Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.47750/jptcp.2023.30.09.003

The Effect of An Educational Program on Intensive Care Units Nurses' Knowledge Regarding Prevention Of Ventilator-Associated Pneumonia

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Submitted: 10 February 2023; Accepted: 18 March 2023; Published: 03 April 2023

ABSTRACT

Background: Ventilator-associated pneumonia is one of the most common Healthcare-Associated Infections (HAI). Worldwide, VAP ranges from 6 to 52% and might be as much as 76% of all intubated patients in some developing countries. VAP accounts for 15% to 45% of the mortality rate in critical care settings. Despite advances in medical science, VAP continues to be one of the biggest threats in ICUs, being responsible for most infections in critically ill patients, and leading to prolonged ventilator dependency and prolonged stays in ICUs.

Aim: This study evaluated the effectiveness of implementing an educational program on the knowledge of ICU nurses from different healthcare sectors regarding VAP prevention guidelines.

Methods: One group pretest-posttest design was used. A total of 156 critical care registered nurses from 12 hospitals attended an educational program of four hours. Eight sessions were conducted in total. Nurses were asked to complete an adapted 19-itemtem questionnaire based on strategies and guidelines adopted by CDC for VAP prevention, which was used to evaluate nurses' actual knowledge of VAP prevention guidelines.

Results: ICU nurses mostly demonstrated a knowledge deficit regarding VAP prevention guidelines (pretest M = 8.79). The educational program was effective in increasing nurses' level of knowledge (posttest M = 14.9). Results have shown a statistically significant mean difference between pretest and posttest ($p < .05$). Nurses' actual level of knowledge was positively correlated with type of health sector, participants' ages, and attendance of previous educational sessions regarding VAP prevention.

Conclusion: The study evaluated the effectiveness of an educational program on critical care nurses' knowledge regarding VAP prevention. The introduced program was efficient and positively influenced nurses' knowledge wherever results demonstrated a knowledge deficit toward VAP prevention guidelines by the nurses who participated in this study. The importance of conducting frequent educational programs is essential to supporting nurses' knowledge. Implementation and dissemination of VAP prevention evidence-based guidelines on caring for intubated patients in critical care units is a prerequisite to improving nurses' level of knowledge and improving quality of nursing care.

Keywords: *Ventilator Associated pneumonia prevention, Educational Program, Critical care nurses, level of knowledge, Evidence-based guideline*

J Popul Ther Clin Pharmacol Vol 30(9):e14–e25; 03 April 2023.

INTRODUCTION

Ventilator-associated pneumonia (VAP) is lung infiltration associated with hyperthermia, leucocytosis, and purulent tracheobronchial secretions. It is developed after two days of intubation, and confirmed by a combination of radiological, clinical, and laboratory tests [1]. When a patient is admitted to an intensive care unit (ICU) and required intubation, the accumulation of contaminated oropharyngeal secretions passively passes through or around the endotracheal tube (ETT) to the lower segment of the lungs and makes the patient vulnerable to VAP. In addition, critically ill patients have an impaired immune defence decreased level of consciousness, and impaired gag and cough reflexes, all of which could increase the risk of VAP, especially when combined with higher ages [2]. Centers for Disease Control and Prevention's recommendations to prevent VAP in patients receiving mechanical ventilation highlight the importance of clinical nursing care that is based on the recent evidence-based guidelines to assure patient safety and enhance the quality of care [3]. VAP prevention is a multidisciplinary responsibility, but nurses have a major role in preventing VAP and implementing these guidelines because they are in direct contact with patients 24 hours per day while providing nursing care and patient monitoring in ICUs. Internationally, many studies have been carried out over the past few years to develop updated guidelines and comprehensive educational material for VAP prevention [4]. Most of these studies were constructed to educate healthcare providers regarding VAP prevention through implementing educational programs. Furthermore, the literature shows that implementing such educational programs proved the key to VAP prevention and reducing the related complications in intubated patients in ICUs [5]. Educating healthcare workers was adopted as one of the CDC recommendations to prevent VAP [6]. Such educational programs are applicable and achievable, do not require many facilities or supplies, and can be implemented at the most basic levels. Education, knowledge gain, and implementing enhanced evidence-based practices may increase the quality of nursing care, while a lack of educational sessions for ICU staff and a knowledge deficit could be barriers to adhering to the evidence-based guidelines to prevent VAP [7].

