

Implementation of a Real-time Compliance Dashboard to Help Reduce SICU Ventilator-Associated Pneumonia With the Ventilator Bundle

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Background: Ventilator-associated pneumonia (VAP) causes significant morbidity and mortality in critically ill surgical patients. Recent studies suggest that the success of preventive measures is dependent on compliance with ventilator bundle parameters.

Hypothesis: Implementation of an electronic dashboard will improve compliance with the bundle parameters and reduce rates of VAP in our surgical intensive care unit (SICU).

Design: Time series analysis of VAP rates between January 2005 and July 2008, with dashboard implementation in July 2007.

Setting: Multidisciplinary SICU at a tertiary-care referral center with a stable case mix during the study period.

Patients: Patients admitted to the SICU between January 2005 and July 2008.

Main Outcome Measures: Infection control data were used to establish rates of VAP and total ventilator days.

For the time series analysis, VAP rates were calculated as quarterly VAP events per 1000 ventilator days. Ventilator bundle compliance was analyzed after dashboard implementation. Differences between expected and observed VAP rates based on time series analysis were used to estimate the effect of intervention.

Results: Average compliance with the ventilator bundle improved from 39% in August 2007 to 89% in July 2008 ($P < .001$). Rates of VAP decreased from a mean (SD) of 15.2 (7.0) to 9.3 (4.9) events per 1000 ventilator days after introduction of the dashboard ($P = .01$). Quarterly VAP rates were significantly reduced in the November 2007 through January 2008 and February through April 2008 periods ($P < .05$). For the August through October 2007 and May through July 2008 quarters, the observed rate reduction was not statistically significant.

Conclusions: Implementation of an electronic dashboard improved compliance with ventilator bundle measures and is associated with reduced rates of VAP in our SICU.

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VENTILATOR-ASSOCIATED pneumonia (VAP) is the most common nosocomial infection in mechanically ventilated patients. It accounts for approximately 60% of deaths among patients with hospital-acquired pneumonia, prolonging hospital stay by an average of 4 to 9 days and increasing direct hospitalization costs by \$40 000 per patient.¹⁻⁶ The Centers for Disease Control (CDC), Joint Commission, National Institute of Medicine, and the Leapfrog Group have all identified VAP rate as a measure of quality of care provided by an institution.⁷⁻⁹ Most hospitals have a set of multidisciplinary patient care practices, termed the *ventilator bundle*, implemented by the patient care team to standardize treatment for patients receiving mechanical ventilation.^{8,10,11}

Bundle parameters aim for faster patient extubation, reducing aspiration, and maintaining a cleaner hypopharynx and oropharynx. However, despite implementation of these parameters, few studies demonstrate a reduction in VAP with the use of the ventilator bundle. Recent studies suggest that the success of the ventilator bundle is dependent on continuous educational initiatives as well as practitioner compliance with the bundle parameters.¹¹⁻¹³ In addition, computerized documentation in the intensive care setting has been previously shown to provide improved compliance with individual patient care measures.¹⁴ In our surgical intensive care unit (SICU), we introduced the ventilator bundle initiative in January 2002. Our ventilator bundle incorporated measures from the CDC Guidelines for Prevention of Nosocomial Pneu-

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monia and included 6 parameters: (1) daily spontaneous breathing screenings and trials to evaluate for the ability to extubate, (2) targeted sedation assessed by the Richmond Agitation and Sedation Scores to maintain the appropriate level of consciousness, (3) head-of-bed elevation of 30° to 45°, (4) oral care, (5) dental care, and (6) hypopharyngeal suctioning.

Despite implementation of the ventilator bundle and intermittent compliance monitoring by the SICU nurse manager team, we did not observe a significant decrease in VAP rates. In a continued effort to increase use of the ventilator bundle parameters and decrease VAP rates, we implemented an electronic VAP dashboard system in July 2007 to measure and record real-time compliance with the 6 ventilator bundle parameters (**Figure 1**).¹⁵ The primary goal of the dashboard was to provide continuous real-time monitoring of every bundle parameter. The SICU dashboard also monitored patients' ventilator status, compliance with SICU deep venous thrombosis prophylaxis, and stress ulcer prophylaxis, and provided direct access to the electronic medical record. We hypothesized that the electronic dashboard would lead to a significant improvement in compliance with the ventilator bundle parameters in our SICU and reduce the rates of VAP.

