Prevention of ventilator-associated pneumonia

A knowledge survey among intensive care nurses in Yemen

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ABSTRACT

الأهداف: تقييم معارف كوادر التمريض العاملين في وحدات العناية المركزة اليمنية حول الاستراتيجيات المبنية على الأدلة لمنع الالتهاب الرئوي المصاحب للتنفس الصناعي و تحديد ما إذا كان هناك أي ارتباط بين المعارف و خصائص المشاركين أو أماكن العمل.

الطريقة: أجريت دراسة وصفية مسحية مقطعية في جميع وحدات العناية المركزة لمستشفيات مدينة صنعاء)37 وحدة في 23 مستشفى(. تم توزع استبيان ذاتي متعدد الخيارات يحتوي على 15 استراتيجية وقائية قائمة على الأدلة لجميع كوادر التمريض بين 23 ديسمبر 2012م و 15 فبراير 2013م. تم تحليل النتائج وتبويبها باستخدام الحزمة الإحصائية للعلوم الاجتماعية، الإصدار 17.

النتائج: تم جمع 387 استبيان)بمعدل استجابة 75.4%(. وكان اغلب إجابات المشاركون صحيحة)60%<(عن العناية الشاملة المنتظمة بالفم، حفظ المريض في وضعية شبه راقد، منع النزع غير المخطط لأنبوب القصبة لهوائية، تفريغ التكثفات من أنابيب التنفس الصناعي، الوقف اليومي للتخدير وتقييم الاستعداد للفطام، أنابيب القصبة الهوائية المزودة بتجويف إضافي لشفط الإفرازات تحت المزمار. وكانت اقل معارف المشاركين)24%<(عن معدل تغيير المرطب و نظام التشفيط، استخدام الأسرة الحركية، و طريقة التنبيب الرغامي. المتوسط الإجمالي لدرجة معرفة كوادر التمريض كان 47.3%)7.1 من 15 درجة(. امتلاك درجة البكالوريوس في التمريض و الحصول على دورة قصيرة في الرعاية التنفسية كانت مصحوبة بمستوى معلومات افضل.

خاتمة: المعارف عن الاستراتيجيات المبنية على الأدلة لمنع التهاب الرئوي المصاحب للتنفس الصناعي كانت متدنية بين أغلبية كوادر التمريض العاملين في وحدات العناية المركزة اليمنية.

Objectives: To evaluate knowledge of nurses working in Yemen intensive care units (ICUs) on evidence-based strategies for preventing ventilator-associated pneumonia (VAP), and to determine if there is any association between certain nurses' as well as workplaces' characteristics and the knowledge scores of nurses.

Methods: A descriptive cross-sectional survey was carried out in 37 ICUs of 23 hospitals in Sana'a city, Yemen. A self-administered multiple-choice questionnaire listing 15 evidence-based preventive strategies was distributed to all nurses and collected between December 2012 and February 2013. The results were analyzed and tabulated using the Statistical Package for Social Sciences Version 17.

Results: Three hundred and eighty-seven questionnaires were collected (response rate 75.4%). The nurses were most frequently correct (>60%) regarding regular oral care, semi-recumbent position, preventing unplanned extubation, emptying of condensate from ventilator tubing, daily sedation interruption and assessment of readiness for weaning, and endotracheal tubes with extra lumen for subglottic secretions drainage. Nurses had the least knowledge (<24%) regarding frequency of humidifier and suction systems changes, use of kinetic beds, and oral route for tracheal intubation. The nurses' knowledge mean total score was 47.3% (7.1 on 15 items). Holding a bachelor degree in nursing and acquisition of a short course in respiratory therapy were shown to be associated with better knowledge scores.

Conclusions: Knowledge of evidence-based strategies for preventing VAP is low among most nurses working in Yemen ICUs.

