventilation [MV] during hospitalization were excluded). We performed an additional regression that considered "time since ICU started the intervention period" as a continuous variable (including and excluding the baseline period) and calculated the IRR for reduction in HAI for each 3-month period of follow up.

RESULTS

Throughout the study period, 6,829 patients hospitalized for a total of 90,433 days in 15 NICUs were enrolled for a total of 19,134 MV-days. The participating hospitals were summarized and classified according to the number of NICUs,

TABLE 3. Microorganisms Related to Ventilator-Associated Pneumonia in Baseline and Intervention Periods

Isolated microorganism	Percentage (no.) of isolates	
	Baseline period	Intervention period
Acinetobactet species	10 (2)	4.8 (2)
Escherichia coli	15 (3)	4.8 (2)
Enterobacter species	5 (1)	2.4 (1)
Klebsiella species	25 (5)	11.9 (5)
Proteus species	0	2.4 (1)
Pseudomonas species	45.0 (9)	50.0 (21)
Staphylocous aureus	0	14.3 (6)
Coagulase-negative staphylococci	0	7.1 (3)
Stenotrophomonas species	0	2.4 (1)

the number of patients per hospital NICU, type of hospital, and country (Table 1).

Patient characteristics, such as sex and weight, are shown in Table 2. We found that although MV use ratio was higher during the intervention period, MV duration was similar in both periods (Table 2).

The multifaceted infection control program showed its effectiveness in relation to correlated improvements in compliance rates. More specifically, during phase 2, we found a statistically significant increase in hand hygiene compliance, which improved from 62% to 81% ($P < .01$; Table 2).

In phase 1, there were 3,153 documented MV-days, and 56 VAPs were recorded, for an overall baseline rate of 17.8 VAPs per 1000 MV-days. In phase 2, after the implementation of the multifaceted infection control program, there were 15,981 MV-days. There were 191 VAPs, for an incidence density of 12.0 VAPs per 1,000 MV-days.

These results showed a 33% reduction in VAP rate from baseline (from 17.8 to 12.0 cases of VAP per 1,000 MV-days; RR, 0.67 [95% CI, 0.50–0.91]; $P = .0009$; Table 2).

Among the isolated microorganisms associated with VAP, the most common was *Pseudomonas* species (which accounted for 45% of isolates during the baseline period and 50% of isolates during the intervention period; see Table 3 for a full bacterial profile).

Rates of VAP decreased immediately after the first 3 months of participation in the INICC, but rates remained at this reduced level with no further clear decrease with increased time in the INICC. During the intervention period (excluding the baseline surveillance), VAP rates decreased by 7% for every 3 months of follow-up (Table 4).

DISCUSSION

We have shown that implementation of the INICC multidimensional infection control strategy resulted in a significant reduction in the rate of VAP in the participating NICUs, which decreased by 33%. In particular, we found that improvement in hand hygiene compliance, which increased to 81%, was strongly correlated with the decrease in VAP rate. All participating hospitals are from countries with lower-middle-income and upper-middle-income economic levels,[20] and it has been reported in the literature that hospitals associated with these socioeconomic conditions, compared with those from developed economies, are also associated with a higher risk of infection because of their resource limitations. Similarly, the type of hospital is another factor that influences the DA-HAI rates, with the economic level of the country having a stronger impact on public hospitals than on academic and private hospitals.[21] Our high VAP rates have also been influenced by this fact, because developing economies reflect their socioeconomic level in a lack of administrative support and insufficient financial resources within hospitals. The type of hospital at which our NICUs were located, however, did not account for the high VAP rate, because only 11% of enrolled patients were from public hospitals.

Reducing DA-HAIs has been an important issue in developed countries and has become particularly important in many US hospitals after the decision by Medicare to not provide increased payments for VAP or central line–associated bloodstream infection. Unfortunately, several healthcare institutions in developing countries lack basic infection control programs, and most caregivers are unaware of VAP rates at their healthcare facilities.[4,22,23] A significant number of VAP preventive strategies have been reported in several studies, which showed the positive impact of basic interventions, such as hand hygiene,[11] early removal of endotracheal tubes,[6] and continuous subglottic suctioning.[6] However, the majority of such studies have not been performed on neonatal patients, but on adult patients, and the majority of such studies are from developed countries.[6,24]