Statement of the Problem

This study designed to evaluate the effectiveness of implementing an educational program on the knowledge of ICUs nurses from different healthcare sectors in Jordan regarding VAP prevention guidelines.

Objectives

To assess the level of critical care nurses' knowledge of VAP prevention.

To assess the effect of an educational program in improving ICU nurses' knowledge about VAP prevention guidelines.

To determine the relationship between the demographic characteristics of the participating ICU nurses and their basic knowledge of VAP prevention guidelines.

Hypothesis

H1- There will be a significant difference between the pretest and posttest knowledge scores regarding the prevention of ventilator-associated pneumonia

H2- There will be a significant association between nurses' level of knowledge and selected demographic variables.

Variables

Independent variable: receiving or not receiving knowledge after conducting of VAP prevention educational program based on CDC guidelines.

Dependent variable: level of nurses' knowledge about VAP; measured by a 19-item questionnaire.

METHODOLOGY

Design

Quasi-experimental, one-group pretest-posttest design was utilized for this study, while data were

collected from November 2013 to February 2014 in different multisectoral ICUs in Jordan.

Ethical Considerations

Ethical approval was obtained from the Graduate Studies Committee at the University of Jordan. Permission approvals were obtained after the correspondence had been sent to the selected hospitals. Before initiating the program, every participant was informed through a written consent form which contained a description of the study and of its purpose, nature, and duration. Participants were requested to write down their names to match pretest with posttest and for purely statistical purposes, with only the researcher able to view the names in connection with the scores. If participants were still concerned, they could use a code for both pretest and posttest. Participation was voluntary, and participants had the right to withdraw whenever they wanted and for any reason without any penalty. Tool approval was sought and granted by the original authors.

Settings

A total of 20 ICUs represented 12 hospitals administrations agreed to participate were selected conveniently to represent all health sectors in Jordan (university, military, governmental, and private) as follows: one university-affiliated hospital, five private, two military, and four governmental hospitals. These hospitals were selected conveniently and based on the Department of Statistics 2012 yearbook [8] according to availability of the three types of critical care units:

Adult general ICU including medical, surgical, and neuro ICU.

Paediatric and neonatal ICU

Coronary care unit (CCU).

Paediatric ICUs were limited in numbers because critically ill paediatric patients were admitted to adult ICUs in most government and military hospitals in Jordan. In addition, medical, surgical, and neuro-adult ICU cases often shared the same general ICUs.

Sampling

The target population is the entire population that the study focuses on, and the study population or the accessible population is that portion of the target population where the sample is taken from. Registered nurses in Jordan were the target population, and registered nurses working in intensive care units were the accessible population where the study sample was selected. After the selection of the participating hospitals, inclusion criteria for participants were as follows: (1) they had to be registered nurses, (2) have at least six months of ICU experience, (3) employed by the participating hospitals, (4) be willing to participate on a voluntary basis. The required sample size to conduct this study using Cohen's d table [9] to compare between two means is as follows: Paired t-test with medium effect size .5 at power of .80 and level of significant .05. The minimum required sample size is 64 participants, therefore. The final available sample size of 156 (N = 156) ICU registered nurses participated who met the required inclusion criteria. The rationale to increase the sample size is to provide for the eventuality of withdrawal from the study or incomplete questionnaires, as well as for more representativeness when comparing between sectors.

Data Collection Procedure

The researcher collected the data and provided the educational program by himself. Access to collected data was guaranteed by submitting the required correspondence to the participating hospitals' administrative managers through The University of Jordan. This included a description of the study and its nature. Settings and dates of the sessions were determined in coordination with the selected hospital's continuous education and training teams or infection control teams who nominated and controlled numbers of participants according to the participation inclusion criteria. They also booked conference rooms at the host hospitals for four hours, from 9:00 am to 1:00 pm.

Data were collected from November 2013 to February 2014. Eight sessions were conducted were held as the following:

Two sessions at the Jordan Nursing and midwife Council (JNMC) premises located in the north. Nurses who attended these two sessions were 42 ICU nurses

Four sessions in the central region at three private hospitals that afforded to host the meetings (one hospital received two sessions). A total of 80 ICU nursee attended all sessions

Two sessions at two different governmental hospitals located in the south, and 34 ICU nurses attended the sessions there.

