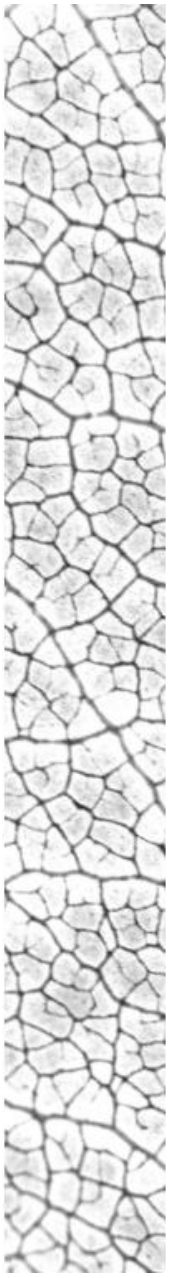

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Reducing incidence rate of ventilator-associated pneumonia (VAP) using prevention bundle in the ICU

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Abstract
Ventilator-Associated Pneumonia (VAP) is the most prevalent healthcare-associated infections in Intensive Care Units (ICU). In decreasing its incidence, a VAP prevention bundle as one of infection control methods had been applied to the ventilated patients. This study aimed to determine the correlation between the use of the VAP prevention bundle and the incidence rate of VAP in the ICU at a regional general hospital. A cross-sectional study was done using surveillance data of the VAP prevention bundle implementation checklist from the infection control committee. The samples were chosen using a stratified random sampling method. They were selected from two ICU wards according to the inclusion and exclusion criteria from January to June 2019 (n: 189). Furthermore, every seven bundles and the incidence rate of VAP were scored and observed. The result showed that there were ten incidences of VAP with a mean of 3.7‰. The highest rate was found in May as 9.8‰ while the standard was less than 5.8‰. Descriptive results showed that 6 of 7 bundles were the highest total scores in 34.9% samples with oral hygiene as a bundle item at most frequently listed in 98.4% patients. Logistic regression also pointed out a significant correlation ($p<0.05$) between the use of the VAP prevention bundle and the incidence rate of VAP. Therefore, there was a significant correlation between the use of VAP prevention bundles and the incidence rate of VAP for ventilated patients in the ICU room. Thus, each VAP prevention bundle must be carried out entirely to affect the incidence rate of VAP.

Keywords: healthcare-associated infections, intensive care units, infection control, VAP, prevention bundle

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INTRODUCTION

Ventilator-Associated Pneumonia (VAP) is a Healthcare-Associated Infections (HAIs) occurred in patients using a ventilator for more than 48 hours (Kalil, et al. 2016). Patients in the Intensive Care Unit (ICU) are at high risk of increasing the incidence rate of VAP. Recent research studies show that 5% of patients tend to be infected in the hospital and increase to 8% if the patient has received an invasive procedure, including a mechanical ventilator (Stubblefield, & Krucik, 2014). Other studies explain that a high prevalence of HAIs is more common in patients in the Intensive Care Unit (ICU) (Morpeth, Ramadhani, & Crump, 2009). A fact stated that the VAP ranked second for the incidence of HAIs (Depuydt, Myny, & Blot, 2006).

The risk of developing pneumonia increases 5 to 10 times if patients are referred to the ICU unit and grow 20 times in patients using mechanical ventilators (Depuydt, Myny, & Blot, 2006).

A mechanical ventilator is one of the devices that supports the patients' life in the ICU. Patients who use mechanical ventilators receive some special treatments in their care. Although mechanical ventilators are successful in supporting breathing in critically ill patients, there are still patients who pass away while using the ventilator or shortly after a mechanical ventilator is put on the patients' body (AllonAmitai, 2018). Mechanical ventilators are used to protect the airway and prevent respiratory failure (Amitai, 2013). A respiratory failure, such as hyperventilation, increased intracranial pressure, or brain herniation can be an indicator that the patient needs mechanical ventilation. Then, the aspiration of infectious material from the stomach has a

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vital role in increasing the prevalence of VAP (Yazdani, et al. 2015).

