

Performance Assessment of Medical Professionals in Prevention of Ventilator Associated Pneumonia in Intensive Care Units

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Purpose: Ventilator-associated pneumonia (VAP) is one of the most common infections in intensive care units (ICU) with a 6–52% incidence. The VAP mortality rate is 50% to 70%. Medical professionals (MPs) working in the ICU are expected to follow the guidelines to prevent VAP. The study aimed to assess the performance of MPs in preventing VAP and to associate the performance with the baseline information.

Methods: An observational cross-sectional study was conducted in the ICUs of selected hospitals in eastern Saudi Arabia. A total of 152 MPs were selected by random sampling. A structured questionnaire including baseline information, knowledge and performance-related questions was used to collect the data. Frequency, mean, and chi-square tests were used for analysis.

Results: Out of 152 MPs, 40.8% had adequate and 7.9% had inadequate knowledge. A high mean score of 12.9 ± 2.2 was obtained by physicians, followed by 11.3 ± 1.6 by nurses, 9.8 ± 2.2 by RTs, and 8.6 ± 2.1 by interns. Overall, 52.6% had satisfactory performance. Approximately 57.9% and 67.8% of MPs cleaned their hands before touching the patient and the ventilator, respectively. Many (79.6%) MPs used personal protective equipment in the ICU. Some (47.4%) of the MPs changed the patient's position regularly. About 77.6% of MPs followed the sterile technique when suctioning the airway. There was a significant association found between the performance of MPs on the prevention of VAP with age ($p < 0.001$), designation ($p < 0.05$), professional experience ($p < 0.05$), managing chronic obstructive pulmonary disease conditions ($p < 0.05$) and training attended ($p < 0.001$).

Conclusion: Although some of the MPs had satisfactory performance regarding VAP prevention in the ICU, more attention should be paid to training them on clinical guidelines to improve health care quality and reduce the rate of VAP.

Keywords: ventilator-associated pneumonia, intensive care units, medical professionals, infection

Introduction

Critically ill patients are at risk of different complications¹ such as acute respiratory distress syndrome (ARDS) and chronic obstructive pulmonary disease (COPD), which can be treated with mechanical ventilation procedures² and respiratory care³ in the Intensive Care Unit (ICU).⁴ Ventilator-associated pneumonia (VAP)⁵ is a lung infection occurring more than 48 hours after the initiation of endotracheal intubation⁶ and mechanical ventilation and is one of the most common infections in ICUs with 6–52% incidence.⁷ VAP mortality rate is 70% in high-risk patients globally.⁸ The incidence ranges from 2 to 16 episodes per 1000 ventilator-days in the United States.⁹ The estimated risk of VAP is 1.5% per day and decreases to less than 0.5% per day after the 14th day of mechanical ventilation.^{10,11} In the Kingdom of Saudi Arabia, the overall VAP rate was 2.97 per 1000 ventilator-days in Ministry of health hospitals.¹²

The primary factor for developing pneumonia in the ICU is mechanical ventilation.¹³ Endotracheal tube intubation, nasogastric tube feeding, malnutrition, and inadequate flow of saliva, which lead to oropharyngeal colonization in patients are other predisposing factors.¹⁴ VAP increases oxygen demand, production of sputum, alveolar collapse, and impaired gas exchange.¹⁵ Further consequences of VAP include prolonging the duration of hospitalization and increasing

the length of stay in the ICU, increasing the cost of treatment, more usage of healthcare resources, and longer duration of mechanical ventilation, thereby causing high morbidity and mortality rates.^{16–20}

