Effectiveness of a multidimensional approach for prevention of ventilator-associated pneumonia in adult intensive care units from 14 developing countries of four continents: Findings of the International Nosocomial Infection Control Consortium*

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Objectives: **The aim of this study was to analyze the effect of the International Nosocomial Infection Control Consortium's multidimensional approach on the reduction of ventilator-associated pneumonia in patients hospitalized in intensive care units.**

Design: **A prospective active surveillance before–after study. The study was divided into two phases. During phase 1, the infection control team at each intensive care unit conducted active prospective surveillance of ventilator-associated pneumonia by applying the definitions of the Centers for Disease Control and Prevention National Health Safety Network, and the methodology of International Nosocomial Infection Control Consortium. During phase 2, the multidimensional approach for ventilator-associated pneumonia was implemented at each intensive care unit, in addition to the active surveillance.**

Setting: **Forty-four adult intensive care units in 38 hospitals, members of the International Nosocomial Infection Control Consortium, from 31 cities of the following 14 developing countries: Argentina, Brazil, China, Colombia, Costa Rica, Cuba, India, Lebanon, Macedonia, Mexico, Morocco, Panama, Peru, and Turkey.**

Patients: **A total of 55,507 adult patients admitted to 44 intensive care units in 38 hospitals.**

Interventions: **The International Nosocomial Infection Control Consortium ventilator-associated pneumonia multidimensional approach included the following measures: 1) bundle of infection-control interventions; 2) education; 3) outcome surveillance; 4) process surveillance; 5) feedback of ventilator-associated pneumonia rates; and 6) performance feedback of infection-control practices.**

Measurements: **The ventilator-associated pneumonia rates obtained in phase 1 were compared with the rates obtained in phase 2. We performed a time-series analysis to analyze the impact of our intervention.**

Main Result: **During phase 1, we recorded 10,292 mechanical ventilator days, and during phase 2, with the implementation of the multidimensional approach, we recorded 127,374 mechanical ventilator days. The rate of ventilator-associated pneumonia was 22.0 per 1,000 mechanical ventilator days during phase 1, and 17.2 per 1,000 mechanical ventilator days during phase 2.The adjusted model of linear trend shows a 55.83% reduction in the rate of ventilator-associated pneumonia at the end of the study period; that is, the ventilator-associated pneumonia rate was 55.83% lower than it was at the beginning of the study.**

Conclusion: **The implementation the International Nosocomial Infection Control Consortium multidimensional approach for ventilator-associated pneumonia was associated with a significant reduction in the ventilator-associated pneumonia rate in the adult intensive care units setting of developing countries. (Crit Care Med 2012; 40:3121–3128)**

Key Words: developing countries; intensive care unit; international multidimensional approach; International Nosocomial Infection Control Consortium; ventilator-associated pneumonia

Ventilator-associated pneumonia (VAP) has been considered to be the most serious healthcare-associated infection, and it was reported to be the leading cause of morbidity and mortality for device-associated infections (DAI), particularly, in the adult intensive care unit (AICU) setting (1, 2). Additionally, in a large body of scientific literature, VAPs are among the most common types of DAI, resulting in a substantial increase in hospital costs and length of stay (LOS (1–3)).

The scope of the burden posed by VAP in developing countries, however, has

***See also p. 3303.**

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The remaining INICC members can be found in the Appendix.

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not been systematically addressed (1). Although surveillance has been reported as an effective tool for the reduction of VAP in the developed world (4), the importance of surveillance for measuring AICU patient infection risks, outcomes, and processes in limited-resource countries remains many times under-recognized (1, 5). As a countervailing strategy, in 2002 the International Nosocomial Infection Control Consortium (INICC) developed an outcome and process surveillance program specifically designed for intensive care units (ICUs) in developing countries (6–8).

Through the implementation of the INICC program, it was demonstrated that there was a notable difference in the VAP rates between the ICUs of hospitals from the industrialized world and those from limited-resource healthcare settings, with rates that were three to five times higher in the latter ones (9–18).