The study's nature and purpose were clarified for participants before every session. Attendance sheets were passed among participants in order that they might obtain certificates for their participation. The four-hour educational session made use of a PowerPoint presentation that included an illustration video. Participants from the host hospital were released from their shifts until the session ended and then dismissed back to their duty shift, while participants from other hospitals were awarded a day off.

The educational program was introduced over three phases

Baseline phase

Pretest conducted using a 19-item questionnaire with an attached consent form and demographic data sheet. This took 20 minutes to be completed. The questionnaire contained instructions on how to respond to the questions.

Educational phase

The educational session is conducted in the form a of 2.5-hour PowerPoint presentation punctuated by a half-hour break. All questionnaire items were included in the educational material.

Post-intervention phase

Twenty minutes for revision in the form of open discussion, then holding the posttests. This contained the same questions as the pretest but in a different order and took ten minutes to be completed. Finally, brochures containing CDCs' guidelines were distributed as guidance for every participant at the end of the session. Posters were also distributed to be posted in each ICU as a gift after the completion of the whole study.

Data Analysis Plan

The Statistical Package for Social Sciences computer software (SPSS) version 20 was used for coding and analyzing the data. Descriptive and inferential statistical tests were processed to assess and analyze the findings based on the level of measurement that matched the required test. A sequence of data analysis started with descriptive analysis to conduct frequencies, percentages, means, and standard deviations to summarize and describe the characteristics of the participants and subgroups' representativeness. The pretest scores' mean reflects the nurses' knowledge baseline. Comparative differences between pretest and posttest scores' means were detected by applying Paired t-Test to assess the intervention effectiveness. Pearson's (r) correlation coefficients were used to assess the relationships between the nurses' knowledge and the demographic variables. One-way analysis of variance ANOVA (f) was used to compare nurses' knowledge scores' mean with other independent variables. Also, a t-test was used to compare two group means. SPSS was used for statistical analysis at 0.5 moderate effect size and power of 0.80. The level of significance was set at alpha level of 0.05 ($p < .05$). In this study, the total score was 19 points out of 19 questions: one point for each correct answer. Participants who selected a correct choice for a certain item were considered to have knowledge of that item; otherwise, they were considered to have no knowledge of that item. A score of 50%, that is, 9.5, was considered the reference point: a lower score than that was considered to reveal a lack of knowledge, and an equal or higher score was considered to indicate knowledge of VAP prevention.

RESULTS

Description of Participants' Demographic Variables

TABLE 1: Description of Participants' Demographic Variables (N = 156)

Variable	n (%)		Pretest M (SD)	
Sector				
University	20	(12.82)	10.6	(2.0)
Private	62	(39.74)	8.4	(2.3)
Military	20	(12.82)	10.2	(2.9)
Governmental	54	(34.62)	8.1	(2.4)
Age	153		30	(7)
Gender				
Male	63	(40.4)	8.6	(3.0)
Female	93	(59.6)	8.9	(2.2)
Education level				
Diploma	15	(9.6)	8.9	(2.1)
Bachelor	129	(82.7)	8.6	(2.6)
Master	12	(7.7)	10.3	(2.3)
ICU experience			5	(4.8)
ICU area				
General	108	(69.2)	8.99	(2.7)
Cardiac	22	(14.1)	7.8	(2.2)
PICU/ NICU	26	(16.7)	8.9	(1.9)
Previous VAP course				
Yes	124	(79.5)	8.5	(2.5)
No	32	(20.5)	9.97	(2.4)
Written policy				
Yes	62	(39.7)	9.7	(2.4)
No	58	(37.2)	8.3	(2.6)
Don't know	36	(23.1)	8.0	(2.3)
N versus Pt ratio				
1 : 1	19	(12.18)	8.4	(3.1)
1 : 2	58	(37.18)	9.5	(2.6)
1 : 3	50	(32.05)	8.2	(2.2)
1 : > 3	19	(12.18)	8.8	(2.5)
Feel VAP competent				
Yes	48	(30.77)	9.3	(2.9)
Not	60	(38.46)	8.3	(2.6)
Somewhat	48	(30.77)	8.9	(2.1)

Nurses' Knowledge of VAP Prevention

The mean pretest score was 8.79, (SD = 2.5, median = 8) out of the 19 questions, the lowest score achieved was four and the highest was 15 out of 19.

