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Abstract

Objective

To explore Australian intensive care nurses' knowledge of ventilator-associated pneumonia and self-reported adherence to evidence-based guidelines for the prevention of ventilator-associated events.

Design

A quantitative cross-sectional online survey was used.

Setting

The study was conducted in two Australia intensive care units, in large health services in Victoria and an Australia-wide nurses' professional association (Australian College of Critical Care Nurses).

Main outcome measures

Participants' knowledge and self-reported adherence to evidence-based guidelines.

Results

The median knowledge score was 6/10 (IQR: 5–7). There was a significant positive association between completion of post graduate qualification and their overall knowledge score $p = 0.014$). However, there was no association ($p = 0.674$) between participants' years of experience in intensive care nursing and their overall score. The median self-reported adherence was 8/10 (IQR: 6–8). The most adhered to procedures were performing oral care on mechanically ventilated patients ($n = 259$, 90.9%) and semi-fowlers positioning of the patient ($n = 241$, 84.6%). There was no relationship between participants' knowledge and adherence to evidence-based guidelines ($p = 0.144$).

Conclusion

Participants lack knowledge of evidence-based guidelines for the prevention of ventilator-associated pneumonia. Specific education on ventilator-associated events may improve awareness and guideline adherence.

Implications for Clinical Practice

- The findings could be used to inform practice and promote discussion on best practices to prevent ventilator-associated pneumonia.
- There is conflicting evidence on the prevention of ventilator-associated pneumonia.
- Education on preventative measures is important as knowledge could improve adherence in practice.

- Future research is needed to investigate other factors which influence the nurses' knowledge and adherence to evidence-based practice to prevent ventilator-associated events.

INTRODUCTION

Ventilator-associated events (VAE) are serious healthcare acquired complications of mechanical ventilation, which can prolong the mechanical ventilation period, increase intensive care and hospital length of stay, increase healthcare costs, increase use of antimicrobials and increase mortality risk in the intensive care unit (ICU) (Klompas, 2019; Klompas et al., 2014a). VAE incidence varies according to type of ICU ranging from 5.8 to 16.0 events per 1,000 mechanical ventilation days with lower incidence in cardiac and medical units and higher in trauma, surgery and neuroscience units (Klompas et al., 2014a). An overall hospital mortality rate of 31 to 35 percent was reported to CDC in 2014 Magill et al., (2016), and is reported as higher in older people (>65years) than those in middle aged groups (Blot et al., 2014).

VAE is an umbrella term referring to a group of conditions, which result in a significant and sustained deterioration in oxygenation (Centres for Disease Control and Prevention, 2018). These conditions include infectious conditions such as Ventilator Associated Pneumonia (VAP), sepsis, and non-infectious conditions such as barotrauma, pulmonary oedema, pulmonary embolism and acute respiratory distress syndrome (CDCP, 2018).

The main cause of VAP is micro-aspiration of subglottic secretions, which might be due to an underinflated endotracheal cuff (Blot et al., 2014). The colonisation of oropharyngeal airways by endogenous flora or pathogens acquired exogenously from the ICU environment, especially healthcare professionals' hands cannot be neglected (Kalanuria et al., 2014). Interventions to inhibit ventilation infections focus on preventing micro-aspiration of oropharyngeal secretions, Blot et al., (2014), avoiding colonisation of upper respiratory airways with exogenous pathogens and contamination of ventilator equipment (Hellyer et al.,

2016). VAP incidence rates of 23.1% were reported in a prospective observational study in a medical and surgical ICU; with a higher risk of mortality (20.2%) than those without (12.0%) (Myny et al., 2005). In Australia and New Zealand, there is a lack of consensus regarding the definition and diagnosis of VAP (Richards and Russo, 2007). One comparative study Elliott et al., (2015) examined VAP rates using a consensus checklist versus physician assessment, and found rates ranged from 25.9% to 26.7% per 1000 mechanical ventilation days respectively. These VAP rates are similar to those reported worldwide and VAP is reported to be the most common healthcare associated infection worldwide (Sousa et al., 2018). Despite this, the lack of agreement regarding VAP diagnosis may have led to limited Australian studies on VAP.

The Institute for Healthcare Improvement, (2012) recommended the use of the ventilation bundle to reduce the risk of mechanical ventilation complications. The ventilation bundle and other evidence-based practices have been adopted in a number of countries (Klompas et al., 2015; Sedwick et al., 2012). However, previous studies reported that nurses' knowledge of evidence-based guidelines for the prevention of VAP in ICU was poor (Aloush, 2017; Blot et al., 2007; Jansson et al., 2013). In addition to a lack of consensus on VAP, VAE is under-studied in Australia. This may be due again to a lack of agreement re-diagnosis. The outcome has been little evaluation of Australian intensive care nurses' knowledge of VAP and adherence to the evidence-based guidelines of VAE prevention.