The American College of Chest Physicians defines VAP as an overview of new and permanent infiltrates on the thoracic photo followed by a sign in the form of blood or pleural cultures containing the same microorganisms in the sputum or tracheal aspiration. In summary, the symptoms and signs of pneumonia are fever, leukocytosis, and purulent secretions (Ibrahim, et al. 2001).

The major route for acquiring endemic VAP is oropharyngeal colonization (Benítez, & Ricart, 2005). Hence, the main attempt to prevent VAP is to focus on aspects of care influencing this process. Some of the factors affecting the pathogenesis of VAP are oral hygiene which changes the cavity flora in the first 48 hours in patients with critical pathogenic diseases. The use of endotracheal tubes that associated with increased injury to the mucosa reduced ciliary function and damaged upper airway defense and the accumulation of subglottic secretion and increasing in gastric pH that leads to gastric colonization of pathogenic organisms leading to aspiration.

The following steps are required to prevent complications of using a ventilator as part of infection control in the management of patients with mechanical ventilation. First, make a correct diagnosis using antimicrobial data. Second, reassess the patient and check between 48 to 72 hours to adjust antibiotic therapy according to the culture results. Third, implement a prevention bundle program to prevent Healthcare-Associated Infections. Three of the core recommendations for VAP prevention bundle which can be practiced every day in the ICU are sustaining good hand hygiene, maintaining the patients' oral hygiene, and positioning the patient in a semi-recumbent (How to Prevent Ventilator-Associated Pneumonia (VAP), 2013).

VAP prevention bundle is a series of care interventions for patients with mechanical ventilators. As it is implemented altogether, it will give significant results compared to the individual application. VAP prevention bundle was originally designed as a strategy in treating patients with ventilation devices. However, many hospitals obtained notable results after implementing the VAP prevention bundle. The hospitals experienced a decrease in the incidence rate of VAP with an average reduction of 45%. After the VAP prevention bundle was implemented in the ICU, the incidence rate of VAP became 0 that month (Guide, 2012).

ICU is a room in the hospital specific for patients with certain conditions that require strict observation. In the ICU, the doctor will monitor the patient for 24 hours. The patients will be connected to medical equipment such as monitors, ventilators, feeding tubes, and drain or catheter to facilitate the process (nhs.uk/conditions/intensive-care). Such equipment is essential to help patients to survive. Despite having benefits, this medical device can also increase the occurrence of Healthcare-Associated Infections. Therefore, it needs thorough efforts to ensure that the patients treated at the ICU can have a positive result.

In the past ten years, many ICUs have implemented a VAP prevention bundle for patients with mechanical ventilators. In particular, many ICUs have conducted VAP prevention bundles as daily interventions aimed at reducing the rate of VAP cases. VAP prevention bundle can refer to one of the councils that handle infection control named Center for Disease Control (Tablan, et al. 2014).several publications explain an effective VAP prevention bundle and the presence of an infection control program that can prevent the incidence rate of VAP (Speck, et al.2016). A study in Taiwan proved that providing a checklist as an effort to implement prevention bundle had increased the prevention bundle's daily compliance target from 50% to 74% (Chung, et al., 2015).

This study aimed to determine the correlation between the use of VAP prevention bundle and the incidence rate of VAP in the ICU at Dr. Soetomo General Hospital.

MATERIALS AND METHODS

Research Design, Population, Sample, and Variables

This study used a cross-sectional method with surveillance data. This research was conducted at Soetomo General Hospital, Surabaya, Indonesia, in the July-August 2019 time frame.