Table 2 shows a summary comparison of numbers of pretest and posttest of correct answers together with the questionnaire, pretest questions were arranged in ascending order from least to the highest number of correctly answered items. According to the pretest, there was a knowledge deficit regarding many VAP-related

topics, including definition, VAP prevention guidelines and strategies, and diagnosis to a lesser extent. Mean pretest and posttest scores were compared to assess the effectiveness of the educational program. This revealed that significantly more questions were answered correctly in the posttest than in the pretest. A significant improvement can be seen in the knowledge of VAP prevention guidelines after the program has been conducted.

TABLE 2 : No. of Correct Answers (N = 156)

Item No.	Question Item	Pretest		Posttest		p
		n	(%)	n	(%)	
14	Frequency with which the humidifiers are replaced	19	(12.1)	112	(71.7)	.109
2	Microorganisms causing VAP	25	(16)	106	(67.9)	.000
16	Frequency with which the aspiration equipment is replaced	32	(20.5)	83	(53.2)	.809
17	Endotracheal tubes with subglottic aspiration	42	(26.9)	126	(80.7)	.000
13	Type of humidifiers	47	(30.1)	134	(85.8)	.000
8	Host-related risk factors for VAP	53	(33.9)	98	(63.4)	.000
18	Kinetic vs standard beds	57	(36.5)	145	(92.9)	.001
7	Treatment-related risk factors for VAP	62	(39.7)	89	(57.0)	.000
12	Frequency with which the ventilator circuits are replaced	65	(41.6)	137	(87.8)	.000
15	Open vs closed aspiration systems	66	(42.3)	95	(60.8)	.000
5	Enteral feeding and VAP	70	(44.8)	110	(70.5)	.000
11	Oral vs nasal route for intubation	75	(48.0)	141	(90.3)	.000
6	Risk factors for VAP development	77	(49.3)	122	(78.2)	.000
4	Supine position and lung capacity	84	(53.8)	121	(77.5)	.000
19	Patient position	101	(64.7)	150	(96.1)	.000
10	Definition of VAP	106	(67.9)	121	(77.5)	.000
9	Matching lung infiltration with culture result for VAP diagnosis	111	(71.1)	139	(89.1)	.000
1	Ventilator best practices guidelines to prevent VAP include; proper hand washing and HOB elevation at (30-45o).	132	(84.6)	147	(94.2)	.000
3	Poor hand washing and VAP	148	(94.8)	149	(95.5)	.475

To answer the second research question, data analysis has shown a mean posttest score of (M = 14.9, SD = 2.7) with a median = 15, where the lowest posttest score was eight and the highest was 19 out of 19. A paired t- Test reported a statistically significant difference between the nurses' knowledge mean pretest and posttest scores (M = -6.109, df = 155, $p < .001$), Table 3.

TABLE 3: Effectiveness of Educational Program (N= 156)

	Mean differences	(SD)	t	Df	P	95% CI	
						L L	U L
Pretest-posttest	-6.109	(2.8)	-26.749	155	0.000*	-6.53	-5.67

Note. SD = standard deviation. df = degree of freedom. CI = confidence interval. *p < .05

Comparison of Knowledge Scores Based on Participants' Characteristics

TABLE 4: Description of Participants' Demographic Variables (N = 156)

Variable	M	
	pretest	posttest
Sector		
University affiliated	10.6	16.6
Private	8.4	14.6
Military	10.2	14.1
Governmental	8.1	16.4
Gender		
Male	8.6	14.7
Female	8.9	15.1
Education level		
Diploma	8.9	13.5
Bachelor	8.6	14.9
Master	10.3	17.0
ICU area		
General	8.99	15.1
Cardiac	7.8	14.9
PICU/ NICU	8.9	13.9
Previous VAP course*		
Yes	9.97	14.8
No	8.5	14.9
Written policy		
Yes	9.7	15.4
No	8.3	14.7
Don't know	8.0	14.5
Nurse versus Pt. ratio		
1:1	8.4	14.0
1:2	9.5	15.3
1:3	8.2	14.4
1: > 3	8.8	15.6
Feel VAP competent		
Yes	9.3	14.9
Not	8.3	14.7
Somewhat	8.9	15.1

Note. * Eight missing sample.

