Lessons learned from a rapid implementation of a ventilator-associated pneumonia prevention bundle

Elyse Ladbrook[1,2] iD **, Stéphane L. Bouchoucha[1,2,3] and Ana Hutchinson[1,2,3]** iD

Abstract

Background: Ventilator-associated pneumonia (VAP) is a common avoidable healthcare associated infection in ventilated critical care patients that can have a detrimental impact on patient recovery. To increase uptake at a local level, care bundles should be designed and implemented in collaboration with the end-users who will implement the bundle into practice.

Aim/objective: The aim in this study was to evaluate critical care nurses' perceptions of the usability of a respiratory care bundle as an effective approach to VAP prevention.

Methods: An exploratory descriptive qualitative study was conducted. A respiratory care bundle consisting of five components was implemented over a 4-week period. Following implementation, a focus group and semi-structured interviews were conducted to obtain nurses' feedback on the useability of the care bundle. Seven intensive care nurses caring for ventilated patients participated in the study.

Findings/results: Participants confirmed that using a care bundle provided a structured approach to nursing care of a ventilated patient and that the use of checklist reminders at the bedside was useful in a busy practice environment. Barriers to uptake and implementation of the bundle were that the unit culture did not prioritise preventative care and the need for a structured interdisciplinary approach to sedation and weaning of mechanical ventilation.

Discussion: To successfully imbed all elements of a respiratory care bundle into practice; an interdisciplinary approach is needed in which there is a strong emphasis on preventative care. These findings highlight the advantages of involving end-users in the development of strategies to decrease VAP.

Background

The increasing complexity of healthcare systems, a focus on the provision of safe and high quality care in addition to increased expectations from healthcare consumers, place multifaceted challenges on healthcare organisations and healthcare professionals (Dudley-Brown et al., 2015). In Australia, the delivery of safe and high quality healthcare is considered a national priority and Australian hospitals are accredited against a set of standards that were developed to improve the quality of health care and protect the public from

[1]Deakin University, Geelong, Australia
[2]School of Nursing and Midwifery, Centre for Quality and Patient Safety Research, Australia
[3]Deakin University Geelong, Centre for Quality and Patient Safety Research, Epworth Healthcare Partnership, Australia

Corresponding author:
Elyse Ladbrook, Deakin University Geelong, School of Nursing and Midwifery, Centre for Quality and Patient Safety Research, 221 Burwood Highway, Burwood, VIC 3125 Australia.
Email: elyse.ladbrook@bigpond.com

harm (Australian Commission on Safety and Quality in Health Care, 2017). The implementation of cost effective strategies to minimise the risk of complications, such as Healthcare-associated Infections (HAI), and their associated financial burden is essential to ensure the continued delivery of quality and safe healthcare (Australian Commission on Safety and Quality in Health Care, 2017; Borgert et al., 2015).

Ventilator-associated pneumonia (VAP) is a nursing sensitive outcome, and it is frequently observed within critical care environments (Micik et al., 2013). VAP is associated with significant morbidity and mortality (Hugonnet et al., 2007; National Health and Medical Research Council, 2010), with crude death rates reported as being between 5% and 65% (National Health and Medical Research Council, 2010). In Australia, there is no mandatory national surveillance system for HAIs and there is limited data regarding the incidence of VAP and the associated cost to healthcare delivery (Russo et al., 2015). The potential financial and economic burden for Australian healthcare settings can be extrapolated from other international settings, where the estimated cost of VAP is between £6000–£22,000 in the United Kingdom and, in the USA between USD $25,000 to $28,000 per patient (Centres for Disease Control and Prevention, 2009; Wagh and Acharya, 2009). In addition to the financial costs associated with HAIs, such as VAP, there are significant indirect social, economic and psychological costs to the patient and their family such as increased healthcare costs, lost productivity, and decreased quality of life (Australian Commission on Safety and Quality in Health Care, 2008; Micik et al., 2013).