METHODS

A quantitative cross-sectional online survey was used in this study.

Research aim and questions

The study aim was to explore Australian intensive care nurses' knowledge of VAP and self-reported adherence to evidence-based guidelines for the prevention of VAE.

The questions were;

1) What is the intensive care nurses' knowledge of VAP prevention practices?
2) To what extent do intensive care nurses adhere to evidence-based guidelines to prevent VAE?

Settings

The study was conducted in two Australian ICUs (ICU A and ICU B) in large health services in Victoria and using an Australia-wide nurses' professional association Australian College of Critical Care Nurses (ACCCN). ACCCN was used to collect nation-wide data, as it is a professional association for critical care nurses, and it has members in every Australian State and Territory (Australian College of Critical Care Nurses, 2018). However, data were collected separately at ICU A and B to allow comparison with other data in these Units for subsequent phases of the study. The two ICUs were conveniently selected for participation as they represent the two different ICU levels in Victoria where patients can be mechanically ventilated for more than 48 hours. The two ICUs are of contrasting size and case mix, which facilitated diverse participant characteristics. ICU A has 24 beds, admitting greater than 2500 patients per annum, and provides specialised cardiothoracic, renal, neurology, obstetrics, surgical and general medical services for critically ill patients. ICU B has 15 beds, admitting more than 1200 patients per annum, and provides specialised surgical and medical care to patients (Australian Institute of Health & Welfare, 2018).

Ethical approval

The low-risk human research ethics application was approved by the Human Research Ethics Committees (HREC) at each of the two health services (study reference HREC/18/MoH/417) and the Monash University HREC (Project number 14750).

Participants

Convenience sampling was used to recruit participants. The inclusion criteria for the study were: registered nurses with more than six months of experience in adult ICU and who were providing care to ventilated patients.

Data collection

Two international questionnaires were adapted with permission from the developers (Labeau et al., 2007; Ricart et al., 2003). There were minor modifications to the questionnaires to reflect contemporary practice: an additional question was added to both questionnaires Labeau et al., (2007); Ricart et al., (2003) as the use of chlorhexidine gluconate mouthwash was added to the ventilation bundle after the questionnaires were developed (IHI, 2012).

The research topic, study aim, and questionnaire were sent to five intensive care and research experts (2 Academics and 3 Clinical Nurse Educators) for face and content validity. The co-authors also reviewed the questionnaire for face validity. The average scale-level content validity index (S-CVI) was 0.97 based on the experts' rating (Polit et al., 2007). No significant changes were suggested. The integrated questionnaire consisted of three sections: (i) demographic data; age, level of education, years of experience and nurses title in ICU; (ii) 10 multiple-choice questions on the nurse's knowledge of evidence-based practice to prevent VAP, (iii) 10 questions examining nurses' adherence to the VAE guidelines, measured using a three-point Likert-type scale.

The participants had different titles in ICU such as Registered Nurse (RN), Clinical Nurse Specialist (CNS), Research Nurse, Associate Nurse Unit Manager (ANUM), Nurse Unit Manager (NUM) and Intensive Care Liaison (ICL). The titles were re-coded into two categories, specialist title (CNS, ANUM, NUM, ICL, Research Nurse) and no specialist title (RN) to enable comparison of the results with other published studies (Blot et al., 2007; Lin et al., 2014). The explanatory statement and survey link were emailed to all nurses in ICU A, ICU B and members of the Australia-wide nurses' professional association ACCCN by their

management delegate. The ACCCN invitational email was delayed facilitating maximal data collection in ICU A and B through organisational recruitment first. The nurses were asked not to participate in the ACCCN survey invitation if they had already done so through their employment network. The explanatory statement explained the anonymity of the survey and voluntary participation.

Data analysis

Data were analysed using SPSS v25 software (IBM Corporation, 2018). Descriptive statistics (frequencies, medians and interquartile range) were used to summarise the survey data, and inferential statistics were used to explore relationships and differences between the study variables (Pallant, 2013). The data were non-normally distributed, so non-parametric tests (Chi-square, Mann Whitney U and Kruskal-Wallis) were used to examine the relationship between nurses' characteristics and their knowledge score (Polit and Beck, 2014) Kruskal-Wallis was used to examine the relationship between nurses years of experience and their knowledge and adherence to evidence-based practice. Linear regression was used to predict the extent of the relationship between total scores and nurses' characteristics. A p-value of < 0.05 was considered statistically significant (Polit and Beck, 2014).