Medical professionals (MPs) working in the ICU are expected to play an important role in the prevention of VAP by following protocols.²¹ Awareness of this protocol by healthcare providers are effective in the prevention of VAP and could reduce its incidence significantly.^{22–24} Some researchers showed the importance of nurses' level of knowledge regarding specific preventive measures of VAP.²⁵ The application of this knowledge to practice is essential in healthcare settings. Few studies have analysed the compliance of nurses on preventive aspects of VAP,²⁶ in which the questionnaires may not be reliable to measure compliance to reflect performance.²⁷ However, the study related to direct observation of practices on VAP prevention in the ICU is lacking. Hence, considering the high functionality of following the guidelines for the prevention of VAP and the lack of evidence-based research, researchers were prompted to assess the performance of MPs in the prevention of VAP in ICUs. The primary objective of the study was to assess the knowledge and performance of MPs in the prevention of VAP in ICU and to associate the performance of MPs in the prevention of VAP with the selected demographic variables.

Materials and Methods

Study Design

An observational cross-sectional study under quantitative design was conducted among MPs to achieve the objectives of the study in the year 2021. The study was carried out according to the guidelines of Helsinki²⁸ and was ethically approved by the Research Ethics Committee, Deanship of Scientific Research, King Faisal University, Al-Ahsa, Saudi Arabia (HAPO-05-HS-003). The research protocol was also approved by the King Fahad Hospital Hofuf, Institutional Review Board (H-05-HS-065) with RCA Number 39-45-2021. Informed consent was obtained from all the MPs involved in the study before data collection and ensured confidentiality, no risk, anonymity, and voluntary participation.

Study Setting and Participants

The research setting included the selected hospitals in the eastern region of the Kingdom of Saudi Arabia. In this research, the study participants were MPs, including physicians, nurses, respiratory therapists (RTs), and interns, by using stratified random sampling. The study participants were selected based on the inclusion criteria, such as the MPs who were interested in participating in the study, including males, females, Saudis, and non-Saudis, with a minimum of six months of experience in the ICU.

Study Sampling

Considering the variables and outcome of the study, assuming the expected 50% of the study population had good practice in following the hospital guidelines to prevent VAP in ICU, with an allowable margin error of 5% at a 95% confidence interval, and accounting for the finite population of 297 MPs, a minimum sample size of 168 was calculated. However, finally, after the stratified randomization sampling,²⁹ a total of 152 MPs from various fields were included in the data collection.

Data Collection

A structured questionnaire with an observational tool was used to collect the data. This questionnaire is an originality tool, and it was evaluated by a panel of experts to validate the tool. A pilot study was conducted to improve the tool.

The structured questionnaires consisted of three parts: The first part of the questionnaire included baseline information, and the second part included the knowledge questionnaire about the prevention of VAP and the third part of the tool about the performance of MPs to prevent VAP.

Baseline Information

The participating professional's baseline information, such as age, gender, the highest educational qualification, designation, professional experience, working sector, unit, managing patients with COPD, and information about training taken on prevention of VAP were included in the first part of the tool.

Knowledge on the Prevention of VAP

The second part of the tool included 16 multiple choice questions regarding the aspects of the prevention of VAP. Each question had four options, of which three were incorrect and one was correct. The structured knowledge questionnaire was validated by medical experts and scored as either one point for a correct response or zero point for an incorrect response. The total knowledge score was summed up and computed for analysis. The score interpretations were counted from 75% to 100% (12 to 16) as adequate knowledge, from 50% to 74% (8 to 11) as moderately adequate knowledge, and below 50% (less than 8) as inadequate knowledge.

Practice on Prevention of VAP

The third part of the tool had 16 structured questions related to the prevention of VAP. The investigators observed the performance of MPs directly, whether they complied or not, and filled in the questionnaire. If the practice achieved by MPs at 75% and above was considered satisfactory performance, and anything below that score was considered unsatisfactory performance. The overall practice was calculated and interpreted by using the frequency distribution table in the results section given below.

The questionnaire was piloted among 15 MPs, and they were excluded from the final analysis. The reliability of the questionnaire was tested ($r = 0.962$) using Cronbach's alpha. The time to fill in the questionnaire ranged from 15 to 20 minutes. Information was included in the tool with an introduction, explaining the objectives of the study and ensuring privacy and confidentiality before distribution. Participation in the study was voluntary. Informed consent was obtained from all the participants before the data collection.