Fiscal constraints imposed on the delivery of healthcare draw attention to the need to provide cost-effective strategies to improve patient outcomes (Cutler and Sluman, 2014). Registered nurses are in a key position to mitigate the risk of HAIs, due to their constant presence at the bedside and their key role in providing direct patient care (Hugonnet et al., 2007). In Australian Intensive Care Units (ICU), nurses are usually only providing care to one patient undergoing mechanical ventilation and are responsible for the delivery of direct respiratory care including maintenance of the artificial airway, mouth care, patient positioning and adjustment of ventilator setting to maintain adequate oxygenation and ventilation (Chamberlain et al., 2018). Their key role in providing respiratory care to ventilated ICU patients means that nurses are pivotal to the implementation of strategies to decrease the incidence of VAP (Australian College for Critical Care Nurses, 2003; Australian Commission on Safety and Quality in Health Care, 2012; College of Emergency Nursing Australasia, 2014; Micik et al., 2013).

The primary aim of VAP prevention strategies is to minimise the risk of microorganisms being introduced into the patient's lower airway and to decrease duration of mechanical ventilation (Infection Prevention Society, 2017; Micik et al., 2013). Whilst there is a wealth of literature supporting the use of evidence-based practice guidelines to mitigate the risk for VAP (Alcan et al., 2016; Infection Prevention Society, 2017; Institute for Healthcare Improvement, 2012; National Health and Medical Research Council, 2010; Resar et al., 2012), typically only half of ventilated patients consistently receive recommended prevention strategies (Alcan et al., 2016; Eom et al., 2014; Klompas et al., 2014; Rello et al., 2012). One of the key implementation strategies used to promote VAP prevention at the bedside is the use of a "care bundle" approach (Resar et al., 2012). The international literature has shown that the introduction of care bundles is associated with both improvements in adherence to key elements of VAP prevention and decreases in VAP rates (Alcan et al., 2016; Hellyer et al., 2016). Many of these strategies are part of the remit of nurses, and the implementation of these strategies is relatively cost neutral, easily performed at the bedside, and associated with a low risk of patient harm. Data presented in the international literature has shown that using this approach is associated with both improvements in adherence to key elements of VAP prevention and decreases in VAP rates (Micik et al., 2013); however, there are limited studies evaluating the use of VAP bundles in Australian ICUs.

To increase uptake at a local level, care bundles should be designed and implemented in collaboration with the end-users who will implement the bundle into practice (Alp et al., 2019; Institute for Healthcare Improvement, 2012). This process ensures that the bundle is useable and that barriers to implementation can be addressed. This study reports the lessons learnt following development and early implementation of a ventilator care bundle.

Methods

Study design

A prospective, exploratory descriptive qualitative study was conducted to obtain nurses' views on the useability of the ventilator care bundle (VCB) at the study site.

Setting

The study took place within an Australian, 31 bed, ICU within a tertiary teaching hospital.

Interventions

The VCB consisted of five core elements: (I) Adherence to Infection Prevention and Control measures (such as Standard Precautions), (II) Head of bed elevation >30°, (III) Mouth care once a shift and oropharyngeal suction when required, (IV) maintenance of the artificial airway and (V) titration of sedation to assess suitability for weaning of mechanical ventilation and extubation.

Table 1. Summary of themes.

Themes from Focus Group	
Theme 1 - A "Care bundle" provides a structured approach to nursing care	
Sub theme	*Use of a care bundle supports integration of evidence into practice.*
Sub theme	*Effective implementation is the key to success*
Theme 2 - Preventative care is not always the main priority.	
Sub theme	*Inconsistent implementation of standard precautions.*
Sub theme	*Need for an interdisciplinary approach to sedation management*

Implementation strategy

Prior to implementation, leadership support was sought and obtained from the ICU medical director and the nurse unit manager. Over a 4-week period, the following education and awareness raising activities were used to promote the VCB: staff education sessions and informal one-on-one teaching at the bedside, and distribution of lanyards and laminated cards listing the VCB elements at the bedside.

Participants

The study participants were nurses working within the ICU and qualified to care for patients requiring mechanical ventilation.

Ethical considerations

The study was approved by the appropriate institutional ethics committees prior to the start of the study. Participants gave written informed consent prior to study participation.

Data collection

Focus groups and interviews. Following the 4-week implementation period, eligible nursing staff were invited to attend a focus group to obtain feedback on the useability and feasibility of the VCB as part of routine clinical care. The focus group was held in a staff meeting room adjacent to the intensive care unit. Nursing staff not available at this time were provided with the opportunity to provide feedback by participating in individual semi-structured interviews. Individual interviews were conducted in a time and place convenient for the participants.