METHODS

SETTING

Vanderbilt University Medical Center (VUMC) is an 832-bed academic tertiary care center with a referral base of approximately 65 000 square miles in the southeastern United States. The SICU is a closed 21-bed unit that admits approximately 1300 acutely ill patients annually, with an average Acute Physiology and Chronic Health Evaluation II (APACHE II) score greater than 17. Patients are admitted from the general, thoracic, vascular, transplant, otolaryngology, urology, and orthopedic surgery services. During this study period, the patient case mix in the SICU was stable regarding primary diagnosis. Patients with medical diagnoses as well as primary surgical diagnoses of trauma, burn, neurosurgical, and cardiac diseases were admitted to other specialized units.

The ventilator bundle has been viewed as a critical component of patient care by all members of the SICU team. Spontaneous breathing trials are performed by the respiratory therapist team. A Richmond Agitation and Sedation Score goal is ordered by the critical care team. Bedside nurses titrate sedation and analgesia to comply with the Richmond Agitation and Sedation Score orders and implement head-of-bed elevation, oral and dental hygiene, and hypopharyngeal suctioning. All critically ill patients in the SICU are maintained on stress ulcer prophylaxis, deep venous thrombosis prophylaxis, and normoglycemia protocol. All attending intensivists in the SICU view critical care protocols, including the ventilator bundle, as integral to patient care.

DESIGN

The effect of implementation of the electronic dashboard on VAP rates in the SICU was assessed using an interrupted time series design.¹⁶ The unit of analysis was a quarter of a year (a 3-month interval). Quarters were chosen to have stable estimates of rates, given the relatively rare occurrence of events.

Bed	Patient name	Age	LOS	Orders		SBT	Spont	Head	Oral	Dental	RASS	Hgb	Teeth	IV/Sx
						Vent	Trial	Elev	Care	Care	Pr	Scr	Swab	
3002B	T, V W	72y	6 d	flowsheet	MAR	v	F	v	v	v	-4	-4	30	v
3003X	N, D	60y	17 d	flowsheet	MAR	v	F	v	v	v	0	-2	45	v
3004B	T, P L	64y	34 d	flowsheet	MAR	v		v	v	v	=1	-1	30	v
3005A	C, D E	61y	7 d	flowsheet	MAR			v	v	v	0	-1	30	v
3005B	B, J	66y	7 d	flowsheet	MAR	v	F	v	v	v	-1	-3	30	v
3006X	W, A A	20y	66 d	flowsheet	MAR	v		v	v	v	-1	-2	30	v
3007X	W, L E	49y	9:14	flowsheet	MAR			v	v	v	0	-1	30	v
3008X	P, J L	69y	50 d	flowsheet	MAR	v	F	v	v	v	0	0	30	v
3009X	R, C	72y	15 d	flowsheet	MAR	v	F	v	v	v	-1	-2	30	v
3011A	P, J E	88y	9 d	flowsheet	MAR			v	v	v	0	0	45	v
3011C	J, W D	69y	2 d	flowsheet	MAR			v	v	v	0	-1	30	v
3011D	P, P, J	55y	10 d	flowsheet	MAR	v	P	v	v	v	0	-3	30	v
3011E	R, R E	74y	9 d	flowsheet	MAR			v	v	v	0	0	v	v
3011F	N, E Y	55y	3 d	flowsheet	MAR			v	v	v	-1	0	30	v
3012A	S, J D	56y	14 d	flowsheet	MAR	v	F	v	v	v	0	0	30	v
3012B	R, M	63y	10 d	flowsheet	MAR	v	F	v	v	v	-2	-2	30	v
3013A	N, B D	60y	8 d	flowsheet	MAR	v	F	v	v	v	-3	-2	30	v
3013B	H, S M	66y	16 d	flowsheet	MAR			v	v	v	0	-1	30	v