The population in this study was all patients who were intubated in two separate ICU rooms in the same hospital consisting of 237 patients. The first ICU room had 16 mechanical ventilations while the second ICU owned 18 devices. During the stratified random sampling process, 183 samples were obtained. The inclusion criteria in the study sample were all patients intubated when the patient was hospitalized at Dr. Seotomo Hospital from January to June 2019 and received implementation of VAP prevention bundle. The uncompleted checklist for the implementation was the exclusion criteria. The independent variable in this study was a number of bundle components implemented in each patient and the incidence rate of VAP as the dependent variable.

Instruments

This research applied the form of the VAP prevention bundle implementation checklist. Trained staff from an infection prevention committee who were also responsible as nurses assessed this form. This form was completed by creating direct observation of the activities for each component bundles carried out while the patient was intubated.

In this form, every patient with VAP prevention bundle consisted of seven items from nine items of the

Table 1. The incidence rate of VAP in January-June 2019

Month	Patients with VAP	Ventilation Days	Incidence Rate (‰)
January	2	476	4.2
February	0	447	0.0
March	2	609	3.3
April	2	436	4.6
May	4	407	9.8
June	0	318	0.0
	Total: 10		Mean: 3.7

Table 2. Mean of Bundle's Scores and Incidence Rates in January-June 2019

Month	Mean of Bundle's Scores	Incidence Rates (%)
January	6.3	4.2
February	5.7	0
March	5.0	3.3
April	5.1	4.6
May	4.7	9.8
June	5.2	0

standard bundle in the hospital has been observed. The seven items were head of bed elevation, oral hygiene, assessment of sedation, peptic ulcer prophylaxis, cuff pressure control, endotracheal tube suctioning, and emptying of condensate. Each component of the VAP prevention bundle was assessed dichotomously (yes/no). The assessment was arranged daily every morning by referring to the medical record for each component bundle completed on the previous day. The incidence rate of VAP was determined based on doctor diagnosis following the specific criteria (Depuydt, Myny, & Blot, 2006; Asoodeh, & Motlagh, 2015).

Research procedures and analysis

In the implementation of the checklist, each bundle component was evaluated and valued at 1. If all bundles worked out, it would get a score of 7. If only 6 of the 7 bundles were in use, then it would have 6 points and so on. In this case, it would get 0 if no bundle was implemented. Otherwise, the incidence rate of VAP had a dichotomous value such as yes or no. Statistical analysis of VAP prevention bundle scores and the incidence rate of VAP utilized with the independent sample t-test and logistic regression methods by IBM SPSS Statistics version 23. The significance level was defined as $p<0.05$.

RESULT

The incidence rate of VAP during the study was quite good. **Table 1** shows the mean of incidence rate of VAP, which is less than the normal limit of 5.8 ‰ [16]. The absence of VAP cases in February and June was the best achievement in the research data period. However, the incidence rate of VAP exceeded the limit in May. It is consistent with the data in **Table 2** where it shows the average bundle score in May was the lowest at 4.7.

This compliance group was divided into two types with a cut-off of bundle score defined as five components. **Table 3** shows the compliance group of patients with a minimum of 5 bundles is 2.4 ‰. On the contrary, the incidence rate of the group of patients who receive less than five components exceed the limit. Comparative analysis of independent sample t-tests also revealed a significant difference ($p<0.05$) between the two groups in reducing the incidence rate of VAP (**Table 4**).

Table 3. Group statistics

Compliance		Group Statistics			
		N (%)	Mean	Std. Deviation	Std. Error Mean
The incidence rate of VAP	Score of bundles > 5	5 (83.3)	2.42	2.25876	1.01015
	Score of bundles < 5	1 (16.7)	9.80		

Table 4. The Independent Sample t-test

		Independent Sample Test			
		t	Df	Sig. (2-tailed)	Mean Difference
The incidence rate of VAP	Equal variances assumed	-2.983	4	.041	-7.38000
	Equal variances not assumed				-7.38000

Table 5. The score of VAP Prevention Bundle Implementation in January-June 2019

Total Scores of Bundle	Patients	
	n	%
1	3	1.6
2	8	4.2
3	13	6.9
4	30	15.9
5	41	21.7
6	66	34.9
7	28	14.8
Total	189	100