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The use of artificial airway and mechanical ventilation (MV) is essential and common life-saving measure in the intensive care unit (ICU) because 76% of ICU patients require ventilatory support. However, MV carries many risks and complications, the most common one being ventilator associated pneumonia (VAP).[1] Ventilator associated pneumonia is defined as a lung parenchymal infection occurring in a patient who has been assisted by invasive MV within the past 48 hours.[2] Ventilator associated pneumonia is an important safety issue, and the most common nosocomial infection in critically ill patients and mechanically ventilated patients.[3,4] It accounts for 27-47% of all ICU-acquired infections,[5] 86% of all nosocomial pneumonias in patients receiving MV,[6] and complicates the course of 9-67% of patients intubated.[3] The VAP incidence rate varies from 3.6 to 73.4 per 1000 ventilator-days, with a mortality rate from 16% to as high as 94% in some specific settings, and when VAP is caused by antibiotic resistant pathogens.[7,8] Ventilator associated pneumonia extends time spent on the ventilator, prolongs ICU and hospital stays, and increases antibiotic consumption, as well as results in additional costs of $40,000-$57,000 per VAP case.[1,9] However, VAP is a preventable complication and many evidence-based guidelines (EBGs) aimed at reducing VAP have been available for many years. There is no single method to prevent VAP, EBGs incorporate dozens of clear evidence-based strategies for preventing VAP.[9,10] Although the prevention of VAP is a multidisciplinary issue, the role of intensive care nurses is essential and should not be underestimated.[2,10] It is thought that quality nursing care based on the etiology and pathophysiology of VAP is an efficient way of preventing VAP.[3] Many nonpharmacological evidence-based strategies aimed at preventing VAP can be seen as part of basic and routine nursing care, direct responsibility of the bedside intensive care nurse, and can easily be instituted at minimal costs; and neglecting any of these could put the patient at risk for infection.[6,10,11] Nevertheless nurses need to have an awareness of the problem as well as evidence-based preventive strategies so as to adhere to such practices and integrate them into their nursing care.[3,12] Nurses' knowledge would facilitate optimal delivery of patient care,[10] bring confidence to make appropriate decisions, and prevent poor outcomes in the recovery of mechanically ventilated patients.[12] However, several recent surveys reported that there is a substantial lack of knowledge among intensive care nurses concerning evidence-based strategies for preventing VAP.[2,3,6,11,12] There is a lack of study on the knowledge of nurses on evidence-based strategies for preventing VAP in Yemen ICUs. The aim of this study was, therefore, to evaluate the knowledge of nurses working in ICUs of Yemen hospitals on evidence-based strategies for the prevention of VAP, and to determine if there is any association between certain nurses' as well as workplaces' characteristics and the knowledge scores of nurses.

Methods. A descriptive cross-sectional survey was carried out to evaluate the knowledge of nurses working in all ICUs in Sana'a city, capital of Yemen. All nurses working in ICUs that provide MV support were included in this study regardless of their qualification, experiences, and nationality. Nurses working in ICUs that do not provide MV for critically ill patients were excluded. The survey was carried out using a self-administered questionnaire, which consisted of 26 items divided into 2 parts. The first part consisted of 11 items directed at the respondents' and workplaces' characteristics: gender, age, nationality, level of nursing education, years of professional and ICU nursing experience, ICU qualifications, having a short course in respiratory therapy, type of ICU and hospital, and university affiliation of the hospital (**Tables 1 & 2**). The second part of the questionnaire consisted of 15 items, in the form of multiple-choice questions (MCQs), directed at respondents' knowledge on VAP-prevention strategies (**Table 3**). The first 9 items of the 15 items were adapted from a previous validated and reliable MCQ questionnaire[13] that has been used previously in several studies to evaluate nurse's knowledge on VAP prevention. The original questionnaire[13] was about 9 nursing-related non-pharmacologic strategies selected from the EBGs developed in 2004 by the Canadian Critical Care Trials Group and the Canadian Critical Care Society.[13] Minor modifications were carried out in heads and response alternatives of some of these 9 MCQs. The remaining 6 items (item 10 through 15, **Table 3**) were nursing-relevant VAP-prevention strategies identified, selected, and added to the questionnaire based on more recent published evidence-based systematic reviews,[1,5,9,10,14] VAP bundles,[8,15,16] and up to date comprehensive EBGs.[17-20] The 15 items were listed (and translated to Arabic language) in the form of MCQs with 4 response alternatives; one correct answer, 2 distractors that are not the correct answer, and the phrase "I do not know" to avoid participant's taking a chance or guessing.

The validity and reliability of the English and Arabic version of the questionnaires were reviewed by 5 experts: 4 senior ICU nurses with bachelor's degree (2 had a short course on respiratory therapy), and a specialist

nursing educator from nursing college. The experts were individually asked if the questionnaire addresses what it meant to address, if all questions were relevant to nursing, clearly worded, well explained, and would not be misinterpreted. The remarks of the experts were considered in revising the questionnaire. The revised questionnaire was then distributed to a pilot group of 12 nurses in 2 ICUs from public and private hospitals to evaluate the difficulty, readability, and time needed to complete. Some modifications in wording were made to increase the clarity of questions.