When comparing pretest and posttest mean scores, results shown that the university sector achieved the highest mean followed by military, private, then the government sector who achieved the lowest mean pretest score (M = 10.6, SD = 2.1; M = 10.2, SD = 2.3; M = 8.4, SD = 2.4; M = 8.1, SD = 3.0) respectively. Nurses' posttest mean scores shown the same pretest order; university nurses got the best scores followed by military, private, and finally the governmental participants were respectively as the follow; M = 16.6 (SD = 2.5), M = 16.4 (SD = 2.6), M = 14.6 (SD = 2.9), M = 14.1 (SD = 2.0). One-way ANOVA compared the mean pretest scores within the different participating sectors and the different kinds of ICUs. This analysis showed that there were significant differences in nurses' knowledge of VAP prevention between the different health sectors ($f = 8.34$, $df = 155$, $p < .001$), Table 5.

Posttest scores mean still showing significant differences between sectors regarding nurses' knowledge ($f = 7.33$, $p < .001$). Running post hoc multiple comparisons using Tukey analysis showed that the pretest mean scores for the university sector was significantly higher than that of the private sector ($p = .002$) and the government sector ($p = .001$). While, mean of military sector was also significantly higher than both that of the private ($p = .017$) and government sectors with ($p = .005$). Analysis of sectors posttest mean scores revealed; university sector significantly higher than private ($p = .014$), and government ($p = .001$). While, posttest mean of military sector was also significantly higher than both of private ($p = .042$) and government sectors ($p = .004$). Tukey analysis did not indicate differences between university and military sectors in the pretest and posttest mean scores.

Nurses age mean was 30 (SD = 7). Pearson's correlation coefficients analysis shown that ICU nurses' ages were shown to have a weak but significant effect on their actual knowledge ($r = 0.168$, $p = .037$), while posttest scores were not affected by their ages. The female means pretest score 8.9 (SD = 2.2) was higher than male mean scores 8.4 (SD = 3.0). Female got better posttest scores mean than male; (M = 15.1, SD = 3.0; M = 14.7, SD = 2.5) respectively.

Those with master's degrees had the highest mean pretest score M = 10.3 (SD = 2.3), followed by those with diplomas (M = 8.9, SD = 2.1). Nurses with bachelor's degrees achieved the lowest mean pretest score M = 8.6 (SD = 2.6). In posttest; master holder achieved the highest scores, bachelor, then diplomas holder (M = 17.0, SD = 1.9; M = 14.9, SD = 2.6; M = 13.5, SD = 2.7) respectively. Educational level has not correlated with pretest nurses' mean scores, while it has a significant relationship with the posttest scores mean ($f = 6.18$, $p = .003$). Tukey analysis shown significant knowledge difference between master holders and diploma ($p = .002$) and bachelor ($p = .021$) regarding their posttest mean scores.

Critical care experience means = 5 (SD = 4.8) was shown to have no effect on nurses' pretest mean scores ($r = .131$, $p = .164$), as well as posttest mean scores ($r = .04$, $p = .617$). General ICU nurses gained the highest mean pretest score M = 8.99 (SD = 2.7), while the lowest was achieved by CCU nurses M = 7.8 (SD = 2.2). PICU and NICU nurses' pretest mean score was M = 8.9 (SD = 1.9). Comparing with posttest mean scores; general, CCU, then PICU/ NICU nurses' (M = 15.1, SD = 2.7; M = 14.9, SD = 2.6; M = 13.9, SD = 2.7) respectively. One-way ANOVA did not reveal any significant relationship between nurses' knowledge and pretest-posttest mean scores based on the area of ICU.

Nurses who attended previous VAP session achieved a higher mean pretest score (M = 9.97, SD = 2.4) than those who had not (M = 8.5, SD = 2.5). Posttest mean scores showed a higher score for who not attended previous sessions before than who were attended VAP prevention session before conducting this educational program (M = 14.9, SD = 2.6; M = 14.8, SD = 2.9) respectively. Conduction of t-Test shown significant statistical relationship between nurses' pretest score and attendance of previous VAP session ($t = 2.99$, $p = .003$), posttest scores did not correlate with any significance.

Nurses who have a written policy or protocol at their units got higher pretest mean scores (M = 9.7, SD = 2.4) than who said that there was no policy or protocol (M = 8.3, SD = 2.6), and the

lowest mean pretest score (M = 8.0, SD = 2.3) was achieved by those who were unaware whether or not their hospital had adopted a similar policy. Posttest mean scores regarding having policy, not having policy, and do not know if have policy or not as; (M = 15.4, SD = 2.4; M = 14.7, SD = 2.8; M = 14.5, SD = 2.9) respectively. There was significant relationship between nurses' actual knowledge and the written policy when available (f = 7.78, p = .001). Tukey post hoc multiple comparisons revealed a statistically significant between the nurses whom having policy for VAP prevention on their units and; who answered not having policy (p = .004), who did not know if they have (p = .002). While posttest mean score was not associated with the written policy if available.