RESULTS

Demographics of participants

The nation-wide (all samples) response rate was 27.3% (294/1075), based on the number of nurses who were invited to participate in the survey. An invitation email was sent to all nurses working in ICU A, B and ACCCN members but some nurses were ineligible due to the selection criteria. The total sample includes nurses who were ineligible as the number of ineligible nurses was not disclosed to the research team. Some participants did not answer all the questions, hence variability in the denominator of each set of results. Demographic characteristics are presented in Table 1. The majority of the participants (73.7%) had a

postgraduate qualification, often with more than 10 years of intensive care nursing experience (39%).

INSERT TABLE 1 HERE

Participants' knowledge

The median score in the knowledge of evidence-based guidelines was 6 (IQR: 5-7) (out of 10). Figure 1 illustrates the total knowledge scores. The most correctly answered question was related to patient positioning (*n* = 261, 90.9%) and the least correctly answered question was related to equipment; use of kinetic beds versus standard (*n* = 66, 23%). Figure 2 illustrates the percentages of participants who responded correctly to each question.

INSERT FIGURES 1 AND 2 HERE

There was a significant difference ($p = 0.006$) in the knowledge score of participants with post graduate qualification (*Mdn* = 7; IQR: 6-8) than the participants without (*Mdn* = 5; IQR: 5-7). The linear regression analysis revealed that post graduate qualification was independently associated with an increase in the total score of 0.55 points ($p = 0.014$) (Table 2) the residuals were approximately normal. However, there was no statistically significant difference ($p = 0.674$) between the participants' years of experience and the nurses' knowledge of VAP prevention. The knowledge of participants who had a specialist title in ICU had no statistically significant difference ($p = 0.308$) to those without a specialist title.

INSERT TABLE 2 HERE

Participants self-reported adherence to ventilation guidelines

The median self-reported adherence to ventilation guidelines was 8 (IQR: 6-8) (out of 10). The most adhered to procedure was performing oral care on mechanically ventilated patients (*n* =

259, 90.9%); and semi-fowlers positioning of the patient (*n* = 241, 84.6%). In contrast, the procedures that were poorly adhered to pertained to the use of sterile gloves for open endotracheal suctioning (*n* = 54, 18.9%) and the use of normal saline irrigation for endotracheal suctioning (*n* = 124, 43.5%) (Table 3). There was no relationship between adherence to evidence-based guidelines and participants' knowledge (*p* = 0.144) or participants' years of experience (*p* = 0.650). There was no difference in adherence between participants who had a specialist title and those without (*p* = 0.479), nor those with or without postgraduate qualification (*p* = 0.236).

INSERT TABLE 3 HERE

DISCUSSION

This study evaluated Australian intensive care nurses' knowledge of VAP, and their experience and adherence to evidence-based guidelines for the prevention of the broader remit of VAE. The evidence-based guidelines in the questionnaire included elements of the ventilation bundle which are directly linked to nursing care; positioning patient in semi-recumbent, the use of 0.12% chlorhexidine mouthwash and daily assessment of readiness for extubation. The participants demonstrated poor knowledge in the elements of the ventilation bundle, but their adherence varied. Post graduate qualification was associated with the participant's total knowledge score of VAP prevention but did not make any difference to adherence practices to prevent VAEs. The participants' years of intensive care nursing experience or their title in ICU did not make any difference to their knowledge or adherence to practice.

More than 70% of the participants indicated that mouth care using chlorhexidine was recommended to reduce VAP. However, less than two-thirds of the participants reported adhering to this guideline. There is contradicting literature on the benefits of chlorhexidine over other practices such as sodium bicarbonate, 1.5% hydrogen peroxide, toothbrushing (de

Lacerda Vidal et al., 2017). Two independent meta-analyses reported the use of chlorhexidine mouthwash in ICU (Klompas et al., 2014b; Price et al., 2014). Klompas et al., (2014b) reported decreased VAP rates in cardiac patients; though it was not significantly associated with patient outcome. Price et al., (2014) reported a statistically significant increase in mortality rates when chlorhexidine was used in general ICUs. In a large retrospective observational cohort analysis with >82,000 patients, of whom >11,000 were exposed to chlorhexidine mouthwash, the authors reported a strong association between use of chlorhexidine and *increased* risk of death (Deschepper et al., 2018). Based on these findings, Bouadma and Klompas, (2018) made a global call to stop using chlorhexidine mouth wash as a precautionary measure until further studies could be completed. However, Ricard and Lisboa, (2018), claimed that more data was required before ceasing the use of chlorhexidine in mechanically ventilated patients. The variability of available literature on the use of chlorhexidine mouthwash might have influenced the way the participants answered the questions.