The Research and Ethical Committee of the Faculty of Medicine and Health Sciences, Sana'a University approved the study, and an ethical clearance was issued. Permission was requested from the hospitals' management and unit managers where the study was conducted. The contextual framework of the study was explained before asking the participants to complete the questionnaire. Participation in the survey was voluntary, and the completion of the questionnaire was assumed to imply consent. Confidentiality of participants (individuals) and participating hospitals was maintained. During the period from December 2012 to February 2013, a 2-page questionnaire was distributed to all nurses in the studied ICUs at the beginning of each working shift. Completed questionnaires were collected at the end of each shift and entered into a personal computer.

Descriptive statistics including frequencies and percentages were used to describe demographics and correct answers for each item of the questionnaire. One point was given for each correct answer. The number of correct answers was divided by the total possible and multiplied by 100 to obtain the proportion of correct answers. Thus, total score for each participant ranged between zero and 15 points (or between zero and 100%). Continuous variables were described as means ± standard deviation (±SD), medians, and interquartile ranges (IQR). Independent-samples t-test, F test, and linear regression analysis were used to determine whether knowledge score was associated with participants' or workplace characteristics. The Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, USA) software version 17.0 for Windows was used for statistical analysis. Statistical significance was set at $p < 0.05$ and 95% confidence intervals.

Results. The questionnaire was distributed to 513 nurses working in 37 ICUs of 23 hospitals (5 teaching and 18 non-teaching) in Sana'a city, Yemen: 14 units in 4 public hospitals, 2 units in 2 military, 4 units in 2 police, and 17 units in 15 private hospitals. Three

hundred and eighty-seven nurses completed and returned the questionnaire (75.4% of the original sample). As demonstrated in **Table 1**, most respondents were Yemeni (69.5%), females (59.2%), aged between 25 and 29 years, and had a 2 or 3 years diploma degree in nursing after secondary school. All respondents stated that they did not have any qualifications in ICU nursing, whereas only 9.8% of them had a short course (for 3-4 months) on respiratory therapy care. While 4.39% of respondents had been working as nurses for ≤1 year and 31.78% had been working as nurses for >5 years, 16.8% of respondents had been working in ICUs for ≤1 year, and 13.7% had been working in ICUs for >5 years. The mean total professional and ICU experiences were 5.2±2.9 and 3.6±2.6 years. Most respondents worked in teaching hospitals and public hospitals, and more than one third worked in general ICUs (**Table 2**).

Table 1 - The population's characteristics.

Characteristic	Respondents (N=387)	
	N	(%)
Total sample	387	100
*Gender**		
Female	229	59.2
Male	155	40.1
Age†		
20-24 years	78	20.2
25-29 years	212	54.8
≥30 years	91	23.5
Nationality		
Yemeni	269	69.5
Non-Yemeni	118	30.5
Highest nursing educational level‡		
Diploma (2 or 3 years) after preparatory school	38	9.8
Diploma (2 or 3 years) after secondary school	253	65.4
Bachelor's degree or higher	91	23.5
Acquisition of short course in respiratory therapy§		
No	335	86.6
Yes	38	9.8
*Total nursing experience (years)**		
≤1	17	4.39
>1-3	88	22.7
>3-5	99	25.58
>5	123	31.78
ICU nursing experience (years)††		
≤1	65	16.8
>1-3	115	29.7
>3-5	72	18.6
>5	53	13.7

Numbers (percentages) may not always add up to 387 (100%) due to missing values. ICU- intensive care units, *3 (0.8%) missing values, †6 (1.6%) missing values, ‡5 (1.3%) missing values, §14 (3.6% missing values, **60 (15.5%) missing values, ††82 (21.2%) missing values

Table 2 - The workplaces' characteristics.