In the INICC program, the multidimensional approach for VAP, the infection-prevention bundle was based on the guidelines published by the Society for Health Care Epidemiology of America and the Infectious Diseases Society of America, which describe evidence-based interventions and recommendations for VAP prevention in the ICU (19). These guidelines provide feasible and cost-effective infection-control measures, relatively applicable to developing countries. In addition, the INICC prevention bundle also followed the recommendation by the Institute of Healthcare Improvement that a ventilator bundle be implemented at every ICU to reduce the occurrence rate of VAP to zero, which was part of the 5 Million Lives campaign, endorsed by leading U.S. agencies and professional societies (20).

Nevertheless, very few studies have been conducted and shown successful interventions for VAP reduction, which would serve as guidance for tackling this problem (1). Likewise, study heterogeneity in developing countries may cause variation in the reported rates (1).

Within the context of developing countries, outcome and process surveillance, integrated in an intervention bundle with performance feedback of infection-control practices, has been shown to successfully reduce and control DAIs in different studies conducted in INICC member hospitals (21–25).

For analytical purposes, the World Bank classifies economies as low income, middle income, or high income. As of 1 July 2011 low-income economies are those that had average incomes of $1,005 or less in 2010; lower-middle–income economies had average incomes of $1,006 to $3,975; upper-middle–income economies had average incomes of $3,976 to $12,275; and high-income had average incomes of $12,276 or more. Low- and middle-income economies are commonly referred to as developing economies. However, this does not imply that economies in the same income group have reached similar stages of development or that high-income economies have reached a preferred or final stage of development. In this study we included two lower-middle–income economies (India and Morocco), and 12 upper-middle–income economies (Argentina, Brazil, China, Colombia, Costa Rica, Cuba, Lebanon, Macedonia, Mexico, Panama, Peru, and Turkey).

This study advances the knowledge of necessary scientific evidence by assessing the specific impact of a multidimensional approach for VAP—which includes a bundle of infection-control interventions, education, outcome surveillance, process surveillance, and feedback of VAP rates and of infection-control practices—on the reduction of the frequency of VAP in 44 AICUs of 38 INICC member hospitals in 14 developing countries of four continents.

METHODS

Setting and Study Design. This before–after, prospective cohort study was carried out in 44 AICUs of 38 INICC member hospitals, in 14 developing countries, of four continents, namely: Argentina, Brazil, China, Colombia, Costa Rica, Cuba, India, Lebanon, Macedonia, Mexico, Morocco, Panama, Peru, and Turkey. These hospitals have actively participated in the INICC surveillance program for at least 1 yr, with an infection-control team comprising a medical doctor with formal education and background in infectious diseases, internal medicine, and/or hospital epidemiology, and infection-control professionals.

The study period was 12 yrs and 8 months, from March 1999 to January 2011, and was divided into two phases: phase 1 (baseline period, consisting in the first 3 months of participation in the INICC program), and phase 2 (intervention period). The Institutional Review Board at each hospital approved the study protocol.

Intervention Period. The intervention period started after 3 months of participation in the INICC surveillance program. The average length of the intervention period was 35.2 months ± SD 17.1 (range 12–57). The INICC multidimensional approach includes the following practices: 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 two components: outcome surveillance (VAP rates and consequences) and process surveillance (adherence to hand hygiene (HH) and other basic preventive infection-control practices (7)).

The investigators at the participating hospitals were required to perform outcome and process surveillance by completing forms, which were then sent for their monthly analysis to the INICC office in Buenos Aires (7).

Outcome Surveillance. The INICC Surveillance Program is focused on the methods and definitions for DAI developed by the U.S. Centers for Disease Control and Prevention for the National Nosocomial Infection Surveillance System/National Health Safety Network program (26, 27). However, the INICC methods have taken into consideration the different socioeconomic status and specific limitations of limited-resource countries, and were adapted for their application in this setting (7). Outcome su rveillance includes rates VAP per 1000 device days, microorganism profile, bacterial resistance, LOS, and mortality in their ICUs.

Process Surveillance. Preventive strategies in INICC member hospitals are based on simple, inexpensive, evidence-based measures, which include outcome surveillance, process surveillance, education, and performance feedback of outcome surveillance and process surveillance (7).

Process surveillance is designed to monitor compliance with easily measurable, key infection-control measures. It includes the surveillance of compliance rates for hand-hygiene (HH) practices and some specific infection-control measures for the prevention of VAP (23–25, 28).