Figure 1. The electronic ventilator-associated pneumonia dashboard. The dashboard serves as a screen saver on every desktop computer in the critical care unit. The left side of the screen indicates patient demographics and provides access to electronic medical records. The right column indicates measures of ventilator bundle as well as patient ventilator status, deep venous thrombosis, and stress ulcer prophylaxis measures. Green indicators mark measures that are in compliance; red indicators, parameters that are out of compliance; and yellow indicators, parameters that are soon due for reimplementation. Ventilator bundle parameters measured are (from left to right): (1) spontaneous breathing trials, (2) Richmond Agitation and Sedation Score, (3) head-of-bed elevation, (4) oral care, (5) dental care, and (6) hypopharyngeal suctioning.

The total study period ranged from January 2005 through July 2008, with implementation of the electronic VAP dashboard occurring in July 2007. The total study duration was divided into 2 periods. The period before the intervention spanned January 2005 through June 2007 and comprised 10 quarters (30 months). The period after the intervention spanned August 2007 through July 2008 and comprised 4 quarters (12 months). July 2007 was designated as the run-in intervention month and was therefore excluded from the analysis.

ELECTRONIC VAP DASHBOARD

Electronic VAP dashboard monitoring was introduced in the SICU in July 2007.¹⁵ The VAP dashboard graphically displays compliance with the ventilator bundle parameters for each ventilated patient at appropriately timed intervals for each measure (Figure 1). Compliance with each parameter is reported by the bedside nurse in real time and verified by the SICU charge nurse each shift. Compliance with an individual parameter is reported with green, yellow, and red indicators. Green indicates that the parameter is in compliance. Red indicates that the parameter is out of compliance. Yellow warns that administration of the parameter is soon due. In patients with a contraindication to any bundle parameter, the reason for the discrepancy from protocol is documented for the duration of the item and is readdressed every time that parameter's compliance is updated.

The electronic dashboard is the default screen saver for all clinical workstations in the SICU. Ongoing measurement of individual and overall compliance with the ventilator bundle parameters was initiated in August 2007. The VUMC uses a 100% electronic medical record system. As such, the clinical workstations are frequently used and highly visible. Compliance with patient-level dashboard parameters were reviewed twice daily during the morning interdisciplinary rounds and evening critical care rounds. In addition, both physician and nursing leadership received daily compliance reports.

Table 1. Infection Rates and Demographic and Clinical Covariates Before and After Intervention

Variable	Mean (SD)		P Value
	Jan 2005-Jun 2007 ^a	Aug 2007-Jul 2008	
VAP rate, events per 1000 ventilator d	15.2 (7.0)	9.3 (4.9)	.01
BSI rate, events per 1000 catheter d	4.5 (3.8)	5.0 (2.4)	.63
Age, y	58.8 (16.5)	59.7 (16.1)	.82
BMI	28.3 (7.2)	32.0 (8.7)	.05
APACHE II	17.8 (5.1)	22.0 (5.6)	.002
Median (IQR) ventilator d before VAP	7 (5.5-10.5)	9 (5-20)	.28
Diagnostic bronchoscopy rate, procedures per 1000 ventilator d ^b	80.7 (22.1)	69.1 (17.8)	.14

Abbreviations: APACHE II, acute physiology and chronic health evaluation II; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); BSI, blood stream infection; IQR, interquartile range; VAP, ventilator-associated pneumonia.

^a July 2007 was designated as a run-in intervention month and excluded from analysis.

^b January 2006 through July 2008.