Characteristic	Respondents (N=387)	
	n	(%)
Type of ICU		
General ICUs (n=18)	140	(36.2)
Medical ICUs (n=3)	45	(11.6)
Post-cardiac surgery ICUs (n=3)	43	(11.1)
Surgical ICUs (n=3)	40	(10.3)
Neurological ICUs (medical + surgical) (n=3)	37	(9.6)
Pediatric ICUs (n=3)	35	(9.0)
Emergency ICUs (n=1)	19	(4.9)
Nephrology ICUs (n=1)	19	(4.9)
Coronary care units (CCUs) (n=2)	9	(2.3)
Type of hospital		
Public (n=4)	207	(53.5)
Private (n=15)	125	(32.3)
Military and police (n=4)	55	(14.2)
University affiliation of the hospital		
Teaching hospitals (n=5)	224	(57.9)
Non-teaching hospitals (n=18)	163	(42.1)
ICU - intensive care units, CCUs - coronary care units		

As indicated in **Table 3**, most nurses knew that it is recommended to keep patients in the semi-recumbent position and to use ETTs with extra lumen for drainage of subglottic secretions. Similarly, most nurses knew that regular comprehensive oral care, preventing unplanned extubation, regular emptying of ventilator tubing condensate, and daily sedation interruption and assessment of readiness for weaning and extubation reduce the risk of VAP. However, only the minority of nurses identified the heat and moisture exchanger (HME) humidifier, closed-suction system, and oral route for intubation, as the recommended strategies. The recommended frequencies of ventilator circuit, suction system, and HME humidifier changes were known by minority of nurses. Thirty-one percent knew that maintaining the tracheal cuff pressure between 20-30 cmH$_2$O is recommended. Similarly, the benefit of non-invasive mechanical ventilation (NIMV) and

Table 3 - Respondents' correct answers for each of the 15 items questionnaire.

Items (questions) and correct answers	n[*] (%[†])
Oral versus nasal route for endotracheal intubation	
Oral intubation is recommended	92 (23.8)
Frequency of ventilator circuits changes	
It is recommended to change circuits for every new patient (or when clinically indicated)	186 (48.1)
Type of airway humidifier	
Heat and moisture exchangers are recommended	162 (41.9)
Frequency of humidifier changes	
It is recommended to change humidifiers every week (or when clinically indicated)	46 (11.9)
Open versus closed-circuit suction systems	
Closed-circuit suction systems are recommended	127 (32.8)
Frequency of closed-circuit suction systems changes	
It is recommended to change systems for every new patient (or when clinically indicated)	87 (22.5)
Type of endotracheal tubes	
ETTs with extra lumen for drainage of subglottic secretions are recommended	233 (60.2)
Kinetic versus standard beds	
Kinetic beds decrease the risk of VAP	80 (20.7)
Patient positioning in bed	
Semi-recumbent positioning (head of bed elevated 30°-45°) is recommended	313 (80.9)
The endotracheal cuff pressure	
It is recommended to be maintained between 20 and 30 cm H$_2$O	120 (31.0)
Non-invasive mechanical ventilation	
NIMV decreases the risk of VAP	155 (40.1)
Daily sedation interruption and assessment of readiness for weaning	
Decrease the risk of VAP	243 (62.8)
Regular emptying of condensate from the ventilator tubing	
Decreases the risk for VAP	282 (72.9)
Prevention of unplanned extubation and subsequent re-intubation	
Decrease the risk of VAP	300 (77.5)
Regular comprehensive oral care (by tooth brushing and rinsing with antiseptic agent)	
Decrease the risk of VAP	321 (82.9)
Total mean number (n) of correct answers ±SD	183.1±92.9
Total mean percentage (%) of correct answers ±SD	47.32±24%
[*]The number (frequency) of the correct answer, [†]The percentage of the correct answer with respect to the total possible number of answers for each item (N=387). ETTs - endotracheal tubes, VAP - ventilator associated pneumonia, cm H$_2$O - centimeter water, NIMV - non-invasive mechanical ventilation	

kinetic beds in reducing the risk of VAP was known by minority of nurses. The most commonly known strategy was regular comprehensive oral care (item 15). The least known strategy was the frequency of humidifier changes (item 4). The nurses' knowledge scores ranged between 13.3% and 80% with a total mean score of 47.32±13.6% (7.1±2.03 on 15 items). According to the grading system of the B.Sc. nursing program, 14 nurses (3.7%) scored between 70-80% (good), 88 nurses (23%) scored between 60-69% (acceptable), and 284 nurses (73.37%) scored between 13.3-59% (poor).