Our findings lead us to consider that VAP reduction in NICUs from developing countries is feasible. To prevent and control VAP, infection control professionals must implement a strategy that is based on an accurate knowledge of VAP rates at their healthcare facility, so as to approach the interventions with cost-effective preventive measures. It is noteworthy that implementation of only a single measure may not be sufficient to control VAP, and doing so requires a culture change that involves the entire ICU team (doctors, nurses, and respiratory therapists).[6] The benefit of multidi-

TABLE 4. Ventilator-Associated Pneumonia (VAP) Stratified by the Length of Time that Each Unit has Participated in International Nosocomial Infection Control Consortium (INICC)

Variable	Cases with MV	VAP	Crude VAP rate per 1,000 MV-days	IRR accounting for clustering by ICU
Months since joining INICC				
0–3 (baseline)	469	55	17.21 (13.21–22.41)	Baseline
3–6	455	36	11.40 (8.23–15.8)	0.78 (0.51–1.2)
6–9	423	36	12.92 (9.32–17.91)	0.87 (0.56–1.33)
9–12	301	27	11.75 (8.06–17.41)	0.78 (0.49–1.26)
12–18	375	32	13 (9.19–18.38)	0.89 (0.56–1.4)
18–24	311	34	12.77 (9.12–17.86)	0.70 (0.45–1.09)
24–36	264	21	9.85 (6.42–15.10)	0.47 (0.28–0.79)
36–48	54	0	...	...
Time since joining INICC in months per month	2,652	241	...	0.97 (0.96–0.99)
Considering time since the intervention as a continuous variable (excluding the baseline period) per month	2,191	191	...	0.93 (0.88–0.98)

NOTE. IRR, incidence rate ratio; MV, mechanical ventilation.
[a] $P = .001$.
[b] $P = .009$.

mensional infection control programs focused on educational interventions has been shown in many studies.[25-31] Nevertheless, educational efforts produce benefits that may be short-lived without regular reinforcement.

Study Limitations

It is important to note that trained infection control professionals performed our VAP surveillance. With the increasing pressure placed on hospitals to report measures of quality, including VAP rates, there is a risk that hospital staff will interpret the VAP definition in a way that appears to minimize their VAP rates.[21] Interestingly, despite the problems associated with considering VAP to be a good quality indicator, we achieved a successful reduction in VAP rates in the NICU setting.

We are aware that we may not be able to sustain current VAP rates indefinitely, but our goal is to sustain a nearly perfect compliance with the ventilator bundle and maintain ICU team motivation for VAP prevention. The improvement shown in INICC member hospitals, in this setting and elsewhere, provides healthcare personnel with simple but effective and inexpensive preventive strategies. We expect that this will result in a wider acceptance of infection control programs in all hospitals in limited-resource countries.

OTHER INICC INVESTIGATORS PARTICIPATING IN THIS STUDY

Argentina: Sandra Guzman, Ariel Boglione, and Oscar Migone (Centro Médico Bernal, Buenos Aires).

Colombia: Nayide Barahona-Guzmán, Alfredo Lagares-Guzmán, and Guillermo Sarmiento-Villa (Universidad Simón Bolívar, Barranquilla).

El Salvador: Ana C. Bran-de-Casares and Lilian de-Jesús-Machuca (Hospital Nacional de Niños Benjamín Bloom, San Salvador).

India: Sweta Shah and Vatsal Kothari (Kokilaben Dhirtubhai Ambani Hospital, Mumbai); Amit Gupta and Narinder Saini (Pushpanjali Crosslay Hospital Ghaziabad).

Mexico: Martha Sobreyra-Oropeza (Hospital de la Mujer, Mexico City).

Morocco: Naima L. Bouazzaoui and Kabiri Meryem (Children Hospital of Rabat, Rabat).

Peru: Favio Sarmiento-López (Hospital Regional de Pucallpa, Pucallpa).

The Philippines: Glenn A. S. Genuino, Rafel J. Consunji, and Jacinto B. V. Mantaring III (Philippine General Hospital, Manila); Victoria D. Villanueva and Maria C. V. Tolentino (St. Luke's Medical Center, Quezon City).

Tunisia: Khaldi Ammar and Asma Hamdi (Hospital d'Enfants, Tunis).

Turkey: Mustafa Yildirim and Selvi Erdogan (Duzce University Medical School Infectious Diseases and Clinical Microbiology, Duzce); Hakan Uzun (Duzce University Medical School Department of Pediatrics); Ali Kaya and Necdet Kuyucu (Mersin University, Faculty of Medicine, Mersin); Sukru Küçüködük (Ondokuz Mayis University Medical School, Samsun).