Data Analysis

All statistical analyses were performed with the Statistical Package for Social Sciences (SPSS) for Windows, version 21.0, International Business Machines (IBM) Corporation, Armonk, New York, USA. Results were reported in accordance with STROBE guidelines. The researchers used descriptive statistics such as frequency and percentages for categorical variables and mean and standard deviation (SD) for continuous variables. In inferential statistics, Chi-square tests were used to evaluate associations between performance and baseline information and to identify *p*-value. Statistical significance is defined as a *p*-value of less than 0.05.

Results

Baseline Information of the MPs

Table 1 displays the baseline information of the MPs, which included age in years, gender, highest educational qualification, designation, professional experience, working sector, and type of work unit. A total number of 152 MPs were included in the analysis most of them 61 (40.1%) were in the age of 31–40 years, and many of the participants, 113 (74.3%) were females. The overall mean score of the age was 37.3 ± 8.98 . About the educational status of them, 52 (34.2%) studied diplomas, 74 (48.7%) had bachelor's degrees and 22 (14.5%) had master's degrees as their highest level of qualification. Few MPs, 4 (2.6%), were doctorates. Regarding the designation of the MPs, 39 (25.7%) were physicians, 71 (46.7%) were nurses, and 16 (10.5%) were RTs. Furthermore, 71 (46.7%) MPs had 1 to 3 years of experience, 28 (18.4%) had 4 to 6 years of experience and 15 (9.9%) had 6 to 9 years of experience. Concerning the working sector, most of the participants, 105 (69.1%), worked in a government hospital and 78 (51.3%) were in medical ICU, 32 (21.1%) in surgical ICU and the remaining 42 (27.6%) in CCU (critical care unit). The training on VAP prevention and infection control attended by MPs within 2 years were shown in Figure 1. Among them, 12 (7.9%) physicians, 24 (15.8%) nurses, 5 (3.3%) RTs and 2 (1.3%) interns were undergone training.

Knowledge on Prevention of VAP

The overall knowledge level of MPs regarding the prevention of VAP is shown in Table 2, in that 62 (40.8%) had adequate knowledge, 78 (51.3%) had moderately adequate knowledge, and 12 (7.9%) had inadequate knowledge. The overall mean score was 11.1 ± 2.4 . A high mean score of 12.9 ± 2.2 was obtained by physicians, followed by 11.3 ± 1.6 by nurses, 9.8 ± 2.2 by RTs, and 8.6 ± 2.1 by interns.

Table 1 Baseline Information of the MPs. (n=152)

Characteristic	Category	N (%)
Age (years)	20–30 years	39 (25.7)
	31–40 years	61 (40.1)
	41–50 years	43 (28.3)
	More than 50 years	9 (5.9)
Gender	Male	39 (25.7)
	Female	113 (74.3)
Educational qualification (highest)	Diploma	52 (34.2)
	Bachelor	74 (48.7)
	Master	22 (14.5)
	Doctorate	4 (2.6)
Designation	Physicians	39 (25.7)
	Nurses	71 (46.7)
	RTs	16 (10.5)
	Interns	26 (17.1)
Professional experience	< 1 year	34 (22.4)
	1–3 years	71 (46.7)
	4–6 years	28 (18.4)
	6–9 years	15 (9.9)
	10 and above years	4 (2.6)
Working sector	Public hospital	105 (69.1)
	Private hospital	47 (30.9)
Working unit	Medical ICU	78 (51.3)
	Surgical ICU	32 (21.1)
	CCU	42 (27.6)
Managing COPD patients	Yes	37 (24.3)
	No	115 (75.7)

Abbreviations: N, number; %, percentage.

