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Original Article

National bundle care program implementation to reduce ventilator-associated pneumonia in intensive care units in Taiwan



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Abstract *Background/purpose:* This study investigated the impact of implementing ventilator-associated pneumonia (VAP) bundle care on the rates of VAP in intensive care units (ICUs) in Taiwan.

Methods: A total of 10 ICUs (bed number, 170), including surgical (SICUs) ($n = 7$), cardiovascular/surgical (CV/S-ICUs) ($n = 1$), and medical ICUs (MICUs) ($n = 2$) from 10 hospitals (7 medical center hospitals and 3 regional hospitals) were enrolled in this quality-improvement project. This study was divided into the pre-intervention phase (1st January, 2012–31st July, 2013) and the intervention phase (1st August, 2013–31st October, 2014).

Results: Among the 10 hospitals, the overall rates (cases per 1000 ventilator-days) of VAP declined significantly ($p = 0.005$; rate ratio, 0.71) from 1.9 in the pre-intervention period to 1.5 in the intervention period. Significant difference in VAP rates between these periods was found in the regional hospitals (from 1.6 to 0.7; $p < 0.001$) and the SICUs (from 2.1 to 1.4; $p < 0.001$), but not in the medical centers (2.0 vs. 1.9; $p = 0.0667$) or CV/S-ICUs (4.5 vs. 4.5; $p = 0.5391$). However, VAP rate increased significantly (cases per 1000 ventilator-days) in the MICUs between the two periods (from 0.5 to 1.0; $p = 0.0489$). For the VAP bundle care elements, the overall compliance rate was 87.7% with 83.6% and 97.9% in the medical centers and regional hospitals, respectively.

Conclusions: Implementing VAP bundle care has effectively reduced VAP in Taiwanese ICUs, but differences in performance and compliance rates of VAP bundle care among the different ICUs and hospital categories did exist.

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Introduction

Ventilator-associated pneumonia (VAP) is associated with poor clinical and economic outcomes.¹ The overall mortality attributed to VAP was 13%, with higher rates for surgical patients and patients with a mild-range severity score upon admission.² In the United States, nosocomial pneumonia (31%) was the most common type of healthcare-associated infections (HAIs), followed by urinary tract infection (UTI, 23%) and primary bloodstream infection (BSI, 14%).³ Of the patients with nosocomial pneumonia, 83% were associated with the use of mechanical ventilators.³ In developing countries, VAP was the second most common HAI (25%).⁴ The VAP rate in intensive care units (ICUs) was 50.87 per 100 ventilator-days with attributed

mortality of 35% and 10 attributed additional days of hospitalization.⁴

Data obtained from the Taiwan Nosocomial Infection Surveillance (TNIS) program which collected the relevant information of HAIs in ICUs of medical centers and regional hospitals in 2011, UTI, BSI, and lower respiratory tract infections were the top three types of HAIs. More than 70% of patients with HAIs were related to catheter interventions, which were commonly used in ICUs. Ventilators were the most important equipment in ICUs for supporting patients in respiratory failure.

Some evidence-based studies have applied effective methods, particularly bundle care interventions, to reduce catheter-related infections. In addition, the bundle may improve the quality of medical services with limited

resources.^{5–11} Many groups have reported reductions in VAP rates through bundle care intervention.^{12,13} In Boston, a medical center hospital reduced the VAP rate in the surgical intensive care unit (SICU) from 10.2 cases over 1000 ventilator-days to 3.4 cases over 1000 ventilator-days by improving adherence to VAP bundles over 38 months.¹⁴ Unsurprisingly, the VAP rate was reduced from 11.05 cases over 1000 ventilator-days to 2.81 cases over 1000 ventilator-days through a bundle care intervention at a regional hospital in southern Taiwan.¹⁵ Although it is an effective way to reduce the rates of VAP and ensure patient safety, different VAP bundle cares include varied elements in different studies.

The purpose of this VAP bundle care intervention project coordinated by the Centers for Disease Control of Taiwan (Taiwan CDC) and the Infection Control Society of Taiwan (ICST) was intended to reduce the rates of VAP in ICUs in Taiwan.