Table 6. Descriptive Data of VAP Prevention Bundle Implementation Check List

Bundle Item	Check List	
	Yes (%)	No (%)
Head of bed elevation	61.4	38.6
Oral hygiene	98.4	1.60
Assessment of sedation	61.9	38.1
Peptic ulcer prophylaxis	59.8	40.2
Cuff pressure control	72.5	27.5
Endotracheal tube suctioning	93.1	6.90
Emptying condensate	70.9	29.10
	Mean: 74%	Mean: 26%

The largest total score of the VAP prevention bundle was six bundles, which was 34.9% of the samples, as shown in **Table 5**. Compliance with the implementation of 3 component bundles or less was quite low, which was less than 10% each. **Table 6** shows that the most common bundle component is oral hygiene, and the least commonly implemented is peptic ulcer prophylaxis. In the logistic regression results, the p-value of the significance to show the impact of VAP prevention bundle to decrease the incidence rate of VAP presented 0.000 ($p<0.05$) with an influence coefficient of 0.882 (**Table 7**).

Table 7. Variable in the Equation (Logistic Regression)

	B.	S.E.	Wald	Df	Sig.	Exp(B)	95% C.I. for EXP(B)	
							Lower	Upper
Bundle Score	-.882	.231	14.553	1	.000	.414	.263	.651
Constant	.904	.883	1.049	1	0.306	2.469		

DISCUSSION

HAIs are the most frequent adverse case in health-care service. WHO factsheet presents that in high-income countries, approximately 30% of patients in ICU are affected by at least one HAIs with infection ranged from 4.4% to 88.9% (World Health Organization, 2019). The number of VAP rate is 1-4/1000 ventilator days, but it can increase up to 10/1000 ventilator days under certain conditions, and if there is no attempt to prevent HAIs (Kalil, et al. 2016). Based on its risk factors, evidence-based prevention guidelines or so-called prevention bundles had published for years and aimed at reducing the incidence rate of VAP. These guidelines always follow the dynamic development of knowledge, and some of them get modifications. A VAP prevention bundle is a collection of interventions applied at once in the management of ventilated patients to get better outcomes significantly, which is to decrease the incidence rate of VAP (SARI Working Group. 2011).

It is proved in this study that the average of the incidence rate of VAP was 3.7 ‰ with ten patients out of 2,693 ventilation days (**Table 1**). However, in May, some cases exceeded the established standard (Sutandhio, et al., 2018). In that month, the incidence rate of VAP jumped to 9.8‰. It was appropriate compared to the data average on the number of bundle components applied per patient, which showed the lowest achievement of 4.7 (**Table 2**).

Based on **Table 3**, as the implementation average of the bundle reaches a value of more than five components in the month, the incidence rate of VAP is following the target set (**Table 3**). Even in February and June, there are no patients diagnosed with VAP.

Hence, if the cut-off score was five bundle components, there was a significant difference between the two groups to decrease the incidence rate of VAP with a significance value less than 0.05 (**Table 4**). This fact can be an input for the infection control committee to evaluate the implementation of prevention bundle to intubated patients.

Descriptive results showed 6 of 7 bundles were the highest total scores in 34.9% samples (**Table 5**). The infection control committee needs to evaluate the number of bundle components implemented to reduce the incidence rate of VAP. Only 14.8% of the sample received a complete bundle implementation. The committee should make a priority list of prevention bundles to carry it out effectively.