Performance on Prevention of VAP

The practice compliance of MPs regarding the prevention of VAP in ICU is reported in [Table 3](#). Regarding hand hygiene, 88 (57.9%) and 103 (67.8%) MPs regularly cleaned their hands with soap and water or an alcohol-based rub before touching the patient and before touching the ventilator, respectively. Most of the MPs 121 (79.6%) complied by wearing personal protective equipment (PPE) strictly while caring for patients and handling ventilators. Approximately 109 (71.7%) MPs either verified or did the oral hygiene of the patient using chlorhexidine twice daily at regular intervals by every 12 hours. Most of the MPs 137 (90.1%) recommended elevating the head of the bed by 30 to 45 degrees to reduce VAP occurrences. Some of the MPs 72 (47.4%) changed the body position of the patient to clear the secretions every 2 hours once regularly and advised suctioning of the patient to clear the

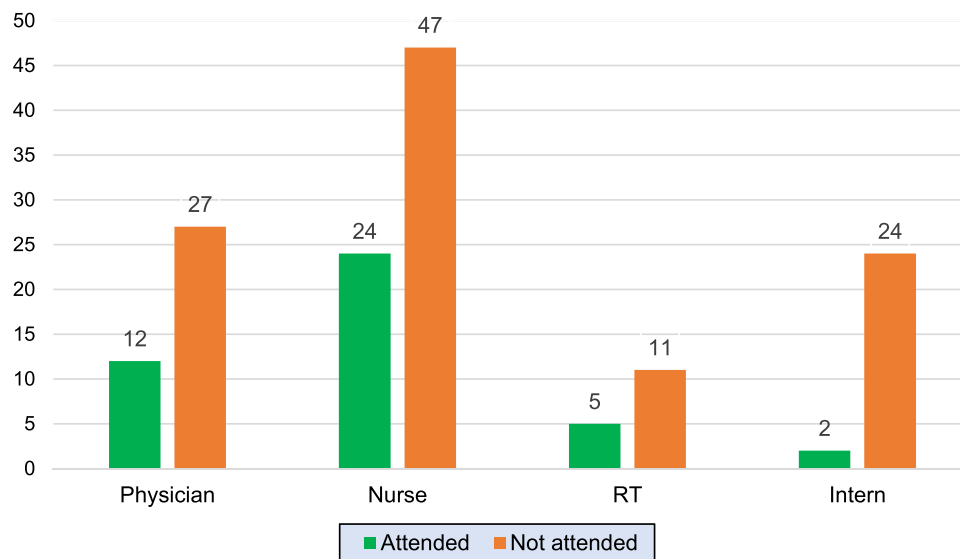


Figure 1 Training attended by MPs on VAP prevention guidelines. (n=152).

subglottic secretions. Approximately 118 (77.6%) MPs followed the sterile technique when suctioning the airway. Around 136 (89.5%) MPs changed the disposable ventilator circuit weekly once regularly, and 84 (55.3%) MPs controlled and maintained cuff pressure properly. Additionally, 52 (34.2%) MPs repositioned the endo tracheal tube (ETT) and 53 (34.9%) MPs controlled and maintained cuff pressure regularly. While 97 (63.8%) MPs used the spontaneous breathing trial regularly, 55 (36.2%) used it rarely. Nearly half of the MPs 78 (51.3%) did chest wall percussion, regularly. Many of the MPs 83 (54.6%) lightened the sedation at regular intervals, to assess for neurological readiness to wean the patient from ventilation. Mostly 141 (92.8%) MPs complied to conservative fluid management for every 24 hours once and 137 (90.1%) MPs administered short course of systemic antibiotics to prevent infection to their patients. Additionally, 93 (61.2%) MPs used some devices, such as the intermittent pneumatic compression (IPC) device, to prevent deep vein thrombosis (DVT). Maximum number 143 (94.1%) of MPs instructed or performed timely evacuation of water container of ventilator circuit. The overall results showed that 80 (52.6%) had satisfactory performance and the remaining 72 (47.4%) needed to improve their performance as they had been unsatisfactory in their practices. There was a significant association found (Table 4) between the performance of MPs on the prevention of VAP with age ($p < 0.001$), designation ($p < 0.05$), professional experience ($p < 0.05$), managing patients with COPD ($p < 0.05$) and training attended within 2 years on VAP prevention guidelines ($p < 0.001$).