Residents and methods

Study design, setting, and participants

In this prospective study, a total of 170 beds from 10 intensive care units (ICUs), including seven surgical ICUs (SICUs), two medical ICUs (MICUs), and one cardiovascular/surgical ICU (CV/S-ICU), were recruited from 10 hospitals (7 medical center hospitals and 3 regional hospitals). The seven ICUs from seven medical centers (two in each were located in northern, middle, and southern Taiwan), consisted of four SICUs (bed numbers of 10, 20, 22, and 30, respectively), two MICUs (bed numbers of 10 and 20, respectively), and one CV/S-ICS (bed number of 10). The three ICUs from three regional hospitals, one was located in northern Taiwan and two in southern Taiwan, were all SICUs with bed numbers of 15, 16, and 17, respectively. This study was divided into two periods: pre-intervention period (1st January, 2012–31st July, 2013) and intervention period (1st August, 2013–31st October, 2014). In the pre-intervention period, several educational programs related to VAP bundle cares were developed by a professional committee (the Committee) that was organized by Taiwan CDC and ICST for all participating hospitals. The rates of VAP in the pre-intervention period and intervention period were collected. During both two periods, members of the Committee provided counseling and inspected the adherence and performance of VAP bundle care in the participating hospitals. This study was approved by the Institutional Review Boards of all participating hospitals.

VAP definitions

VAP was diagnosed only if it occurred 48 h after the endotracheal tube was inserted with a mechanical ventilator and was based on radiological evidence (new or progressive infiltration on chest radiography or computed tomography images), clinical condition (body temperature over 38 °C or below 36 °C, tachypnea, hypoxia/desaturation, respiratory distress, and purulent sputum), and laboratory data (abnormal white blood cell count, C-reactive protein, and gas exchange).^{16,17}

Ventilator-associated pneumonia bundle cares

The five bundle elements of VAP bundle care were selected based on the systemic review on VAP management and prevention guidelines by the Committee.^{16,18} The five elements included (1) assessment of intubation daily, (2) interruption or lightening of sedation daily, (3) daily routine oral hygiene by 0.12%–0.2% chlorhexidine gluconate (CHG), (4) semi-recumbent position/head-of-bed (SRP/HOB) elevation (30–45°), and (5) evacuation of water in the circuit. Performance of hand hygiene before suction and post procedures and maintenance of cuff pressure around the endotracheal tubes at 20–25 cmH₂O were also evaluated.¹⁹

Prior to intervention, the Committee provided (1) a checklist of the elements, (2) daily care assessment forms, (3) training materials for all elements in the bundle cares, including video, step-by-step working handbooks and standard operating procedures, (4) relevant publications and posters related to VAP bundle care to promote awareness among all involved staffs, (5) process and outcome measurement indicators and definitions, (6) common issues with implementing bundle care interventions, (7) handbooks for VAP bundle cares, and (8) protocols for implementing VAP bundle cares.

Statistical analysis

Data were collected through the Infection Control Society of Taiwan's website by the respective usernames for each hospital. Results were presented as the rate ratio (IRR) and 95% confidence interval (CI) with accompanying *p* values. Analyses were performed using Microsoft Excel 2013 (Microsoft Corporation, Redmond, WA, USA), and a *p* value < 0.05 was considered significantly different.

Results

VAP rates

During the 34-month study period (1st January 2012–31st October 2014), a total of 142 VAP cases were identified from 10 hospitals with a total of 81,027 ventilator-days from 170 beds of the different ICUs (Table 1). Fig. 1 shows the significantly decreasing trend of rates of VAP (*p* = 0.0058) by a six-month breakdown (only four months in the end of the intervention, July to October in 2014) during the pre-intervention and intervention periods. VAP rate decreased starting in the pre-intervention period from 2.84 per 1000 ventilator-days between January and June in 2012 to 1.31 per 1000 ventilator-days from January to June in 2013. Among the 10 hospitals, the overall VAP rates (cases per 1000 ventilator-days) declined significantly (*p* = 0.005; IRR, 0.71; CI 0.59–0.86) from 1.9 in the pre-intervention period to 1.5 in the intervention period. Significant differences in the VAP rates (cases per 1000 ventilator-days) between the pre-intervention and intervention periods occurred in the regional hospitals (from 1.6 to 0.7; *p* < 0.001) and SICUs (from 2.1 to 1.4; *p* < 0.001). VAP rates (cases per 1000 ventilator-days) between the pre-intervention and intervention periods were not significantly

Table 1 Ventilator-associated pneumonia (VAP) rates (cases per 1000 ventilator-days) categorized by hospital scale and intensive care unit (ICU).