Table 6 depicts the mean compliance of the implementation of the VAP prevention bundle that is not yet completed. A quarter of the sample does not get a bundle implementation. Oral hygiene, as a bundle component, is the most frequently listed in 98.4% of patients. Oral hygiene, endotracheal tube (ETT) suctioning, and cuff pressure control are the three most bundle components used during the study period. It is in line with a research study conducted in Brazil. Ozlem et al. concluded that an absolute decrease in VAP cases rate could be achieved with the VAP prevention bundle, including the measurement of cuff pressure control, oral care with chlorhexidine, and full utilization of ETT suctioning drainage (Ozlem, Yasemin, Cigdem, 2017). In Holland, a researcher found that the oral care bundle had decreased VAP. The comparing of periods revealed the VAP rate per 1,000 ventilators days declined significantly to zero incidence (Heck, 2012).

Oral hygiene should be combined with aqueous chlorhexidine solutions 0.12-2% for every eight hours. Concerning the chlorhexidine level used, a trial administering a high concentration of 2% solution showed a significant reduction of VAP (Lerma, et al. 2014). Antiseptics were ideal substances in oral hygiene to decrease the incidence rate of VAP. However, further research is needed to determine the correlation between chlorhexidine levels and the effectiveness in overcoming the incidence rate of VAP. The European Respiratory Society guidelines favored oral hygiene but did not give any recommendations on chlorhexidine use for VAP prevention bundle(Guillamet, & Kollef, 2018).

As displayed in the table, the implementation of ETT suction component has reached 93.1%. The health workers in the ICU have to be aware of the terms and conditions in using this bundle. There are performing suction depending on the indication, avoiding routine suction, and maintaining suction pressure. All of these are to ensure that the respiratory mucosa still works properly. Additionally, it needs to make sure that they perform suction with an aseptic technique (Yazdannik, Atashi, & Ghafari, 2018). Defluzianet conducted a meta-analysis and concluded the utilization of ETT suctioning prevented early-onset VAP at a significant level (Dezfulian, et al. 2005).Moreover, it was reported regarding the ETT that the use of super-thin polyurethane cuff together could avoid leakage of secretions and could reduce the incidence rate of VAP (SARI Working Group. 2011).

The third position of compliance with 72.5% is cuff pressure control. Research in Barcelona found that

there was a significant relationship between bundle cuff pressure control and decreased incidence rate of VAP. In that study, the incidence could decrease by 25% (Rello, et al. 2013). As part of the VAP prevention bundle, the evaluation of ETT pressure should generally be maintained at the pressures at 20–30 cm H_2O to allow an optimal closure within the trachea. Furthermore, some of the investigators said that the cuff pressure with less than 20 cm H_2O is more frequently used by manual cuff than the continuous pressure (Ozlem, et al. 2017).

Nurses and doctors need to be up-to-date with the latest techniques in regulating bundle pressure control. ETT allows the drainage of tracheal secretions, in which deflating the cuff of an ETT to prepare the tube removal is necessary to make sure the secretions have been cleared from the above of the tube cuff (Tablan, et al. 2014). Therefore, maintaining the cuff pressure is also sufficient to prevent the leakage of secretion into the lungs (Yazdannik, Atashi, & Ghafari, 2018).

There are at least two types of cuff pressure, namely intermittent and continuous cuff pressure monitoring. A study found that there were differences between these two types of cuff pressure in reducing aspiration, loading tracheal secretion, and decreasing the incidence rate of VAP (Nseir, et al. 2011). However, several other studies showed no significant differences between the types and shapes of ETT cuffs in reducing VAP (Guillamet, & Kollef, 2018).

Table 6 presents that the implementation rate of 70.9% is emptying of condensate. The ventilator humidifier must be under the patients' beds to prevent condensate from reaching the patient. In this bundle component, draining and emptying of condensate from the ventilator tube to the water trap must be applied periodically. Then, the ventilator tube must be drained to optimize the components of this bundle (Yazdannik, Atashi, & Ghafari, 2018). A study suggests not to place a filter or trapper at the distal end of the expiratory-phase tubing of the breathing circuit to empty the condensate (Tablan, et al. 2014).