OUTCOME MEASURES

Primary outcome measured the effect of the implementation of the electronic dashboard on VAP rates in the SICU. Rates of VAP were obtained from VUMC Infection Control, which provides continuous surveillance of all ICUs and reports to the National Healthcare Safety Network (NHSN) maintained by the CDC. To establish the diagnosis of VAP, 3 criteria had to be met: (1) continuous ventilator support for more than 48 hours, (2) presence of fever higher than 38.5°C, and/or leukocytosis greater than 12 000/μL, and/or radiographic evidence of pulmonary infiltrate, and (3) positive culture obtained from a bronchoalveolar lavage defined as presence of more than 10⁴ colony-forming units per milliliter. Rates of VAP were defined as the number of events per 1000 ventilator days. Ventilator days were obtained from the SICU database; a ventilator day was defined as any calendar day for which the patient was charged for mechanical ventilation. Bloodstream infection (BSI) rates were used as a control for the effect of the intervention in the SICU population. Rates of BSI were also collected by Infection Control and reported to the CDC as part of NHSN. Rates of BSI were defined as the number of culture-positive events per 1000 central venous catheter days. They were chosen as a control event because the implementation of the electronic VAP dashboard was not expected to reduce BSI rates; however, general infection control measures would be expected to reduce the rates of both VAP and BSI. In both the VAP and BSI groups, monthly rates were converted to quarterly rates to comply with the study design. In addition, bronchoscopy rates, defined as the number of diagnostic bronchoscopies per 1000 ventilator days, were measured between January 2006 and July 2008 (study period with reliable bronchoscopy data). Rates of diagnostic bronchoscopy were compared to account for VAP screening practices before and after intervention.

A secondary outcome of interest measured compliance with the ventilator bundle parameters. Individual and overall compliance with bundle parameters was assessed daily between August 2007 and July 2008. Complete compliance was measured as the proportion of patients who were simultaneously in compliance with all 6 components of the ventilator bundle. A single

red indicator in any of the bundle parameters excluded that patient from complete compliance for any given day.

To control for the severity of illness, individual cases of VAP were identified and reviewed from the SICU patient database. To avoid selection bias, retrospective medical record and database review of the first 6 patients diagnosed with VAP per quarter identified patients' age, APACHE II score,¹⁷ and body mass index (calculated as weight in kilograms divided by height in meters squared) on admission to SICU. We also calculated the number of days each patient spent on the ventilator prior to diagnosis of VAP.

STATISTICAL ANALYSIS

Differences in the VAP, BSI, and diagnostic bronchoscopy rates as well as demographic and clinical characteristics between the preintervention and postintervention groups were compared using the *t* test. Ventilator days prior to development of VAP were skewed and compared using the Wilcoxon rank sum test. Summary statistics are provided as mean (standard deviation) or median (interquartile range), as indicated. Quarterly individual parameter compliance was compared via 95% confidence intervals (CI). The change in complete compliance was estimated with linear regression. The effects of VAP dashboard intervention were estimated from a piecewise linear regression model. The model included terms for secular trend in the predashboard era, the effect of the intervention, and the change in secular trend after intervention. There was no evidence of serial autocorrelation. All parameters were estimated assuming independence of quarterly proportions. Expected VAP rates for the postintervention quarterly comparisons were projected from the predashboard era linear regression model. To assess the observed effect of the intervention, quarterly rates of VAP after intervention were compared with the expected rates, assuming no intervention. All analyses were performed using the STATA version 10.1 statistical software (STATA, College Station, Texas). This study was reviewed and approved by the institutional review board of the VUMC.

RESULTS

STUDY GROUP COMPARISONS

There were 121 cases of VAP in 7907 ventilator days in the 10 quarters between January 2005 and June 2007. In comparison, there were 31 cases of VAP in 3309 ventilator days in the 4 quarters between August 2007 and July 2008. As such, we observed a significant mean (SD) overall reduction in VAP rates from 15.2 (7.0) per 1000 ventilator days in the preintervention group to 9.3 (4.9) per 1000 ventilator days in the postintervention group ($P = .01$). Infection rates and demographic and clinical covariates between these patient populations are summarized in **Table 1**. There were no significant differences between preintervention and postintervention groups in age ($P = .82$), days spent on the ventilator prior to development of VAP ($P = .28$), or rates of diagnostic bronchoscopy ($P = .14$). Patients in the postintervention period had significantly higher APACHE II scores (mean [SD], 22.0 [5.6] vs 17.8 [5.1]; $P < .002$) and demonstrated a trend toward higher body mass index (mean [SD], 32.0 [8.7] vs 28.3 [7.2]; $P = .05$). We did not observe improvement in our control BSI group between the preintervention and postintervention periods (mean [SD], 4.5 [3.8] vs 5.0 [2.4] events per 1000 catheter days; $P = .63$).