HH compliance by healthcare workers is determined by measuring the frequency of HH performances when clearly indicated, and such practices are monitored by the hospital's infection-control professionals during randomly selected 1-hr observation periods, three times a week. Although healthcare workers know that HH practices are regularly monitored, they are not actually aware of the precise moment in which observations are taking place (7).

Infection-control professionals were trained to detect HH compliance and record HH opportunities and compliance through direct observation. The INICC direct observation comprises the "Five Moments for Hand Hygiene," as recommended by the World Health Organization. The Five Moments were designed on the basis of the evidence concerning DAI prevention and control, and include the monitoring of the following moments: 1) before patient contact; 2) before an aseptic task; 3) after body-fluid exposure risk; 4) after patient contact; and 5) after contact with patient surroundings (29).

Training and Validation. The INICC Chairman trained the principal and secondary investigators at hospitals from Argentina, Colombia, India, Mexico, and Turkey. In the remaining countries, investigators were self-trained by means of a manual and training tool, which described how to perform surveillance and complete surveillance forms. Investigators have continuous e-mail and telephonic access to a support team at the INICC Central Office in Buenos Aires, Argentina, which is in charge of responding to all queries within 24 hrs. The INICC Chairman further reviews all queries and responses.

Surveillance forms for individual patients allow internal and external validation, because they include every clinical and microbiological criterion for each type of DAI, such as temperature, blood pressure, use if invasive devices, cultures taken, culture results, antibiotic use. Surveillance also includes a form in which positive cultures are registered and matched with patients' forms.

On a monthly basis, participating hospitals submitted the completed surveillance forms to the INICC Central Office, where the validity of each case was checked and the recorded signs and symptoms of infection and the results of laboratory studies, radiographic studies, and cultures were scrutinized to assure that the National Nosocomial Infection Surveillance System criteria for device-associated infection were fulfilled.

The infection control team member who reviewed the forms completed at the participating AICU was able to verify that criteria for infection had been met accurately in each patient. Additionally, the original patient data forms were further validated at the INICC Central Office, before data on the reported infection were entered into the INICC's database. To that end, queries were submitted from INICC office in Buenos Aires to the ICT teams at each hospital, challenging those cases with suspected VAP, and data were uploaded after receiving the reply from hospital teams. Finally, the INICC team performed consistency analyses of database, such as age, sex, dates, among other data, and reviews of medical records that compared data registered in forms and data in medical records.

Performance Feedback. The concept of using performance feedback of outcome surveillance and process surveillance as a valuable control measure in limited-resource hospitals was based on its effectiveness as proved in previous INICC studies (21–25, 28).

The INICC Central Office team prepared and sent monthly chart reports to each participating hospital, which detailed their rates of VAP, microbiology profile, and rates of adherence to HH, among other infection-related data.

The participating ICU staff received feedback on their performance at monthly meetings, by means of the review of the monthly charts, which were posted in a prominent location in the ICU.

Bundle Components. Our bundle included the following interventions:

1) Conduction of active surveillance for VAP (30);
2) Adherence to HH guidelines (31);
3) Maintenance of patients in a semirecumbent position (30–45 degrees elevation of the head of the bed (32));
4) Performance of daily assessments of readiness to wean and use of weaning protocols (33);
5) Performance of regular oral care with an antiseptic solution (34);
6) Use of noninvasive ventilation whenever possible and minimization of the duration of ventilation (19);
7) Preferable use of orotracheal instead of nasotracheal intubation (35);
8) Maintenance of an endotracheal cuff pressure of at least 20-cm H_2O (36);
9) Removal of the condensate from ventilator circuits (19), and keeping the ventilator circuit closed during condensate removal (37);
10) Change of the ventilator circuit only when visibly soiled or malfunctioning (38);
11) Avoidance of gastric overdistention (39);
12) Avoidance of histamine receptor 2 (H_2)–blocking agents and proton pump inhibitors (40);
13) Use of sterile water to rinse reusable respiratory equipment (19).

We performed direct observation of HH compliance, duration of the ventilation, and ventilation ratio use, using a structured observation tool at regularly scheduled intervals (7).

Definitions. We applied Centers for Disease Control and Prevention National Health Safety Network definitions for VAP (27). VAP is diagnosed in a mechanically ventilated patient with a chest radiograph that shows 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 (27).