The three bundle components, namely assessment of sedation, head of bed elevation, and peptic ulcer prophylaxis, have the same implementation value with the range of 60%. The duration of ventilation to reduce the incidence rate of VAP has been included in the Society for Healthcare Epidemiology of America guidelines. For this reason, an assessment of sedation must be conducted periodically to minimize it in the framework of weaning of mechanical ventilators. Assessment of sedation has to be considered as an important and fundamental element of the many VAP prevention bundles (Guillamet, & Kollef, 2018).

Based on a study in Turkey, 61.4% of patients have received the head of bed elevation implementation. This bundle component was successful in reducing the incidence rate of VAP because one of the causes of lung infection was gastric acid aspiration fluid. The elevated head position prevents gastro esophageal reflux. A study considered the head position as one of the most effective methods for preventing VAP (Heck, 2012).In addition, researchers in Mexico also believes that the head of the bed elevation 30^o-45^o provides the safest positioning for VAP prevention in stable patients (Guillamet, & Kollef, 2018). Moreover, studies on peptic ulcer prophylaxis discovered that the use of histamine type 2 receptor blockers, proton pump inhibitors, and antacids might increase the risk of VAP, especially in patients receiving enteral nutrition. The risk of bleeding should be complemented against VAP using prophylaxis for ulcer agents (Yazdannik, Atashi, & Ghafari, 2018).

This study proved that there was a significant correlation between the use of VAP prevention bundles and the incidence rate of VAP for ventilated patients in the ICU with a significance value of $p<0.05$ (**Table 7**).

A prevention bundle should be implemented in all critical care areas, including ICU for mechanically ventilated patients. Although the VAP prevention bundle is an effective method for reducing VAP rate, modifications to introduce specific prevention strategies is also an essential factor based on scientific evidence so that the incidence rate of VAP decreases (Rello, et al. 2013).

In a recent review, the VAP prevention bundle as an infection control strategy was an effective method for declining the incidence rate of VAP in ICU. Many studies in other countries expose a significant correlation between the implementation of the VAP prevention bundle and the incidence rate declining of VAP. Saudi Arabia researchers found that the implementation of the VAP prevention bundle ended in the reduction of VAP rates from a mean of 9.3 to 2.2 in 2 years (Al-Tawfiq, & Abed, 2010).A study in Egypt demonstrated if the bundle was not carried out properly, the incidence rate of VAP would rise to 26 per 1000 ventilator days. It highlights that the compliance of the VAP prevention bundle in the ICU can decline the incidence rate of VAP (Mohamed, 2014). Research in Taiwan has also attested that after almost two years of intervention. It resulted that the incidence rate of VAP decreased by more than 50%. The bundle included assessment of sedation, peptic ulcer prophylaxis, oral hygiene, endotracheal tube suctioning, head of bed elevation to between 30^o-45^o, and cuff pressure control (Chung, et al. 2015).Another study in Taiwan explained that a multidisciplinary care bundle reduced the cases of ventilator days and the incidence rate of VAP, as well as improved the quality of care. After implementing the VAP prevention bundle, the incidence rate of VAP lowered to 0% (Chen, Chen, Hsueh, 2014).(Last, combined strategies also could increase the compliance for VAP prevention bundle and decreased incidence rate of VAP from 8.34 to 4.78 in Belgian ICU (Reper, et al. 2017).

LIMITATION OF THE STUDY

This study was limited to secondary data of patients treated in two ICU rooms at Soetomo General Hospital during January-June 2019. The data were evaluated by the relevant committees, including the infection control committee. The data were also used as a consideration in decreasing the incidence rate of VAP. Hence, the data can change even after this research is completed.

CONCLUSION

There was a significant correlation between the use of VAP prevention bundles and the incidence rate of VAP for ventilated patients in the ICU room. Therefore, each VAP prevention bundle, as an infection control tool, including head of the bed elevation, oral hygiene, assessment of sedation, peptic ulcer prophylaxis, cuff pressure control, endotracheal tube suctioning, and emptying of condensate should be served entirely to affect the incidence rate of VAP.

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