Table 2. Individual Ventilator Bundle Parameter Compliance in the 4 Quarters After Implementation of Electronic VAP Dashboard

Parameter	Mean Compliance, % (95% CI)			
	Aug 2007-Oct 2007	Nov 2007-Jan 2008	Feb 2008-Apr 2008	May 2008-Jul 2008
SBT	86 (75-97)	91 (87-94)	93 (92-95)	97 (95-100)
RASS	85 (82-89)	88 (82-94)	93 (88-99)	98 (97-98)
HOB elevation	92 (89-95)	92 (87-97)	96 (93-100)	98 (97-99)
Oral care	84 (78-90)	87 (86-88)	94 (88-100)	98 (97-98)
Dental care	95 (94-97)	95 (92-98)	99 (97-100)	99 (99-100)
HySx	73 (53-92)	76 (65-87)	92 (83-100)	95 (94-96)

Abbreviations: CI, confidence interval; HOB, head of bed; HySx, hypopharyngeal suctioning; RASS, Richmond Agitation and Sedation Score; SBT, spontaneous breathing trials; VAP, ventilator-associated pneumonia.

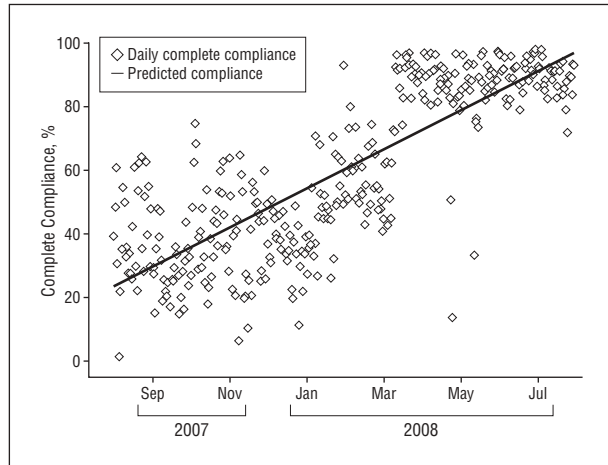


Figure 2. Complete compliance between August 2007 and July 2008. The fitted line is from a simple linear regression model.

COMPLIANCE MEASURES

Individual and complete compliance with specific ventilator bundle parameters significantly improved during the year of VAP dashboard implementation. Individual parameter compliance improved significantly in 5 of 6 ventilator bundle parameters (**Table 2**). The greatest significant increase in individual parameter compliance was noted in hypopharyngeal suctioning, which improved from 73% (95% CI, 53-92) to 95% (95% CI, 94-96). The rate of complete compliance also improved significantly during the next 4 study quarters (**Figure 2**). Real-time data were available on a daily basis, and a linear trend was observed; the proportion of patients in complete compliance improved by 0.2% per calendar day ($P < .001$), with an average improvement of 6% per month. Average complete compliance improved from 39% in August 2007 to 89% in July 2008 ($P < .001$).

TIME SERIES ANALYSIS

The overall VAP rate using the preintervention vs post-intervention analysis decreased after the introduction of the electronic VAP dashboard. However, using a more rigorous interrupted time series design that adjusts for secular trends, this decrease did not achieve statistical significance ($P = .37$) (**Figure 3**). To further examine the effect of the intervention with the time series analysis,

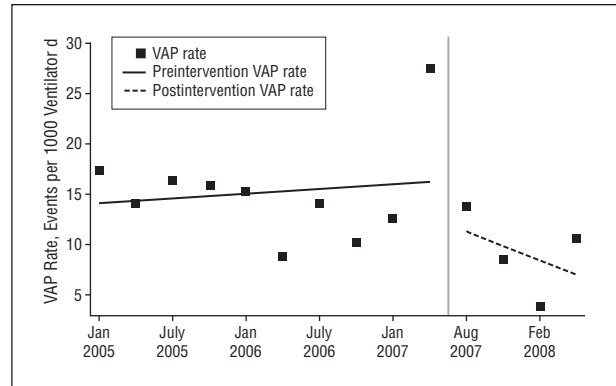


Figure 3. Quarterly rates of ventilator-associated pneumonia (VAP) between January 2005 and July 2008. The vertical line demarcates the preintervention and postintervention periods.