The most adhered to evidence-based guidelines were part of the ventilation bundle; semi-recumbent positioning, and daily assessment of readiness for extubation (CDCP, 2018; IHI, 2012). This suggests that the participants had an awareness of the ventilation bundle preventative measures. Benner, (1982) states that experience is learning through repeated exposure to the procedure that leads to acquiring and perfection of thoughts and ideas. The two evidence-based guidelines might be regarded as good practice or are part of policy and procedures in the ICU, which might have helped with the reported adherence.

The least adhered to practices were related to endotracheal suctioning; the use of normal saline irrigation and the use of sterile gloves for open endotracheal suctioning. The use of normal saline routinely before endotracheal suction has been discouraged by the American Association for Respiratory Care (AARC) due to a lack of conclusive evidence to support routine use (Restrepo, 2010). In an experimental study by Speksnijder et al., (2015), exogenous colonisations between patients who were suctioned with sterile gloves and those

without were the same. There were no reported benefits of using sterile gloves for open endotracheal suction (Speksnijder et al., 2015).

This study found limited association between knowledge of and self-reported adherence to evidence-based guidelines. While most participants understood the evidence-based guidelines, they did not necessarily follow it in practice. The differences in adherence practices might be due to specific organisation policies, which do not support the practice Labeau et al., (2008) and the availability of resources. Low adherence rates to VAP prevention were also reported by Lambert et al., (2013) in a large international study of ICU doctors. These findings are consistent with the reported healthcare professionals' good theoretical knowledge of hand hygiene guidelines having no influence on their compliance (De Wandel, 2017; De Wandel et al., 2010). The reported low adherence shows there are other factors which influence adherence to evidence-based practice than theoretical knowledge.

Most of the participants in this study held post graduate qualifications in intensive care nursing and had a better knowledge score than those without the qualification. These findings confirm the results of previous studies (Blot et al., 2007; Lin et al., 2014). This finding is not a surprise, given that the ACCCN recommended a post graduate intensive care nursing qualification for nurses employed in ICU (Australian College of Critical Care Nurses, 2017). Healthcare professionals' knowledge is associated with their attitude, which is a key factor of behavioural intention (De Wandel, 2017). This shows the importance of post graduate qualification and knowledge in intensive care nursing. However, Labeau et al., (2016) reported healthcare professionals' lack of knowledge as spread over all hospital-acquired infections, which might be related to lack of awareness of available evidence-based practices.

In this study, the nurses' years of experience in intensive care nursing had no significant association with their knowledge score, which was also reported by (El-Khatib et al., 2010). This finding is contrary to previous studies, which reported that more experienced intensive

care nurses had significantly better knowledge results than those with less experience (Blot et al., 2007; Jansson et al., 2013; Labeau et al., 2008). The findings of this study are not consistent with Benner's five stages of nursing competence, which state that at each stage there is increased reliance on previous experience Benner, (1982); therefore, more experienced nurses would be expected to have a better knowledge of VAP. There has been a wide range of evidence-based practices to prevent VAP, and different countries have adapted specific guidelines (Labeau et al., 2008). It might be that some of the evidence-based practices in the questionnaire were not common practice in Australian ICUs, so the participants could not relate to them.

This study has limitations. First, self-reporting can threaten the reliability of the findings because participants relied on their memory to answer the knowledge questions. The participants may have had a particular interest in VAP prevention. The participants' current VAP or VAE prevention practices in ICU A and B were not collected. The sample was small, meaning that Type II error cannot be excluded. However, the sample represented different age groups, levels of experience and education, and different nursing titles, which shows interest in the issue of VAE prevention at different levels. Therefore, these results can be regarded as representative of Australian intensive care nurses (Cooper and Brown, 2017). This study is a national survey, which produced data that can help to improve our understanding of nurses' knowledge and adherence to VAE prevention in Australian ICUs.

CONCLUSION

The findings of this study demonstrate that Australian intensive care nurses had some awareness of evidence-based guidelines to prevent VAE. Post graduate qualification in intensive care nursing is of great importance, as education is associated with nurses' knowledge of VAP guidelines. The nurses' education is one component which influences knowledge. It remains crucial to promote continuous educational services on current evidence-based guidelines to increase awareness of VAE prevention. Future research to

investigate nurse's socio-behavioural determinants to VAE prevention might help us understand factors associated with adherence. Further studies on chlorhexidine mouth wash in medical and surgical non-cardiac mechanically ventilated patients would be important in clinical practice.

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