ACKNOWLEDGMENTS

We thank the many health care professionals at each member hospital who assisted with the conduct of surveillance, including the surveillance nurses, clinical microbiology laboratory personnel, and the physicians and nurses who provided care for the patients during the study. Without their cooperation and generous assistance, this INICC would not be possible. We thank Mariano Vilar, Debora Lopez Burgardt, and Alejo Ponce de Leon, who work at INICC headquarters in Buenos Aires, for their hard work and commitment to achieve INICC goals; the INICC country coordinators (Altaf Ahmed, Carlos A. Álvarez-Moreno, Apisarnthanarak Anucha, Luis E. Cuéllar, Bijie Hu, Hakan Leblebicioglu, Eduardo A. Medeiros, Yatin Mehta, Lul Raka, Toshihiro Mitsuda, and Virgilio Bonilla Sanchez); the INICC Advisory Board (Carla J. Alvarado, Gary L. French, Nicholas Graves, William R. Jarvis, Patricia Lynch, Dennis Maki, Russell N. Olmsted, Didier Pittet, Wing Hong Seto, and William Rutala), who have so generously supported this unique international infection control network; and Patricia Lynch, who inspired and supported us in following our dreams despite obstacles.

Financial support. The funding for the activities performed at INICC headquarters were provided by V.D.R. and the Foundation to Fight against Nosocomial Infections.

Potential conflicts of interest. All authors report no conflicts of interest relevant to this article. All authors submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and the conflicts that the editors consider relevant to this article are disclosed here.

Address correspondence to Victor Daniel Rosenthal, Corrientes Avenue #4580, Floor 11, Apartment A, Buenos Aires 1195, Argentina (victor_rosenthal@inicc.org).