Discussion

Among hospital-acquired infections, VAP is one of the serious health problems that result in a higher mortality and morbidity rate.^{30,31} The findings of the present study showed that 62 (40.8%) had adequate knowledge regarding the VAP

Table 2 Frequency Distribution of Level of Knowledge Regarding Prevention of VAP. (n=152)

Level of Knowledge	Adequate Knowledge	Moderately Adequate Knowledge	Inadequate Knowledge	Mean \pm SD
	N (%)	N (%)	N (%)	
Physician (n=39)	28 (18.4)	10 (6.6)	1 (0.7)	12.9 \pm 2.2
Nurse (n=71)	29 (19.1)	40 (26.3)	2 (1.3)	11.3 \pm 1.6
RT (n=16)	3 (2)	10 (6.6)	3 (2)	9.8 \pm 2.2
Intern (n=26)	2 (1.3)	18 (11.8)	6 (3.9)	8.6 \pm 2.1
Overall	62 (40.8%)	78 (51.3%)	12 (7.9%)	11.1 \pm 2.4

Table 3 Frequency Distribution of MP's Performance Regarding Prevention of VAP in ICU. (n=152)

Performances to Prevent VAP	Compliance N (%)	Non-Compliance N (%)
Hand hygiene with soap and water or an alcohol-based rub before and after touching the patient.	88 (57.9)	64 (42.1)
Hand hygiene with soap and water or an alcohol-based rub before touching the ventilator.	103 (67.8)	49 (32.2)
PPE usage strictly while caring the patients and handling ventilator.	121 (79.6)	31 (20.4)
Oral hygiene of the patient using chlorhexidine at regular intervals.	109 (71.7)	43 (28.3)
Head elevation of bed to 30 to 45 degrees.	137 (90.1)	15 (9.9)
Suctioning of the patient to clear the subglottic secretions.	72 (47.4)	80 (52.6)
Use sterile technique when suctioning the airway.	118 (77.6)	34 (22.4)
Use of disposable ventilator circuit and change regularly.	136 (89.5)	16 (10.5)
Control and maintain cuff pressure.	84 (55.3)	68 (44.7)
Use spontaneous breathing trial.	97 (63.8)	55 (36.2)
Do chest wall percussion	107 (70.4)	45 (29.6)
Lighten sedation at regular intervals, to assess for neurological readiness to wean the patient from ventilation.	83 (54.6)	69 (45.4)
Conservative fluid management.	141 (92.8)	11 (7.2)
Administer short course of systemic antibiotics.	137 (90.1)	15 (9.9)
Use devices to prevent DVT	93 (61.2)	59 (38.8)
Timely evacuation of water container of ventilator circuit.	143 (94.1)	9 (5.9)

Abbreviations: N, number; %, percentage.

prevention guidelines. The overall mean score of knowledge level was 11.1 ± 2.4 . A high mean score of 12.9 ± 2.2 was obtained by physicians, followed by 11.3 ± 1.6 by nurses, 9.8 ± 2.2 by RTs, and 8.6 ± 2.1 by interns. A similar study was conducted on the impact of education on VAP in the ICU, in which the nurse's knowledge as reflected in their test mean score was 63.17 ± 9.34 .³² A cross-sectional study, involving ICU nurses in major hospitals in Tanzania demonstrated that 79.3% of nurses had a mean knowledge score of 3.86 ± 1.56 , based on ten questions.³³ Another study showed that the median value of total points scored by nurses on the questionnaire was 4.00 ± 2.00 ,³⁴ and 15.91 ± 2.68 .³⁵