An interview guide was used to structure both the focus group discussion and individual staff interviews. All participants gave written informed consent to study participation. There were two topics explored in the focus group and individual interviews; (1) Staff feedback on the useability of the VCB as an approach to the implementation of evidence-based practice guidelines including infection prevention and control measures, and (2) The effectiveness of

the implementation strategies that were used to promote the VCB.

The focus group was audio recorded to facilitate transcription of the discussion for later analysis. The themes from both the focus group and the individual interviews were combined for thematic analysis.

Data analysis

Content and thematic analysis were used to analyse participant interviews and the focus group data. The interviews and focus group data were transcribed verbatim. Transcripts were coded, categorised and key themes identified by two researchers (EL and AH), this process involved the following steps: i) repeated reading of the text and highlighting important phrases (coding); ii) identifying key content areas (categorising); iii) grouping similar ideas into the content areas and labelling them; iv) revising and linking similar categories together (identifying themes); and v) organising the identified themes in to major themes and sub-themes. Supporting quotes for each identified theme and sub-theme were extracted by the two researchers. Once this process was completed the thematic structure and appropriateness of the supporting quotes was reviewed and confirmed by a third researcher (SB).

Results

There were a total of seven participants, focus group ($n=5$) and individual staff interviews ($n=2$). The major themes that emerged about the useability of the VCB were: (1) A "Care bundle" provides a structure approach to nursing care and (2) Preventative care is not always the main priority. The sub-themes associated with each of these two major themes are summarised in Table 1.

Theme 1. A "Care bundle" provides a structured approach to nursing care

Participants expressed positive feedback on the use of a VCB to provide a structured approach to the provision of

nursing care. "It looks really good and it is good that it prompts and gives advice" (Participant 4). In addition there was a general consensus that the VCB, as a structured tool was beneficial to nurses with varying levels of expertise and experience.

> Any extra assistance in the way you can do your job or guidance on what you should be doing, what you should be doing more frequently is always useful (Participant 1).

Generally there was consensus that there was both a need for and a lack of formal guidelines targeting implementation of nurse-led strategies to mitigate the risk for VAP, "There are no current formal guidelines or protocols in the unit that target VAP… well at least if they exist I don't know about them…to be honest I've never seen one" (Participant 5).

Participants were receptive to implementing change to improve current practice, consistency and overall quality of care provided "I have never used a care bundle before but I think it would enhance continuity of care, … which could minimise the risk for missed steps in preventative care" (Participant 5) and another participant commented, "You always need a policy, procedure or guidelines for prevention of VAP" (Participant 2).

Nursing staff mentioned they were aware of current documentation requirements within their daily tasks however; felt that a more targeted approach could be beneficial:

> We currently have a care plan that includes like anything, that's sort of like a tick box care plan but includes minimal things that are specific to ventilation. (Participant 5)

> So there's like a quick tick box which is like brushes teeth three times a day for ventilated patients (Participant 1).

Use of a care bundle supports integration of evidence into practice. There was a consensus that there was a need for guidance for the provision of nursing care that specifically targeted approaches to decrease risk of hospital-acquired respiratory tract infections. Participants commented, "I feel that there isn't specific procedures or policies or guidelines regarding reducing the rate of VAP or basic care for the ventilated patient in regards to suctioning, and oral care" (Participant 6) and "prior to that there wasn't any strict guidelines for people to follow, so people only did what they thought was necessary" (Participant 5).

Nursing staff were receptive to the idea of having a formal and structured approach to the provision of evidence-based nursing care targeting the prevention of VAP; "Anything that would reduce the risk of VAP is worth doing" (Participant 4). This view was supported by other participants who agreed that their main focus was on achieving the best outcomes for patients.

If you have evidence behind you and you know what you are doing works… people are more likely to adhere to evidence-based practice because it has been proven to have better outcomes and we all just want better outcomes for the patient (Participant 6).

I don't like to do something that I do not know to be based on current evidence because I want to ensure I keep my patient safe (Participant 5).

Effective implementation is the key to success. Participants commented that the implementation strategy was fundamental to the success of a bundled approach to care provision, "I think it is great and it needs to be implemented. Care bundles have [been] demonstrated to work and as long as they are implemented appropriately and properly with the right education, with a feedback loop to help people understand why" (Participant 6).