Nurses holding bachelor's degrees or higher had significantly better scores than nurses holding diploma degrees after secondary or primary school (50.5±12.8% versus 46.5±13.5% and 42.98±13.8%; *p*=0.007). Nurses who attended a short course in respiratory therapy had a better score than nurses who did not attend the course (54.2±12.6% versus 46.5%, *p*=0.057). No other nurses'

Table 4 - Scores on 15 items according to population's and workplaces' characteristics.

Characteristic	Knowledge Score[*]			Test
	Score from 15 Mean±SD	Score from 100 Mean±SD	Median (IQR)	*p*-value
Total sample	7.10 ± 2.03	47.3 ± 13.6	7 (6-9)	
Gender				
Female	7.06 ± 2.03	47.1 ± 13.6	7 (6-9)	t = 0.319
Male	7.13 ± 2.05	47.5 ± 13.7	7 (6-9)	*p*=0.750
Age (years)				
20-24	6.91 ± 1.96	46.07 ± 13.0	7 (5-8)	F= 0.890
25-29	7.07 ± 2.05	47.1 ± 13.7	7(6-9)	*p*=0.411
≥30	7.32 ± 2.06	48.79 ± 13.8	7 (6-9)	
Nationality				
Yemeni	7.02 ± 1.95	46.8 ± 13.0	7 (6-8)	t = -1.051
Non-Yemeni	7.27 ± 2.22	48.5 ± 14.8	7 (6-9)	*p*=0.295
Highest level of nursing education				
Diploma after preparatory school	6.45 ± 2.07	42.98 ± 13.8	6 (5-8)	F = 5.035
Diploma after secondary school	6.98 ± 2.03	46.55 ± 13.5	7 (5-8)	*p*=0.007 [†]
Bachelor degree or higher	7.58 ± 1.91	54.5 ± 12.6	7 (6-9)	(III#I,II) [‡]
Acquisition of short course in respiratory therapy				
No	6.98 ± 2.03	46.5 ± 13.5	7 (6-8)	t = 3.533
Yes	8.13 ± 1.89	50.5 ± 12.8	8 (6-10)	*p*=0.001 [†]
Total nursing experience (year)				
≤1	7.71 ± 1.9	51.37 ± 12.6	8 (6-9)	F = 0.634
>1-3	7.1 ± 1.85	47.34 ± 12.29	7 (6-8)	*p*=0.594
>3-5	6.97 ± 2.1	46.46 ± 14.01	7 (5-9)	
>5	7.09 ± 2.13	47.26 ± 14.20	7 (6-9)	
ICU experience (years)				
≤1	6.92 ± 1.77	46.15 ± 11.8	7 (6-8)	F=0.738
>1-3	6.94 ± 2.2	46.26 ± 14.7	7 (5-9)	*p*=0.530
>3-5	7.18 ± 1.97	47.87 ± 13.1	7 (6-8)	
>5	7.38 ± 2.1	49.18 ± 13.97	7 (6-9)	
Type of ICU				
General ICUs	6.83 ± 1.87	45.5 ± 12.5	7 (5-8)	F = 1.482
Medical ICUs	7.38 ± 1.96	49.2 ± 13	7 (6-9)	*p*=0.162
Post-cardiac surgery ICUs	7.09 ± 1.73	47.3 ± 11.5	7 (6-8)	
Surgical ICUs	7.90 ± 2.07	52.7 ± 13.8	8 (6-10)	
Neurological ICUs (medical + surgical)	6.92 ± 2.28	46.1 ± 15.2	7 (5.5-9)	
Pediatric ICUs	7.40 ± 2.28	49.3 ± 15.2	8 (6-9)	
Emergency ICUs	6.84 ± 1.89	45.6 ± 12.6	6 (5-9)	
Nephrology ICUs	6.68 ± 2.47	44. 6 ± 16.5	8 (5-9)	
Coronary care units (CCUs)	7.33 ± 2.92	48.9 ± 19.4	8 (4-10)	
Type of hospital				
Public	6.98 ± 2.15	46.5 ± 14.4	7 (5-9)	F = 2.164
Private	7.06 ± 1.79	47.09 ± 11.9	7 (6-8)	*p*=0.116
Military and police	7.62 ± 2.08	50.8 ± 13.8	7 (6-9)	
University affiliation of the hospital				
Teaching hospitals	7.02 ± 2.09	46.8 ± 13.9	7 (6-9)	t = - 0.917
Non-teaching hospitals	7.21 ± 1.97	48.1 ± 13.1	7 (6-9)	*p*=0.360

[*]On a total of 15 items (one point per item), [†]*p*-value indicates significant difference between the subgroups, [‡]Scheffee test show significant difference between the nurse holding bachelor degree or higher from one side, and the nurses holding diploma after preparatory school and nurse holding diploma after secondary school from the other side, IQR - interquartile range, ICUs - intensive care units, CCUs - coronary care units.

demographics or workplaces' characteristics significantly affected the knowledge score of nurses (**Table** 4).