The current study indicated that 57.9% of MPs regularly cleaned their hands, which was supported by similar research in which 57% adhered to hand hygiene.³⁶ In our study, 79.6% of the MPs complied with the protocol by wearing PPE strictly. This finding was supported by a study on compliance with the standards for the prevention of VAP by nurses in the ICU, in which the use of PPE was 80.3%.³⁷ In the present study, 71.7% adhered to the oral hygiene of the patient using chlorhexidine. The adherence rate was 45.6% in a multi-centre study done by Eom et al,³⁸ and 87.5% in another study.³⁷ In this study, 90.1% of MPs recommended elevating the head of the bed by 30 to 45 degrees to reduce VAP occurrences. Similarly, the compliance rate was 98% in the study conducted on adherence to the VAP bundle and the incidence of VAP in the surgical ICU.³⁹ However, the adherence rate was evidenced at 65.9% in the research³⁸ which was low. There was 80% adherence in one study,⁴⁰ and 96.6% in another study.³⁷

A semi-upright position in ventilated patients is recommended to prevent VAP and is an essential component of the ventilator bundle.^{35,41} Because, the aspiration of oropharyngeal secretions and gastric contents containing bacteria leading the pathogenesis of VAP in supine position than in patients in a 45° position.^{42,43} In our study, 47.4% MPs changed the body position of the patient every two hours, once regularly to clear the secretions and suctioning to clear the

Table 4 Association Between the MP's Performance Regarding Prevention of VAP and Baseline Informations. (n=152)

Characteristic	Category	Satisfactory Performance	Unsatisfactory Performance	Chi-Square Test
Age (years)	20–30 years	31	8	$\chi^2 = 18.9565$ $P = 0.000279^{***}$
	31–40 years	22	39	
	41–50 years	21	22	
	More than 50 years	6	3	
Gender	Male	22	17	$\chi^2 = 0.3005$ $P = 0.5836$ NS
	Female	58	55	
Educational qualification (highest)	Diploma	23	29	$\chi^2 = 3.4075$ $P = 0.332965$ NS
	Bachelor	45	29	
	Master	12	10	
	Doctorate	2	2	
Designation	Physician	21	18	$\chi^2 = 8.3692$ $P = 0.038967^*$
	Nurse	39	32	
	RT	12	4	
	Interns	8	18	
Professional experience	< 1 year	10	24	$\chi^2 = 10.6169$ $P = 0.031224^*$
	1–3 years	36	35	
	4–6 years	16	12	
	6–9 years	11	4	
	10 and above years	3	1	
Working sector	Public hospital	56	49	$\chi^2 = 0.0671$ $P = 0.795642$ NS
	Private hospital	24	23	
Working unit	Medical ICU	39	39	$\chi^2 = 4.4366$ $P = 0.108794$ NS
	Surgical ICU	23	9	
	CCU	23	19	
Managing COPD	Yes	13	24	$\chi^2 = 6.4752$ $P = 0.010939^*$
	No	68	47	
Training attended	Yes	31	12	$\chi^2 = 22.1207$ $P = 0.00001^{***}$
	No	33	76	

Notes: *Significance at $p < 0.05$; ***Significance at $p < 0.001$.