In addition, participants provided feedback on the strategies used to support implementation and uptake of the VCB at the study site. Lanyard cards were well received by the majority of participants, as "they are a useful tool, they are easy to get to and use and are a great resource" (Participant 6) and "we currently don't have anything specific with us all the time to show us what to do, so definitely more useful than what we have… it's non-existent really" (Participant 1). One participant preferred a protocol or a guideline to reminders on lanyards stating "I don't find lanyards useful, I wear them but don't find that I regularly refer to them" (Participant 5).

There were mixed responses in relation to the use of checklists to prompt the implementation of VCB tasks for every shift encounter. Some of the participants welcomed the inclusion of prompts throughout the shift to ensure that the task was completed in the most appropriate timeframe. "There is a lack of prompting within the [digital health record] system. We don't actually have a system that we go through and use… I think reminders are needed because you get really caught up doing other things" (Participant 2); "I believe that 2-hourly prompts would be most appropriate it would give 3–4 prompts per shift" (Participant 5) and "I think prompts would always be good, because time flies and you always forget" (Participant 4). There was a consensus that prompts needed to be appropriate to avoid alarm fatigue, "You wouldn't want something popping up all the time when you're really busy and know you need to have it done but you just can't" (Participant 4).

In comparison other participants expressed concerns regarding a lack of critical thinking and accountability when checklists were used to record the provision of care bundle elements. "I think that tick box care plans are useless because people tick the box even when they haven't done it" (Participant 5) and another participant commented:

…by giving nurses a tick box they don't have to think outside the square and they don't think about what they should do, they just do what they are told to do…I think that adequate education to ensure that staff understand what they are adhering to is as important, otherwise they will just check a box because they have to (Participant 6).

Participants were in agreement that experienced registered nurses were an invaluable resource to support practice change in the unit and that role modelling by the leadership team was essential to achieve practice change.

I feel that people are more receptive to the knowledge and skills being translated by senior staff, we potentially get more "buy-in" from staff and establish support between colleagues (Participant 6).

Theme 2. Preventative care is not a priority

Although use of the VCB was viewed positively by the study participants staff identified that an important barrier to successful implementation was the low priority placed on preventative care in a time-critical environment.

Like you'll have a sick patient and you're flat chat [busy] with them and sometimes the mouth care gets missed and doesn't happen as frequently as you would like it to… you have 1000 infusions and you've got things going on all the time so it kind of gets put down at the bottom of the list (Participant 2).

This was reiterated by Participant 1, who stated. "Anyone that's high acuity …your priority list is important as they are critically ill and you want to make sure everything else is sorted before you get to that [preventative care]."

Inconsistent implementation of standard precautions. There were differing views on how participants viewed adherence to infection prevention and control activities within the department, "I think our infection control is pretty good… It also depends on the individual and how well they don their PPE. Over all I think it's good" (Participant 2). In contrast, another participant commented that fundamental IPC measures such as use of standard precautions were sometimes overlooked:

I think overall it is done poorly, for example I often see staff walking around the unit in a disposable gown and [they] do not change the gown between patients, I also see people emptying IDCs [indwelling catheter] at the end of a shift into the same urine bottles. […] I feel there is room for improvement (Participant 5).

Need for an interdisciplinary approach to sedation management. A lack of engagement by the medical team in preventative care was also discussed, this was reflected by an ad hoc approach to weaning sedation and mechanical ventilation support. Participants agreed that the sedation

management plan was often not documented, but rather an informal verbal exchange between medical and nursing staff at the bedside. This unstructured approach to sedation and weaning meant that it was difficult to consistently implement and document the VCB recommendations related to sedation management.

Like the team will come round and say "Wake and wean" or "wake, wean sedation", but there's no real target RASS [sedation] score of 0… they have a tab [on the electronic medical record] … that they can fill out for targets and plans but we don't always have goals set there. (Participant 2).

It's been in my experience that nursing staff are at times not involved in discussions about sedation and daily plans during the AM round. I believe that we would benefit from more written guidance regarding sedation in the patient's management plan (Participant 5).

The participants reported that the use of sedation breaks and spontaneous breathing trials were not considered routine practice within the ICU, "So we don't do sedation vacations in the unit it's usually like turn propofol off or halve the propofol [infusion] and wait and see how they [patients] react" (Participant 4). Another participant noted a lack of consistency when managing sedation within the department.