Statistical Methods. Patients' characteristics during baseline and during intervention period in each AICU were compared using Fisher's exact test for dichotomous variables and unmatched Student's *t* test for continuous variables. Relative risk ratios with 95% confidence intervals were calculated for comparison of rates at baseline and subsequent intervention period.

To analyze the time evolution of VAP rates in AICUs, we performed a time-series analysis of VAP rate, as a variable, during the whole study period. We used a regression model with Auto-Regressive Integrated Moving Average errors, which allows us to fit structural changes in trends as well as in the level of the variable being analyzed, taking into consideration time dependency. Analyses done allowed the adjustment of a linear trend model of the type

$$VAP_{\text{rate}} = \beta_0 + \beta_1 t + u_t$$

where u_t refers to random errors with a normal distribution.

For model-adjustment purposes, we used REGRESSION, autocorrelation function, and time series model procedures of SPSS Statistics 17.0 (SPSS Inc, Chicago, IL).

RESULTS

During the study period, 55,507 patients, hospitalized for 358,565 days in 44 AICUs were enrolled in the study, with a total of 137,666 mechanical ventilator (MV) days (see Tables 1 and 2).

Patients characteristics were similar during both periods, although average severity of illness score was lower and the percentage of patients with cardiac failure was higher (see Table 2).

Regarding process surveillance, we found that semirecumbent position was 85.1%, and was improved by 6%, removal of the mucus from ventilator circuits was 80.7%, and was improved by 5%, HH

Table 1. Characteristics of participating adult intensive care units by type, country and hospital type

Data	Adult Intensive Care Units, n	Adult Intensive Care Unit Patients, n
Country		
Argentina	5	11,567
Brazil	4	2,085
China	2	1,128
Colombia	4	4,782
Costa Rica	1	230
Cuba	1	1,076
India	9	20,968
Lebanon	1	996
Mexico	1	2,202
Morocco	3	1,023
Panama	1	2,535
Peru	1	360
Turkey	3	1,843
Total countries: 14	44 ICUs	55,507
Type of intensive care unit, n (%)		
Coronary	4 (9%)	9,674
Cardio-surgical	1 (2%)	2,202
Medical	2 (5%)	2,047
Medical–surgical	31 (70%)	35,548
Surgical	5 (11%)	4,415
Ward	1 (2%)	1,621
Type of hospital, n (%)		
Academic teaching	16 (42%)	16,779
Private community	7 (18%)	5,442
Public hospital	15 (39%)	33,286

compliance compliance was improved by 17%, nebulizer without turbidity was improved by 27%, absence of pharyngeal lake was improved by 18%; however, removal of the condensate from ventilator circuits (73%), and respiratory therapy done (92.5%) did not improve significantly (see Table 3).

During baseline, the VAP rate was 22.0 VAPs per 1000 MV days, and during intervention VAP rate was 17.2 per 1,000 MV days (relative risk 0.78; 95% confidence interval 0.68–0.90; p <.0004). These results showed a 22% VAP rate reduction (see Table 4).

A time-series analysis was carried out, and the estimated model from available data was the following: *VAP_rate* = 22.491–0.211 *t*; that is, the VAP rate at the start of the intervention period was 22.5 per 1,000 MV days, and reduced by 0.21 per 1,000 MV days for every additional month. Details of the final time-series model estimates are presented below:

ARIMA Model Parameters

	Estimate	Standard Error	*T*	Significance
Constant	22,491	0.665	33,833	0.000
Mo	–0.211	0.019	–11,124	0.000

The R^2 obtained was .681, and Ljung-Box Q statistic indicated the absence of statistically significant autocorrelations in residuals (Q = 11.144, df = 18, significance = 0.888).

The adjusted model of linear trend shows a 55.83% reduction of the rate of VAP at the end of the study period; that is, the VAP rate is 55.83% lower than it was at the beginning of phase 2. (Fig. 1)

Microorganisms profile is shown in Table 5.

Antibiotic resistance and antibiotic use are shown in Tables 6 and 7, respectively.