we compared individual postintervention VAP rates to the expected preintervention trend, assuming no intervention. All 4 quarters demonstrated a reduction in VAP, with 2 quarters achieving significant differences between expected and observed rates, assuming no intervention: November 2007 through January 2008 (difference, 8.3 per 1000 ventilator days; 95% CI, 0.5-16.1) and February 2008 through April 2008 (difference, 13.2 per 1000 ventilator days; 95% CI, 4.4-22.0) (**Figure 4**). For August 2007 through October 2007 and May 2008 through July 2008, this difference was not statistically significant (difference, 2.8 per 1000 ventilator days; 95% CI, -4.0 to 9.7 and 6.6 per 1000 ventilator days; 95% CI, -3.2 to 16.5, respectively). Rates of BSI during the same preintervention and postintervention periods surrounding the introduction of the electronic VAP dashboard did not change ($P = .98$) (**Figure 5**).

COMMENT

Most interventions aimed at reducing VAP rates focus on the implementation of individual ventilator bundle parameters. The ventilator bundle was implemented at our institution in 2002. However, despite intermittent compliance monitoring and education initiatives, we failed to notice a significant reduction in VAP rates. In an effort to improve use of the ventilator bundle and monitor compliance with the parameters, we introduced an electronic VAP dashboard in July 2007. A pre-

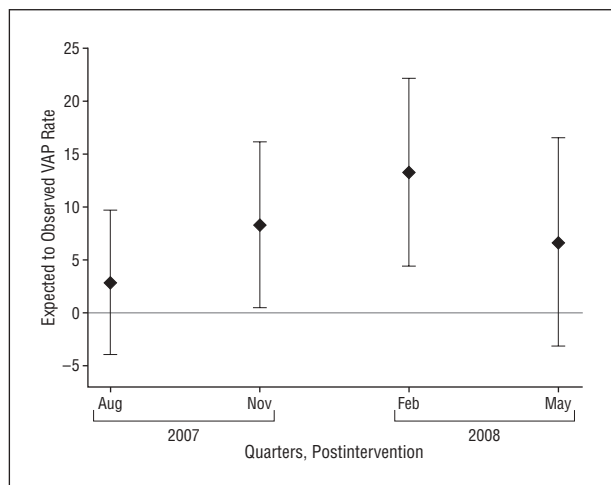


Figure 4. Expected to observed ventilator-associated pneumonia (VAP) rates, assuming no intervention. The month designation indicates the first month of the corresponding quarter. The vertical bars indicate 95% confidence intervals.

intervention vs postintervention analysis demonstrated a 39% reduction in VAP rates from 15.2 to 9.3 cases per 1000 ventilator days. A time series analysis allowed us to adjust for secular trends and revealed an overall reduction in the VAP rates, with significant reduction in 2 of 4 quarters after implementation of the electronic dashboard.

Current CDC guidelines recommend a goal VAP rate of 4.1 per 1000 ventilator days in a SICU population, based on median rates published by the NHSN.¹⁸ Even during the post-VAP dashboard implementation era, our average VAP rate is twice the suggested CDC goal. Nevertheless, while prior to the electronic compliance measures the lowest VAP rate per quarter was 8.8 per 1000 ventilator days, we achieved a quarterly VAP rate as low as 3.3 per 1000 days after implementation of the VAP dashboard. The current NHSN goals are not risk-adjusted for the severity of illness. Previous studies have linked higher APACHE II scores to greater risk of VAP.^{5,19,20} Our postintervention cohort includes postoperative surgical patients with an average APACHE II score of 22. In our opinion, risk-adjusted VAP goals should be instituted to provide feasible quality improvement targets for individual critical care units.