The linear regression analysis (R^2=0.06) revealed that holding a bachelor's degree in nursing and acquisition of a short course in respiratory therapy were shown to be associated with better knowledge scores (*p*<0.009 and *p*<0.028). Other nurses' and workplaces' characteristics were excluded by the linear regression analysis model.

Discussion. The findings of this study highlight that nurses working in Yemen ICUs had a significantly low level of knowledge regarding evidence-based strategies for preventing VAP. The addition of 6 new items to the questionnaire used in this study, 4 of them answered correctly by most nurses, elevate the knowledge total mean score obtained in this study to 47.3% and make it comparable with other studies that reported total mean scores from 37.3-48%.[2,11,12,21-23] The knowledge mean score on the first 9 items of the questionnaire was 38.1% (3.4 on 9 questions), which is lower than mean scores reported in other previous studies that used the same 9 items questionnaire: 41.2% in Belgium,[22] 44.4% in Turkey,[3] 45.1% in 22 European countries,[23] 45.2% in South Africa,[12] 46.6% in South European countries,[11] 53.1% in Korea,[24] 59.9% in Finland,[25] and 78.1% in Lebanon.[26]

The low knowledge scores obtained in this study reflect the fact that most nurses (>75%) are only diploma holders. In Yemen, the curriculum of diploma degree after secondary school gives only 48 credit hours of teaching (theory and clinical) in critical care nursing areas. As suggested elsewhere,[27] diploma nurses are not prepared or knowledgeable enough to provide evidence based or specialty care. Alongside this, the current study found that the level of nursing education is a strong influence on knowledge level. As nurses' education level increased, their level of knowledge also increased. This result is in accordance with the results of other studies in which the same 9 item questionnaire was used.[3,11,23,25] Furthermore, the low knowledge scores reflect the fact that no nurse has a special degree in ICU nursing, and Yemen ICUs are staffed with general trained nurses. The acquisition of a specialized ICU qualification was associated with a significantly better knowledge score.[22,24] As mentioned in other studies,[2,23,25] the absence of consistent policies and procedures and the absence of established in-service training programs in the most hospitals in Yemen are other important explanations for this knowledge deficiency.

Other factors may contribute to the high scores obtained in the other studies, such as the different data collection tools (that comprise of different number of items and sometimes not only limited to VAP prevention strategies),[4,21,28] different ICU health care delivery models that include respiratory therapists,[26] and the relatively small number of participants and/or the limited setting of those studies (namely, single ICU or single major tertiary hospital).[3,4,12,25,26,28] It is thought that with an increase in numbers of participating nurses and institutions, the total score obtained might change in a positive or negative direction.[3]

A short course in respiratory therapy care was provided by some Yemen hospitals, and the acquisition of this course was associated with better knowledge scores. However, the number of nurses who had taken a course on respiratory therapy was <10% of the entire sample, and thus, the result should be interpreted with caution. In contrast to this finding, another study found no differences in knowledge among nurses and respiratory therapists working in the ICU.[28]

Contrary to previous studies,[3,4,11,22-25] we found that seniority does not indicate better knowledge score. This difference is thought to stem from the fact that most nurses in this country acquire their knowledge of taking care of critically ill patients from their basic education or from hospital policies and procedures, and no more knowledge can be gained during the years of ICU experience due to the lack of in-service training provided to nurses.[2,21,27] At the same time, only 13.7% of participants had >5 years ICU experience; thus, the results should be interpreted with caution. Moreover, it is felt that the nurses' relatively limited ICUs experience and young age could contribute to the low score obtained in this study.

In this study, strategies related to oral care, patient positioning in bed, prevention of unplanned extubation, and emptying of condensate from the ventilator tubing were known by the majority of nurses. This high level of correct answers may be related to the routine practices[3] and to the fact that these strategies are usually taught in basic nursing education, considered a nursing responsibility, and directly under the control of nurses.[13,29] This finding is congruent with the results of other studies in which the patient positioning in bed,[4,11,22-26,28] and the regular oral care[25] were the most well-known strategies.