Table 2. Patient characteristics at baseline period and intervention period

Variables	Phase 1 Baseline Period	Phase 2 Intervention Period	*p*
Length of period in mos, mean (range)	3 mos	35.2 (12–57 mos)	
Number of patients	3,889	51,618	
Patient characteristics at admission			
Average severity of illness score mean, SD	3.0 ± 1.2	2.8 ± 1.1	.0001
Sex, n (%)			
Male	2,352 (60.5%)	30,784 (59.6%)	.2674
Female	1,535 (39.5%)	20,778 (40.3%)	
Age, mean ± SD	57.2 ± 19.5	57.6 ± 19.9	.181
Endocrine diseases, n (%)	464 (11.9%)	6,058 (11.7%)	.7001
Cardiac failure, n (%)	796 (20.5%)	11,709 (22.7%)	.0015
Cardiac surgery, n (%)	197 (5.1%)	2439 (4.7%)	.2674
Thoracic surgery, n (%)	21 (0.5%)	203 (0.4%)	.3970
Trauma, n (%)	106 (2.7%)	1,240 (2.4%)	.2411
Stroke, n (%)	95 (2.4%)	1,196 (2.3%)	.713
Previous infection, n (%)	181 (4.7%)	2,305 (4.5%)	.5522
Patient characteristics at discharge			
Length of stay in days, mean	6.9 ± 11.4	6.4 ± 9.4	.008

Table 3. Hand-hygiene compliance and mechanical ventilator care in the participating adult intensive care units

	Phase 1 Baseline Period (mos 1–3)	Phase 2 Intervention Period	% of Change	*p*
Adherence to hand-hygiene guidelines % (n)	55.0%	65.7%	17%	.0001
Mechanical ventilator use ratio, mean (95% confidence interval)	0.38	0.38		.9753
Mechanical ventilator duration, mean ± SD	6.8 ± 11.2	6.3 ± 10.6		.099
Maintenance of patients in a semirecumbent position (30–45 degrees elevation of the head of the bed)	85.1%	89.9%	6%	.001
Nebulizer without turbidity	59.2%	80.3%	27%	.0001
Pharyngeal lake present	70.8%	58.3%	18%	.0001
Removal of the mucus from ventilator circuits	80.7%	84.7%	5%	.0001
Removal of the condensate from ventilator circuits	73.0%	73.2%	0.3%	.8153
Respiratory therapy done	92.5%	91.8%	1%	.1116

Mechanical ventilator use ratio: mechanical ventilator use ratios were calculated by dividing the total number of mechanical ventilator days by the total number of patient days. Mechanical ventilator days are the total number of days of exposure to mechanical ventilation by all the patients in the selected population during the selected time period. Patient days are the total number of days that patients are in the intensive care unit during the selected time period.

DISCUSSION

In many studies, it has been demonstrated that VAP is associated with increased hospital LOS (3, 41),excess healthcare costs (3), and increased attributable mortality (41).The fact that patients hospitalized in ICUs frequently require mechanical ventilation makes them especially vulnerable to develop VAP. Unfortunately, many healthcare institutions in developing countries lack basic infection-control programs and most caregivers are unaware of VAP rates at their healthcare facilities (2, 5, 6, 9–18, 42, 43).

Reducing DAIs has been considered a primary healthcare matter that needs immediate attention (44). As reported in different studies from the United States, the frequency of DAI can be reduced by as much as 30%, leading to a correlated decrease in hospital costs (45). The implementation of a multidimensional approach for VAP reduction proved effective a long time ago. It has been demonstrated in different studies that VAP prevalence can be substantially prevented through effective basic interventions, such as HH (46), semirecumbent positioning (47), early removal of endotracheal tubes (48), maintenance of endotracheal cuff pressure, and continuous subglottic suctioning (49).

In our study, we noticed a significant improvement in semirecumbent position, removal of the mucus from ventilator circuits, HH compliance, nebulizer without turbidity, and absence of pharyngeal lake; however, removal of the condensate from ventilator circuits, and respiratory therapy done did not improve significantly.

In general, patients' characteristics were similar during both periods, although ASIS score was lower and the percentage of patients with cardiac failure was higher during the intervention period.

On the one hand, we noticed a significant reduction in patients with usage of antibiotic, a reduction in patients using quinolones, and ceftriaxone; but on the other, we also noticed a reduction in LOS. Probably both reductions, in antibiotic usage and LOS, resulted from the reduction in VAP rates after adopting the multidimensional approach.