REFERENCES

1. van der Zwet WC, Kaiser AM, van Elburg RM, et al. Nosocomial infections in a Dutch neonatal intensive care unit: surveillance study with definitions for infection specifically adapted for neonates. *J Hosp Infect* 2005;61(4):300–311.
2. Richards MJ, Edwards JR, Culver DH, Gaynes RP. Nosocomial infections in combined medical-surgical intensive care units in the United States. *Infect Control Hosp Epidemiol* 2000;21(8):510–515.
3. Garland JS. Strategies to prevent ventilator-associated pneumonia in neonates. *Clin Perinatol* 2010;37(3):629–643.
4. Rosenthal VD. Health-care-associated infections in developing countries. *Lancet* 2011;377(9761):186–188.
5. Youngquist P, Carroll M, Farber M, et al. Implementing a ventilator bundle in a community hospital. *Jt Comm J Qual Patient Saf* 2007;33(4):219–225.
6. Coffin SE, Klompas M, Classen D, et al. Strategies to prevent ventilator-associated pneumonia in acute care hospitals. *Infect Control Hosp Epidemiol* 2008;29(suppl 1):S31–S40.
7. Murila F, Francis JV, Bland A, Kumbla S, Doherty R, Sehgal A. Interpreting positive cultures of endotracheal aspirates: factors associated with treatment decisions in ventilated neonates. *J Paediatr Child Health* 2011;47:728–733.
8. Aly H, Badawy M, El-Kholy A, Nabil R, Mohamed A. Randomized, controlled trial on tracheal colonization of ventilated infants: can gravity prevent ventilator-associated pneumonia? *Pediatrics* 2008;122(4):770–774.
9. Nakwan N, Wannaro J, Thongmak T, Pornladnum P, Saksawad R, Chokephaibulkit K. Safety in treatment of ventilator-associated pneumonia due to extensive drug-resistant *Acinetobacter baumannii* with aerosolized colistin in neonates: a preliminary report. *Pediatr Pulmonol* 2011;46(1):60–66.
10. Tablan OC, Anderson LJ, Besser R, Bridges C, Hajjeh R. Guidelines for preventing health-care–associated pneumonia, 2003: recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee. *MMWR Recomm Rep* 2004;53(RR-3):1–36.
11. Boyce JM, Pittet D. Guideline for hand hygiene in health-care settings: recommendations of the Healthcare Infection Control Practices Advisory Committee and the HIPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. *Am J Infect Control* 2002;30:S1–S46.
12. Burns KE, Adhikari NK, Meade MO. Noninvasive positive pressure ventilation as a weaning strategy for intubated adults with respiratory failure. *Cochrane Database Syst Rev* 2003(4):CD004127.
13. Tantipong H, Morkchareonpong C, Jaiyindee S, Thamlikitkul V. Randomized controlled trial and meta-analysis of oral decontamination with 2% chlorhexidine solution for the prevention of ventilator-associated pneumonia. *Infect Control Hosp Epidemiol* 2008;29(2):131–136.
14. Salord F, Gaussorgues P, Marti-Flich J, et al. Nosocomial maxillary sinusitis during mechanical ventilation: a prospective comparison of orotracheal versus the nasotracheal route for intubation. *Intensive Care Med* 1990;16(6):390–393.
15. Stamm AM. Ventilator-associated pneumonia and frequency of circuit changes. *Am J Infect Control* 1998;26(1):71–73.
16. Heyland DK, Drover JW, MacDonald S, Novak F, Lam M. Effect of postpyloric feeding on gastroesophageal regurgitation and pulmonary microaspiration: results of a randomized controlled trial. *Crit Care Med* 2001;29(8):1495–1501.
17. Cook DJ, Reeve BK, Guyatt GH, et al. Stress ulcer prophylaxis in critically ill patients: resolving discordant meta-analyses. *JAMA* 1996;275(4):308–314.
18. Rosenthal VD, Maki DG, Graves N. The International Nosocomial Infection Control Consortium (INICC): goals and objectives, description of surveillance methods, and operational activities. *Am J Infect Control* 2008;36(9):e1–e12.
19. Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care–associated infection and criteria for specific types of infections in the acute care setting. *Am J Infect Control* 2008;36(5):309–332.
20. World Bank. World Bank clasification of economies. 2007. http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS/0,,contentMDK:20421402p̃agePK:64133150p̃iPK:64133175 t̃heSitePK:239419,00.html. Accessed October 5, 2008.
21. Rosenthal VD, Lynch P, Jarvis WR, et al. Socioeconomic impact on device-associated infections in limited-resource neonatal intensive care units: findings of the INICC. *Infection* 2011;39:439–450.
22. Rosenthal VD. Device-associated nosocomial infections in limited-resources countries: findings of the International Nosocomial Infection Control Consortium (INICC). *Am J Infect Control* 2008;36(10):S171.e7–12.
23. Rosenthal VD, Maki DG, Jamulitrat S, et al. International Nosocomial Infection Control Consortium (INICC) report, data summary for 2003–2008, issued June 2009. *Am J Infect Control* 2010;38(2):95–104.e2.
24. Garland JS. Strategies to prevent ventilator-associated pneumonia in neonates. *Clin Perinatol* 2010;37(3):629–643.
25. Kelleghan SI, Salemi C, Padilla S, et al. An effective continuous quality improvement approach to the prevention of ventilator-associated pneumonia. *Am J Infect Control* 1993;21(6):322–330.
26. Rosenthal VD, Maki DG, Rodrigues C, et al. Impact of International Nosocomial Infection Control Consortium (INICC) strategy on central line-associated bloodstream infection rates in the intensive care units of 15 developing countries. *Infect Control Hosp Epidemiol* 2010;31(12):1264–1272.
27. Cuellar L, Rosenthal VD, Fernández-Maldonado E, Castañeda-Sabogal A, Antencio-Espinoza T. Extra Mortality of Nosocomial

Infections at 4 Hospitals of Peru: Findings of the International Nosocomial Infection Control Consortium (INICC). Paper presented at: 16th Annual Scientific Meeting of The Society for Healthcare Epidemiology of America, 19 March 2006; Chicago, IL.
28. Rosenthal VD, Guzman S, Safdar N. Reduction in nosocomial infection with improved hand hygiene in intensive care units of a tertiary care hospital in Argentina. *Am J Infect Control* 2005; 33(7):392–397.
29. Higuera F, Rosenthal VD, Duarte P, Ruiz J, Franco G, Safdar N. The effect of process control on the incidence of central venous catheter-associated bloodstream infections and mortality in intensive care units in Mexico. *Crit Care Med* 2005;33(9): 2022–2027.
30. Rosenthal VD, Guzman S, Safdar N. Effect of education and performance feedback on rates of catheter-associated urinary tract infection in intensive care units in Argentina. *Infect Control Hosp Epidemiol* 2004;25(1):47–50.
31. Rosenthal VD, McCormick RD, Guzman S, Villamayor C, Orellano PW. Effect of education and performance feedback on handwashing: the benefit of administrative support in Argentinean hospitals. *Am J Infect Control* 2003;31(2):85–92.