Abbreviations: ARDS, acute respiratory distress syndrome; CCU, critical care unit; CDC, centers for disease control and prevention; COPD, chronic obstructive pulmonary disease; DVT, deep vein thrombosis; ETT, endo tracheal tube; IBM, International Business Machines; ICU, intensive care unit; IPC, intermittent pneumatic compression; MPs, medical professionals; PPE, personal protective equipment; RTs, respiratory therapists; SD, standard deviation; SPSS, statistical package for social sciences; STROBE, strengthening the reporting of observational studies in epidemiology; USA, United States of America; VAP, ventilator associated pneumonia; WHO, World Health Organization; NS, non-significant.

subglottic secretions, that was supported by Tabaeian et al.³⁷ A study proved the effects of 45° semi-upright position improves ventilation and oxygenation in mechanically ventilated intensive care patients, in which peripheral oxygen saturation (SpO₂) and end-tidal carbon dioxide (ETCO₂) improved significantly for the 45° position compared with <10° position.⁴⁴

The sterile technique when suctioning the airway was followed by 77.6%. But the use of sterile techniques for airway suctioning through the open method by nurses was shown in a study ($p = 0.175$).³⁷ The effect of ventilator circuit changes on ventilator-associated pneumonia was proved by many researchers.⁴⁵ In this research, 89.5% of MPs changed the disposable ventilator circuit regularly, and 55.3% of MPs controlled and maintained cuff pressure properly. There was 34.2% compliance in repositioning the ETT and 34.9% in controlling and maintaining the cuff pressure regularly. Additionally, a matched case-control study conducted among mechanically ventilated patients admitted to the ICU reported that patients who had a history of ETT repositioning were twice as likely to develop VAP as patients who had no history of ETT.⁴⁶

Spontaneous breathing trials can be performed on low levels of pressure support, and continuous positive airway pressure.⁴⁷ This current study finding reported that 63.8% of MPs used the spontaneous breathing trial regularly, which was consistent with a study.⁴⁸ Nearly, half of the MPs (51.3%) were done with chest wall percussion. This was not indicated in another study. However, the effect was proved.⁴⁹ More than half of the MPs 54.6% have lightened the sedation at regular intervals, to assess for neurological readiness to wean the patient from ventilation. But, in another study, the least adherence to the management of sedation and analgesia.⁵⁰ About the conservative fluid management⁵¹ and administration of a short course of systemic antibiotics,⁵² 92.8% and 90.1% MPs complied to prevent infection to their patients respectively. IPC device⁵³ was used to prevent by 61.2% of MPs. Most of them (94.1%) performed timely evacuation of the water container of the ventilator circuit. These findings were compared with another study.³⁷

There was a significant association found between the performance of MPs on the prevention of VAP with age ($p < 0.001$), designation ($p < 0.05$), professional experience ($p < 0.05$), managing patients with COPD⁵⁴ ($p < 0.05$) and training attended within 2 years on VAP prevention guidelines ($p < 0.001$). Nevertheless, it should also be noted that, in the present study, 16 preventive measures were included. The strength of the present study was the method used for data collection, which was conducted by direct observation of the MPs' performances, without causing any reaction or change in their behavior, and therefore, the results demonstrated their real performance of them. In the previous study⁵⁵ a total of 12 preventive measures were included through direct observation of the nurses, and the rate of compliance was low. In addition to that, this is the first study to assess the performance of MPs, including physicians, nurses, RTs, and interns. Overall, the findings of this study showed satisfactory performance of the MPs. The weakness of the current study was the parameters in compliance of MPs for a given patient or unit observed by using a "yes" or "no" checklist rather than a rating scale. In addition, to measure sustained compliance, longer follow-up was needed, which was the limitation. However, considering the prevalence of VAP⁵⁶ and its various complications, it is necessary to expand the study with larger samples. The factors causing the low or unsatisfactory performance of MPs will be further studied in the future. Also, it is recommended that a preventive clinical guide for VAP need to be circulated to all MPs.

Conclusion

The findings of the study evidenced that, approximately half of the study participants had adequate knowledge and satisfactory performance regarding VAP prevention in ICU. However, more attention should be paid to planning and providing appropriate and regular training programs for all MPs to update the information and follow the clinical guidelines and necessary facilities must be provided with high-quality services in the ICU to improve health care quality, and by the way to reduce the rate of VAP.

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Disclosure

The authors report no conflicts of interest in this work.

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