Infection-control professionals need to implement a VAP preventive strategy based on the accurate knowledge of VAP rates at their institutions, so as to approach the problem with cost-effective preventive measures. The positive impact of multidimensional infection-control programs that focus on educational interventions has been shown in many studies (6, 21, 23, 49–54).

However, such educational efforts may be short-lived if regular reinforcement is absent. Similarly, a reduction in VAP rates cannot be expected to derive from surveillance by itself, unless the collection of this data is used for the improvement of patient-care practices, such as performance feedback (21, 22). Therefore, it is essential to support educational efforts with regular feedback in the form of monthly occurrence rates of VAPs to derive substantial benefit from preventive strategies (21, 22, 28, 54, 55).

VAP control may not be sufficient or feasible if a single measure is implemented, but it requires a culture change involving the entire ICU team (doctors, nurses, respiratory therapists (19)). It was shown in studies performed by INICC that implementation of a multifaceted prevention model for VAP, which includes a bundle of interventions, such as outcome and process surveillance, education, feedback of VAP rates, and performance feedback, resulted in a significant reduction in rates of VAP over the study period (21, 22, 28, 54, 55).

Using a time-series analysis with a linear trend model, the rate of VAP was reduced by 55.83% in the participating AICUs by the end of the study. This reduction occurred during phase 2, after adopting the VAP prevention model.

Table 4. Ventilator-associated pneumonia rates in the participating adult intensive care units

	Phase 1	Phase 2	Relative Risk (95% Confidence Interval)	*p*
	Baseline Period	Intervention Period		
Number of VAP	226	2,191		
Number of mechanical ventilator days	10,292	127,374		
VAP rate per 1,000 mechanical ventilator days	22.0	17.2	0.78 (0.68–0.90)	.0004
VAP rate per 100 patients	5.8%	4.2%	0.73 (0.64–0.84)	.0001
Mortality per 100 patients (95% confidence interval)	14% (12.7–14.9)	15% (14.9–15.6)		

VAP, ventilator-associated pneumonia.

Mechanical ventilator use ratio: Mechanical ventilator use ratios were calculated by dividing the total number of mechanical ventilator days by the total number of patient days. Mechanival ventilator days: the total number of days of exposure to mechanical ventilation by all of the patients in the selected population during the selected time period. Patient days: the total number of days that patients are in the intensive care unit during the selected time period.

Table 5. Microorganism profile of ventilator-associated pneumonia in the participating adult intensive care units divided into phase 1 and phase 2

	Phase 1	Phase 2
Isolated Microorganisms	Baseline Period	Intervention Period
Acinetobacter species	24% (43)	25% (426)
Candida species	4% (7)	3% (48)
Citrobacter species	0% (0)	0.1% (2)
Corynebacter species	0% (0)	0.4% (7)
Escherichia coli	6% (11)	5% (89)
Enterobacter species	2% (3)	4% (74)
Enterococcus species	1% (1)	1% (13)
Haemophilius species	0% (0)	0.2% (3)
Klebsiella species	13% (24)	10% (173)
Micrococcus species	0% (0)	0.1% (2)
Morganella species	0% (0)	0.1% (1)
Pneumococcus species	0% (0)	0% (1)
Proteus species	2% (4)	1% (20)
Providencia species	0% (0)	0% (5)
Pseudomonas. species	32% (58)	26% (448)
Staphylococcus aureus	12% (21)	19% (319)
Coagulasa-negative Staphylococci	1% (2)	3% (43)
Serratia species	2% (3)	1% (14)
Stenotrophomonas species	1% (1)	1% (15)
Streptococcus species	2% (3)	1% (12)