Pearson's correlation coefficients analysis shown no relationship between ICU nurses' knowledge and number of beds on their pretest scores (r = .095, p = .270) and posttest (r = .131, p = .124). Even the same test did not revealed relationship between nurses' pretest scores mean and the number of nurses in the unit, but there was a statistically significant relationship based on the posttest mean scores (r = .184, p = .033). Nurses to patient ratio of 1:2 was reported by 58 participants (37.18%), these nurses achieved the best mean pretest score M = 9.5 (SD = 2.6), while 50 nurses (32.05%) worked on a 1:3 ratio, these nurses obtained the lowest mean score (M = 8.2, SD = 2.2). Nineteen nurses (12.18%) worked on a 1:1 ratio (M = 8.4, SD = 3.1), and the same percentage reported working on ratio of more than 1:3 (M = 8.8, SD = 2.5). Posttest descriptive analysis revealed; 1:1 (M = 14.0, SD = 2.6), 1:2(M = 15.3, SD = 2.7), 1:3 (M = 14.4, SD = 2.6), and 1: > 3 (M = 15.6, SD = 2.7).

Participants who reported feeling of competent were achieved higher pretest score mean than "not competent" and "somewhat competent" regarding VAP risk factors and complications (M = 9.3, SD = 2.9; M = 8.3, SD = 2.6; M = 8.9, SD = 2.1) respectively. Posttest mean scores revealed that nurses who answered with somewhat competent got better mean scores than who felt of competent and felt not competent (M = 15.1, SD = 2.2; M = 14.9, SD = 2.9; M = 14.7, SD = 2.9) respectively.

TABLE 5: Relationships between variables and nurses' knowledge (N = 165)

		pretest					posttest		
Variable	r	t	F	P		r	t	F	P
Sector			8.34	0.000*				7.33	0.001*
Age	0.168			0.037*		0.076			0.353
Gender		-0.67		0.504			-0.906		0.366
Educational level			2.46	0.089				6.18	0.003*
ICU experience	0.131			0.164		0.04			0.617
Area of ICU			2.123	0.123				2.039	0.095
Previous VAP course		2.99		0.003*			-0.215		0.830
Written policy			7.87	0.001*				1.5	0.226
Number of beds	0.095			0.270		0.131			0.124
Number of nurses	0.102			0.242		0.184			0.033*
Nurse: patient ratio			2.28	0.083				2.31	0.079
Feel of competent			2.127	0.123				0229	0.796

Note. *p < .05
p < .05

J Popul Ther Clin Pharmacol Vol 30(9):e14–e25; 03 April 2023.

SUMMARY

In general, the participated ICU nurses showed a deficit of knowledge based on pretest mean scores (M = 8.79). Whenever there was a statistical mean difference between nurses' knowledge pretest and posttest scores, it may be affected by the conduction of the educational program. There were relationships between nurses' level of knowledge and health sectors, age of participants, and attendance of previous VAP educational sessions based on pretest scores. Posttest mean scores revealed significant relationships with health sector, education level, and nurses' number at ICU.

DISCUSSION

Educational Program and Nurses' Knowledge

The current study results revealed a knowledge deficit on VAP prevention guidelines among nurses in different types of ICUs representing all Jordanian healthcare sectors across the country. Nurses' knowledge deficit was supported when nurses got low pretest knowledge scores, and the achieved outcome scores were in general low.

In Jordan, nurses' knowledge deficit may be caused by leakage of VAP prevention sessions and the need to be updated regarding CDC guidelines, and that's highlighted the need to prevent VAP through conducting frequent educational programs [10].

The educational program was successful in increasing the participated critical care nurses' knowledge since there was a statistically significant difference between nurses' pretest and posttest knowledge mean scores. After the educational session, nurses were more knowledgeable about VAP and its preventive recommendations as they got significantly higher knowledge scores than before introducing the program.