While our 1-year postintervention data support use of the ventilator bundle in conjunction with an electronic compliance dashboard, longer follow-up is needed to demonstrate sustained improvement in VAP rates. Many studies suggested improvement in VAP with the use of the ventilator bundle using the simple preintervention vs postintervention study design.^{13,21,22} We conducted a more rigorous interrupted time series analysis to account for secular trends that may have been due to more nonspecific infectious control measures.¹⁶ However, owing to the paucity and high variability of individual VAP events, we grouped VAP rates by quarters to improve the accuracy of regression parameter estimates. This limited our preintervention and postintervention data to 10 and 4 points, respectively. In 2 of the 4 postintervention quarters, we were able to detect a sig-

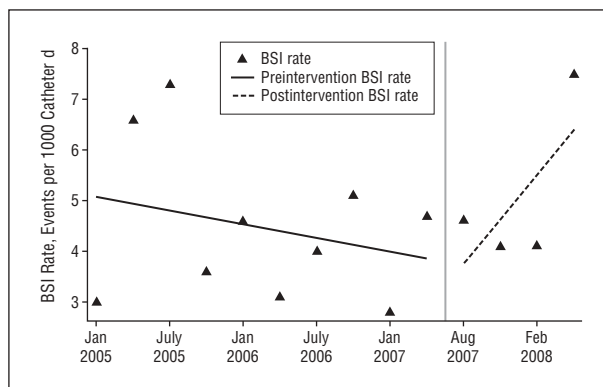


Figure 5. Quarterly rates of blood stream infection (BSI) between January 2005 and July 2008. The vertical line demarcates the preintervention and postintervention periods.

nificant difference between the observed VAP rates and the expected rates. However, in the other 2 postintervention quarters, the detected reduction in VAP rates did not achieve statistical significance. Longer follow-up, preferably performed 10 quarters after the introduction of the electronic dashboard, is needed to solidify the relationship between the introduction of the electronic dashboard and sustained reduction of VAP.

Given the paucity of VAP events, we could not adjust for potential confounders within our model. As such, our study included 2 separate controls. First, we investigated the relationship between BSI rates and our electronic VAP dashboard intervention. As expected, we did not detect any improvement in BSI rates in the post-VAP dashboard era. Second, we used univariate analyses to account for the severity of illness between the preintervention and postintervention eras. While the common measurement used in estimating severity of illness in SICU patients is the APACHE metric, we felt that the duration of time spent on the ventilator also contributes to the risk of developing VAP.²³⁻²⁵ While we did not detect a difference in ventilator days prior to development of VAP, APACHE II scores were, in fact, significantly higher in the postintervention patients. Not only did these univariate metrics reassure us that the postintervention group was not selected from a healthier patient population, but the higher APACHE II scores suggested that patients in the postintervention group had more severe illness.

We believe that complete compliance (simultaneous compliance with all ventilator bundle measures) is critical to the success of VAP prevention. Traditionally, compliance has been described as the proportion of all individual parameters that were in compliance for a given patient or unit. It is currently unknown whether each of the ventilator bundle parameters contribute equally to reducing VAP. However, theoretically, even a single non-compliant measure would predispose that patient to increased risk of VAP. Over the course of electronic compliance monitoring, complete compliance has dramatically increased, with about 90% of the current SICU patients receiving every parameter of the ventilator bundle simultaneously and continuously. Further studies are needed to investigate the role of individual bundle parameters in reducing VAP rates. In addition, longer fol-

low-up is needed to ensure sustained compliance with the ventilator bundle.

Additional reduction in the rates of VAP is needed. Our 1-year data after introduction of the electronic dashboard suggest a trend toward a significant reduction in the rates of VAP when the ventilator bundle is used in collaboration with an electronic monitoring and compliance system. Adjunct respiratory care devices such as silver-coated endotracheal tubes and endotracheal tubes with dorsal suction adapters equipped for continuous aspiration of subglottic secretions have been shown to reduce VAP rates up to 36%.²⁶⁻²⁸ Reduction in VAP requires an ongoing multimodality approach focused on patient care initiatives aimed at early extubation, decreasing the risk of aspiration, and maintaining a cleaner hypopharynx and oropharynx. Use of the electronic dashboard has improved compliance with ventilator bundle parameters and was associated with significant reduction in VAP rates in our SICU.