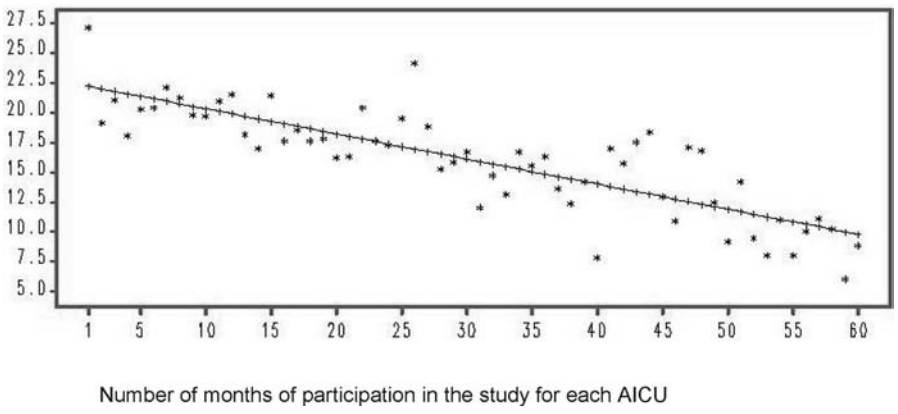

Figure 1. Observed values of ventilator-associated pneumonia (*VAP*) rate and adjusted model. Number of months of participation in the study for each adult intensive care unit (*AICU*). VAP × 100 mechanical ventilator (*MV*) days.

Table 6. Antibiotic resistance in the participating adult intensive care units divided into phase 1 and phase 2

	Phase 1		Phase 2		
	Baseline Period		Intervention Period		
	No. of Isolates	% of Resistance	No. of Isolates	% of Resistance	*p*
Staphylococcus aureus					
% resistance to methiciline	13	85	472	77	.7548
Acinetobacter species.					
% resistance to Imipenem	38	32	901	51	.0956
Pseudomonas species.					
% resistance to Piperaciline-Tazobactam	60	43	796	35	.2839
% resistance to imipenem	81	52	1237	37	.0292
% resistance to Ciprofloxacine	43	65	745	46	.0762
Klebsiella species.					
% resistance to imipenem	37	3	413	5	.5998

Table 7. Use of antibiotics in the adult intensive care units divided into phase 1 and phase 2

	Phase1		Phase 2		
	Baseline Period		Intervention Period		*p*
Patients without antibiotics	1,408	36.2%	21,087	40.9%	.0002
Patients treated with piperaciline-tazobactam	195	5.0%	2,791	5.4%	.2730
Patients treated with ciprofloxacine	257	6.6%	2,908	5.6%	.0087
Patients treated with imipenem	192	4.9%	2,355	4.6%	.3712
Patients treated with ceftriaxone	687	17.7%	6,227	12.1%	.0001

Within the scope of developing countries, this study is among the first few studies that have reported a substantial reduction in VAP rates in the AICU setting, proving the success of this kind of infection-control approach (1).

For the future, we plan to include the process surveillance and performance feedback of other variables that could not be measured during this multidimensional approach, such as: performance of daily assessments of readiness to wean and use of weaning protocols, performance of regular comprehensive oral care with an antiseptic solution, use of noninvasive ventilation whenever possible and minimization of the duration of ventilation, preferable use of orotracheal instead of nasotracheal intubation; maintenance of an endotracheal cuff pressure of at least 20-cm H_2O, avoidance of gastric overdistention, and avoidance of histamine receptor 2 (H_2)–blocking agents and proton pump inhibitors.

It is noteworthy that VAP is considered a good quality indicator, and trained infection-control professionals are under great pressure to achieve improved VAP rates. This may result in a risk that healthcare workers may involuntary construe the VAP definition so as to attenuate manifest rates of VAP rates (19). Despite this difficulty, infection-control professionals at the INICC AICU setting were able to obtain successful prevention of VAP. Although we are conscious of the challenge involved in sustaining present VAP rates indefinitely, and in improving them continously, we aim at improving compliance of the model for VAP prevention by upholding the motivation of the AICU team.

CONCLUSIONS

We expect that these preventive strategies, which have proven to be effective in the INICC AICUs by means of the implementation of the multidimensional approach for VAP prevention, result in a wider acceptance of infection-control programs in hospitals worldwide, leading to significant VAP reductions, thus. For that reason, any hospital may participate in the INICC network, which was set up to respond to the compelling need in the developing world to significantly prevent, control, and reduce VAPs and their adverse effects. Through the INICC network, investigators are freely furnished with training and methodological tools to perform outcome and process surveillance, and to implement an effective infection-prevention model for VAPs, and at the same time, the publication of these findings serves to foster relevant scientific evidence-based literature.

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