In general, several areas of knowledge deficit in VAP prevention were identified including diagnosis and definition as well as updated VAP prevention practices. There was a clear lack of knowledge on humidifiers; nurses did not recognize that heated humidifiers and heat and moisture exchangers must be combined, connected to the ventilator and changed weekly. Furthermore, participants showed poor knowledge related to the suction system; most ICU nurses did not know that closed suction is recommended or that aspiration equipment should be replaced for every new patient, if there is no clinical indication to remove it.

Other areas require development and further care is taken over them; the deficit in nurses' ability to differentiate between the major causative microorganisms responsible for early- and late-onset of VAP, and a need for them to be informed about VAP risk factors as well as enteral feeding policies.

Critical care nurses who participated in this study may still commitment to the old recommendations that have been updated many years ago, which make patients vulnerable to a high risk of VAP incidence and increases the possibility of harmful complications. Worldwide, as CDC recommended considering educating ICU healthcare workers as one of the evidence-based guidelines for VAP prevention, this study touches the need to focus on educating ICU nurses as the milestone in preventing VAP [11].

Participants' Demographic Characteristics

The ICU nurses' level of knowledge was statistically differing regarding the healthcare facility sector. Although pretest score mean was low and indicated nurses' knowledge deficit regarding VAP prevention at the level of all participating healthcare sectors, university and military participated nurses achieved significantly better scores than nurses who represented private and government sectors. This result could be related to the availability of VAP policy forms at some of university or military ICU units, as well as some of their nurses who had attended previous sessions about VAP.

Age of participants have significantly associated with ICU nurses' actual level of knowledge on VAP prevention but not affected the posttest knowledge scores. Maybe the nurses who are old ages have attended previous VAP educational sessions.

Neither the gender of participants nor their educational level was shown to be associated

with an effect on ICU nurses' level of knowledge. Participants' critical care experience was not shown to affect their knowledge level, and that is congruent with a previous study [12] that mentioned; ICU experience did not enhance nurses to get better knowledge scores than those who have less experience or who have no experience at all. On the other side, critical care experience plays a key role in enriching ICU nurses' knowledge of VAP prevention [13].

This study reported that nurses' levels of education and their critical care experience had not associated with their basic knowledge; there is a need to keep nurses' knowledge continually updated with the most recent evidence-based guidelines to ensure patient safety and enhance the quality of care and patient outcomes.

Results revealed a significant statistical mean difference between nurses who attended previous VAP educational sessions and others who had not attended any previous sessions; the participants who had attended previous educational sessions on VAP were more knowledgeable than others. while it is recommended that attendance of continuous VAP educational programs was associated with better nurses' level of knowledge scores regarding VAP prevention guidelines than those who had not participated in such sessions before [14]. Whenever the lack of VAP prevention programs adversely affects nurses' levels of knowledge, it could be helpful to conduct frequent VAP prevention educational programs around the country representing all health sector facilities.

Areas of critical care unit; general ICU, CCU, and PICU/NICU did not show a relationship with nurses' knowledge regarding VAP prevention. Even general ICU nurses have the best mean pretest scores but that was not associated with significant differences with the nurses from the other ICU areas. While number of nurses and number of patients at the critical care unit were not correlated with nurses' basic level of knowledge, there was statistical significance between nurses' posttest mean scores and their number at the critical care unit. Nurses who have policies in their units were more knowledgeable than others who have not. The presence of policies and protocols may make ICU nurses more aware of VAP monitoring and prevention guidelines, that's why ICUs may need to adopt such policies to keep the nurses well-informed and educated about VAP and its prevention.

Nurses' feeling of competency in VAP practices was not associated with their level of knowledge, maybe their feeling of competency was based on their previous attendance of VAP educational sessions, or they have VAP prevention policies at their ICUs.

Limitations of the Study

This study covered all sectors in different sites, but the quality of care may vary from one institution to another; therefore, there is a need to involve more hospitals within the same region and the same sector, to avoid unfair generalized findings. Many nurses took longer than they were supposed to complete the questionnaire. The hospitals were selected conveniently which limits the generalizability of findings, as well as selection bias could occur as the more interested or the more skilled nurses may be more likely to participate.

CONCLUSION

This study revealed an ICU nurses' knowledge deficit regarding VAP prevention guidelines, and that an educational program was effective at increasing their knowledge. Nurses' levels of knowledge were associated with their healthcare sector, age, attendance of a previous educational session on VAP, and presence of VAP policy; but neither their educational level, length of experience, area of work, nor their feelings of competency on VAP were not shown to influence their knowledge.

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