Hospitals and ICUs (no. of hospitals or beds)	VAP	Pre-intervention (1st Jan., 2012–31st July, 2013)	Intervention (1st Aug. 2013–31st Oct., 2014)	<i>p</i> Value ^a	Rate ratios (95% confidence interval)
All hospitals (10)	Infection rate	1.9	1.5	0.005	0.71 (0.59–0.86)
	No. of cases	97	45		
	Ventilator-days	51,363	29,664		
Medical centers (7)	Infection rate	2.0	1.9	0.0667	0.82 (0.66–1.01)
	No. of cases	73	39		
	Ventilator-days	36,500	21,010		
Regional hospitals (3)	Infection rate	1.6	0.7	< 0.0001	0.71 (0.26–0.65)
	No. of cases	24	6		
	Ventilator-days	14,858	8654		
SICUs (7)	Infection rate	2.1	1.4	< 0.0001	0.41 (0.45–0.73)
	No. of cases	80	32		
	Ventilator-days	38,538	22,071		
CV/S-ICUs (1)	Infection rate	4.5	4.5	0.5391	0.89 (0.62–1.28)
	No. of cases	12	7		
	Ventilator-days	2692	1556		
MICUs (2)	Infection rate	0.5	1	0.0489	1.9 (1.00–3.60)
	No. of cases	5	6		
	Ventilator-days	10,133	6037		

SICUs, surgical ICUs; CV/S-ICUs, cardiovascular/surgical ICUs; MICUs, medical ICUs.

^a *p* values in boldface indicate significant differences in VAP rates (cases per 1000 ventilator-days) between pre-intervention and intervention phases.

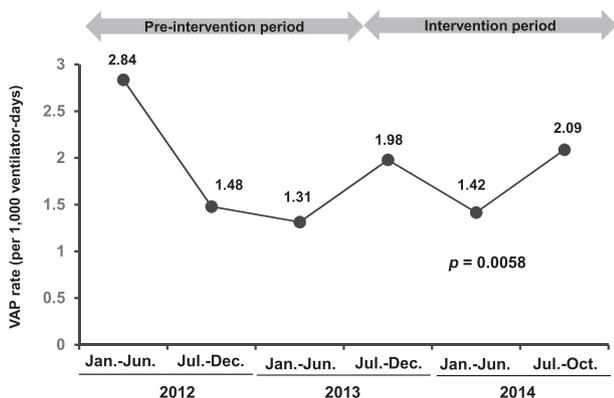


Figure 1. Trend of rates (cases per 1000 ventilator-days) of ventilator-associated pneumonia (VAP) from 10 intensive care units from January 2012 to October 2014.

different in the medical centers (2.0 vs. 1.9; *p* = 0.0667) and CV/S-ICU (4.5 vs. 4.5; *p* = 0.5391). However, VAP rates (cases per 1000 ventilator-days) significantly increased in the MICUs between the two periods (0.5 vs. 1.0; *p* = 0.0489) (Table 1).

Compliance with hand hygiene and bundle care practice elements

Table 2 shows the overall compliance with hand hygiene, cuff pressure attainment, and 5 other practice elements of VAP bundle care in the participating hospitals and ICUs. The overall hand hygiene compliance rate in all participating

ICUs was high, at 95.2% among 2855 hand hygiene opportunities: 92.84% (1803) in medical centers and 99.53% (1052) in regional hospitals. In general, compliance rates for hand hygiene, sufficient cuff pressure maintenance, and practice of the five bundle care elements were better in the regional hospitals than in the medical centers, except for the hand hygiene adherence rate by nurses, which was lower in regional hospitals than that in medical centers (Table 2).

Discussion

In this study, the overall VAP rate of 1.5 per 1000 ventilator-days after bundle care intervention was lower than that in other studies.^{5,8} Recent studies with different bundle care items for VAP reduction report that they reduced the VAP rate from 8.6 per 1000 ventilator-days to 2.0 per 1000 ventilator-days.⁷ One study reported that the annual VAP rate was reduced to between 1.3 and 2 per 1000 ventilator-days and even zero for several months while VAP bundle compliance was over 90%.²⁰

In this study, the overall VAP infection rate (cases per 1000 ventilator-days) was significantly reduced after bundle care intervention, especially in the regional hospitals (from 1.6 to 0.7) and SICUs (from 2.1 to 1.4). Patients in different ICU types were reported to have different VAP rates, which could be related to many factors. SICU patients had a greater risk of VAP than MICU patients, and VAP rates went up over time.²¹ Through adherence to VAP bundle care management, VAP rates dropped in the SICU from 10.2 per 1000 ventilator-days to 3.4 per 1000 ventilator-days.²² In this study, VAP rates in the SICU significantly decreased

Table 2 Compliance with bundle care elements for ventilator-associated pneumonia (VAP) in the intervention period among different hospital categories and intensive care units (ICUs).