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Author Contributions: Dr Zaydfudim had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design:* Zaydfudim, Starmer, Ray, and Pinson. *Acquisition of data:* Zaydfudim, Starmer, and May. *Analysis and interpretation of data:* Zaydfudim, Dossett, Starmer, Arbogast, Feurer, and Pinson. *Drafting of the manuscript:* Zaydfudim. *Critical revision of the manuscript for important intellectual content:* Dossett, Starmer, Arbogast, Feurer, Ray, and May. *Statistical analysis:* Zaydfudim, Dossett, Arbogast, and Feurer. *Obtained funding:* Zaydfudim and Pinson. *Administrative, technical, and material support:* Starmer, May, and Pinson. *Study supervision:* Starmer, Ray, May, and Pinson.

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DISCUSSION

Heidi Frankel, MD, FCCM, Dallas, Texas: It is my pleasure to provide commentary on this work of Dr Zaydfudim and colleagues at Vanderbilt University on a difficult and, unfortu-

nately, not rare condition affecting our surgical ICU [intensive care unit] patients.

Several years ago, it was widely held that implementing a simple so-called bundle would render VAP to the status of a “never event,” much like a retained foreign body or wrong-site surgery. Our regulatory agencies, and CMS [Centers for Medicare and Medicaid Services] in particular, were poised to penalize institutions for causing VAPs. But because brave individuals came to the forefront and questioned this dogma, and because high-volume institutions like Vanderbilt started releasing data such as these, VAP has been deleted from the CMS list of preventable conditions. It appears that emergent surgical, neurosurgical, and trauma patients may develop their pneumonia prehospital and at a rate far higher than in medical patients, in whom many of the benchmarks have been derived. Moreover, it appears by defining VAP by BAL [bronchial alveolar lavage] microbiological as opposed to clinical criteria, as surgical ICUs often do, that we further increase the number of VAPs—that is, surgical intensivists grade themselves more strictly than do medical intensivists.

However, Dr Zaydfudim, rather than congratulate you on improving your bundle compliance, my questions are going to challenge you to think about how you are going to effectively lower your VAP rate that is still double the NHSN benchmark, however flawed that benchmark is. I present you this challenge, because at my institution, Parkland, in Dallas, we too have just completed a similar study in our surgical, trauma, and neurosurgical patients that we will also present nationally. We found that, despite a 96% bundle compliance, our VAP rates are astronomical.

1. Have you started to further discriminate your surgical ICU patients to assist you in interpreting these data? Are your VAP rates equivalently high in emergent surgical patients as in elective ones? What are your trauma VAP rates?

2. Has your administration or have you started to contemplate whether “gaming” the system makes sense—for example, have you reconsidered not using a BAL definition for VAP?

3. Clearly the bundle alone is insufficient to make VAP truly preventable in many surgical patients. What other interventions are you entertaining—silver-coated endotracheal tubes, selective decontamination, etc, and what is your strategy to employ them?

Dr Pinson: The purpose of this study was to determine whether implementation of the VAP bundle would reduce ventilator-acquired pneumonia, with the institution of this electronic dashboard as another step to try to improve the results. One of the drivers was a paper published by Christine Cocanour in which she pointed out that if people focused on accountability you could, in fact, improve the results. Then last year at this meeting, there was a paper that indicated that the VAP bundle did not work in SICU and trauma patients. So this controversy is what drove our study.

Now to answer Dr Frankel’s question, what we are going to do to reach this benchmark that has been set out by the CDC. First of all, I am not sure that we are prepared to accept those benchmarks as stated for an SICU or trauma unit, as the rates are clearly higher in these units than they are in other critical care units, and the benchmarks that are being put forward by the CDC are across the board. There are plenty of papers out there that demonstrate VAP rates in the same range that we have reported for SICUs, and there are plenty of papers out there for trauma units that reported an even higher range of 20 to 30, so I question whether, for this fairly high-risk group of patients, the CDC-stated target is realistic. Having said that, we will continue to improve compliance with the best evidence-based medicine that is available. We will continue monitoring over a longer period of time and see what kind of results we get. There are some other potential interventions that evidence demonstrates may be viable alternatives, such as the silver-impregnated tubes and posterior suction channel tubes.

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