However, most nurses had a significantly low level of knowledge regarding some very important strategies, like the recommended route for tracheal intubation, frequency of ventilator circuit changes, type of humidification and suction systems, frequency of humidification and suction systems changes, endotracheal cuff pressure, and type of MV (invasive versus noninvasive). These results are generally

attributed to many reasons: absence of unit policies, those strategies are not usually addressed in basic education and are usually acquired from unit policies or in-service education, not directly under control of nurses, and usually involve collaboration with physicians and respiratory therapists or performed by respiratory therapists/technicians.[3,13,29] These findings are supported by other previous studies that revealed that only the minority of nurses knew the recommended route for tracheal intubation (18.7%),[22] frequency of ventilator circuit changes (2.8-48.6%),[4,11,12,22-24] type of suction systems (16.9-46.6%),[11,22,23] frequency of suction system changes (4.6-26.7%), type of humidification system (19.28-48.5%),[3,11,12,23-25] frequency of humidifier changes (5.0-37.2%),[3,11,12,22-26] and endotracheal cuff pressures.[29]

In 5 items (questions 1, 5, 8, 4, 6), nurses were convinced that interventions without evidence-based preventive value are preferred over the evidence-based interventions with preventive value. In this study, as in another study,[22] nurses more often thought both oral and nasal routes for intubation were the best methods, when the oral route is the recommended. The present study findings are consistent with other studies in which nurses conversely thought both open and closed systems are recommended, while the closed-suction system is the recommended.[11,22,23] In opposition to the findings of other studies,[3,11,12,22-26] in this study most nurses believed that kinetic beds increase or do not influence the risk of VAP, when kinetic beds decrease the risk for VAP. In this study, as in other studies,[3,11-13,22-26] nurses chose changing HME humidifier and closed-suction system too often (every 48 and 24 hours), when a change every week and for every new patient, are recommended. Furthermore, in this study 26.9% of nurses indicated to change ventilator circuits every 48 hours. This suggests that in daily practice HME humidifiers, closed-suction systems, and ventilator circuits are changed too frequently. The possible explanation for these findings might be the absence of policies, and the influence of manufacturers' recommendations to change these devices too often.[26]

Approximately 19% of nurses reported not to know the answer to items related to the frequency of closed-suction system changes, 20% reported not to know the benefit effects of kinetic beds, and 21% reported not to know the benefits of ETT with extra lumen in reducing VAP incidence. These findings are similar to what was noted in other studies,[11,12,22-25] and reflect that those strategies are not available locally and seldom used in Yemen ICUs and nurses may simply not be aware or familiar with these strategies. These strategies (especially kinetic beds) are not readily available because of their cost, feasibility, and safety.[8,12]

The current study has some limitations. First, some respondents partially failed to complete the questionnaire, such as 21.2% of respondents did not record their ICU experience. Second, the study setting was limited to ICUs in Sana'a city, the capital of Yemen. Nevertheless, we believe that the size of sample and the amount of participating ICUs cover >50% of potential respondents and ICUs in which the MV is applied in Yemen. Furthermore, the higher response rate would be able to more accurately reflect the knowledge level of nurses who work in Yemen ICUs. Third, knowledge of recommended strategies does not necessarily reflect appropriate practice.[13,21,26] Thus, evaluation of what is actually practiced at the bedside for VAP prevention is the next logical step for future study.

In conclusion, knowledge of evidence-based strategies for preventing VAP is low among the majority of nurses working in Yemen ICUs (73.4% of nurses scored <60%). This low score reflects the fact that Yemen ICUs are staffed with general trained, diploma holder nurses, the lack of in-service training, and the absence of consistent policies in ICUs. Holding a bachelor degree in nursing and acquisition of a short course in respiratory therapy was shown to be associated with better knowledge scores. These results stress the need of hospitals to organize and implement in-service educational programs for infection prevention in general, and for VAP prevention in particular, for all staff involved in the care of the mechanically ventilated patients. The ICUs should develop and review their policies and procedures (if they have) to include the current EBGs for VAP prevention. For nursing schools and colleges, the curriculum of the basic nursing programs should be modified to include the most recent EBGs for VAP prevention.

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