Practices and elements of bundle care	Compliance, % (no. of opportunities)					
	Medical centers	Regional hospitals	SICUs	CV/S-ICUs	MICUs	Overall
Overall	92.84 (1803)	99.53 (1052)	95.23 (2254)	97.02 (163)	94.4 (438)	95.20 (2855)
Hand hygiene						
Physicians	96.6 (1876)	100.0 (1057)	97.47 (2307)	97.02 (163)	99.78 (463)	97.8 (2933)
Nurses	97.06 (1,1885)	99.91 (1056)	97.55 (2309)	100.0 (168)	100.0 (464)	98.07 (2941)
Respiratory therapists	93.05 (1807)	99.72 (1054)	95.35 (2257)	98.81 (166)	94.4 (438)	95.4 (2861)
Sufficient cuff pressure (20–25 cmH ₂ O)	97.01 (1884)	99.91 (1056)	97.51 (2308)	100 (168)	100 (464)	98.03 (2940)
All elements	83.60 (11,909)	97.7 (5722)	86.26 (12,813)	97.93 (1133)	90.05 (3685)	87.7 (17,631)
Daily extubation assessment	89.64 (12,744)	99.81 (5846)	90.77 (13,483)	100 (1157)	96.53 (3950)	92.47 (18,590)
Interruption or lightening of sedation	93.46 (13,315)	98.05 (5743)	94.91 (14,098)	98.44 (1139)	93.38 (3821)	94.8 (19,058)
Oral hygiene with CHG	99.91 (14,233)	99.95 (5854)	99.97 (14,849)	100 (1157)	99.73 (4081)	99.92 (20,087)
SRP/HOB elevation (30–45°)	99.35 (14,154)	99.81 (5846)	99.52 (14,782)	98.96 (1145)	99.54 (4073)	99.49 (20,000)
Evacuation of water in the circuit	99.84 (14,223)	99.97 (5855)	99.91 (14,840)	100 (1157)	99.73 (4081)	99.88 (20,078)

SICUs, surgical ICUs; CV/S-ICUs, cardiovascular/surgical ICUs; MICUs, medical ICUs; CHG, chlorhexidine gluconate; SRP/HOB, semi-recumbent position/head-of-bed elevation (30–45°); ISSD, intermittent subglottic secretion drainage.

from 2.1 per 1000 ventilator-days to 1.4 per 1000 ventilator-days. The scenario was also found in a study of 5 SICUs of a medical center in northern Taiwan that the VAP rate decreased from 3.3 per 1000 ventilator-days to 1.4 per 1000 ventilator-days through VAP bundle cares.⁸

Patients undergoing heart surgery were associated with a high frequency of VAP and poor attributable outcomes related to VAP.²³ In this study, VAP rates in the CV/S-ICU from a medical center remained the same (4.5/per 1000 ventilator-days) during the two periods. A prospective study demonstrated that 7.9% of all patients who underwent major heart surgeries had at least one episode of VAP (34.5 cases per 1000 ventilator-days) and the mortality of these patients was high (57.1%).²³

In MICUs, the VAP rates increased significantly after bundle care intervention, but infection rate remained much lower than that in SICU patients. We did not collect APACHEII or SOFA scores for disease severity adjustment. For developing countries, the VAP rate is reported to be from 10 to 41.7 per 1000 ventilator-days, which is higher than in our study.²⁴ An epidemiology study reported the HAP rate to be as low as 0.5–0.85 per patient-days in Taiwan, but VAP rate was reported.²⁵

In this study, 75% of ventilator-days were from SICUs, and 82.5% of VAP cases were from SICUs during pre-intervention, decreasing to 71.1% during intervention. During the VAP bundle care intervention period, the VAP rate markedly declined in SICUs compared to other ICUs, indicating that bundle care was more effective in SICUs than in other ICUs.

In this study, VAP rate decreased obviously in the pre-intervention period only after education. Until the project ended, the VAP rate was sustained at a lower level although a mild elevation of VAP rate was noted just after intervention and before the end of the project (Fig. 1). In

general, most recruited hospitals showed a decrease in VAP rates since a series of educational programs. In fact, improvement starts before the true intervention period but with initial 6 months after the education instead. Comparing the VAP rate of the initial 6 months with the residual period, the VAP rate dropped from 2.83 to 1.58 per 1000 ventilator-days, which is a little higher than the average of VAP rate in the intervention period.

In conclusions, implementing VAP bundle care has effectively reduced VAP in Taiwanese ICUs, but differences in performance and compliance rates of VAP bundle care among the different ICUs and hospital categories did exist.

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Conflict of interest

There is no conflict of interest.

Ethical approval

This study was approved by the Institutional Review Boards of the National Taiwan University Hospital (201502026RINB), Chung Shan Medical University Hospital (CSMUH No: CS15022) and Mackay Memorial Hospital (15MMHIS016e). Signed consent forms were obtained from all enrolled subjects.

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