I feel that there are conflicting directives at times between members of the medical team, … [differences between] the Intensive Care team and the home teams…A standardised approach to weaning sedation could provide support to staff throughout their shifts in comparison to sudden/abrupt cessation of sedation during the round (Participant 5).

The participants' responses highlighted that without full engagement of the medical team in consistently documenting sedation and weaning plans it was not possible for the bedside nurse to effectively and consistently implement the bundle element relating to sedation breaks and weaning.

Discussion

The introduction of the VCB into clinical practice was well received by staff and the implementation strategies used to promote uptake of the VCB raised staff awareness of the importance of using a systematic approach to providing preventative care to ventilated ICU patients. In the focus groups and interviews participants highlighted that to achieve practice change, greater multidisciplinary involvement and a stronger focus on patient safety and preventative care was needed.

Although the nurse participants were able to implement recommendations for upright patient positioning, provision of mouth care and management of artificial airway suctioning and cuff pressure checks, they identified difficulties in implementation of recommendations for titration of sedation without greater involvement of the medical team. Not only was there a perception that adherence to existing guidelines

was unsatisfactory, there were also some reluctance to implement sedation titration without clear direction from the medical team. Whether the formulation of clear protocols to enable collaboration with the medical team, and a greater sense of ownership of sedation management amongst nurses, would result in greater uptake of evidence into practice needs to be evaluated in prospective studies (Balas et al., 2013).

This feedback highlighted the need to engage both the ICU medical and nursing staff in the development and implementation of a standardised and structured approach to weaning to minimise the duration of mechanical ventilation. Such approach has been shown to be beneficial by Balas et al. (2013) in the context of a care bundle to minimise the incidence of delirium in ICU through implementation of a careful approach to monitoring of sedation. While the context is different, findings in Balas et al. (2013) highlighted the need not only for a whole of unit approach to bundle implementation to increase adherence but also underscored the reluctance of many healthcare professionals to follow new policies in an environment where there are already multiple existing policies.

Another key barrier to successful implementation of the bundle was that the unit culture did not prioritise preventative care. Rashnou et al. (2017) identify unit culture as a significant barrier to the successful implementation of VAP prevention strategies, acknowledging that the lack of local evidence-based practice guidelines may have been a major contributing factor. Likewise Maxwell et al. (2018) recognised the importance of addressing the impact of unit culture as a key factor in successful implementation of evidence-based practice. These findings are consistent with a recent review of literature by van Buijtene and Foster (2018) that suggests organisational culture may impede the prevention of HAI and implementation of IPC strategies.

Other barriers to the successful implementation of the care bundle, identified by the registered nurses participating in the focus group, included conflicting time critical priorities, a perceived reluctance from other members of the nursing team to accept changes to current practice and a lack of collaboration between disciplines. These findings are consistent with barriers to implementation recognised in other studies that have evaluated the utilisation and integration of evidence based practice within healthcare (Melnyk et al., 2012; Stavor et al., 2017). Whilst this study has identified that the model of care used by registered nurses, to plan, implement and evaluate nursing care may not always prioritise preventative care, the study findings highlight important barriers that need to be addressed for successful translation of evidence into routine practice (Stavor et al., 2017).

Limitations

Although this study had some limitations, such as a small sample size and single study site, as a snapshot of current practice, the findings have highlighted similar issues translating evidence into clinical practice identified in other studies (Balas et al., 2013; Fernandez et al., 2015). Future research is needed to evaluate whether sustained use of a structured implementation strategy and engagement of all members of the inter-disciplinary team is able to demonstrate improvements in adherence to best practice for all elements of the VCB (Parisi et al., 2016).

Conclusion

The short-term implementation strategy used that included staff education and promotion of the VCB using checklist and reminder cards attached to staff lanyards was an effective approach to raising awareness of the importance of VAP prevention. The study participants agreed that using a care bundle approach was a useful way to structure preventative care in their practice context; but identified that implementation of recommendations that involved changes in pharmacotherapy was beyond their scope of practice. To achieve practice change and increase overall adherence, greater involvement of the ICU leadership team in promoting the VCB and a multidisciplinary approach to sedation and ventilation management is required. Promotion of a practice environment in which the multidisciplinary clinical leadership team places a strong emphasis on all aspects of preventative care for critically-ill patients, including adherence to the key principles of IPC is required for successful, implementation of a VAP prevention bundle.

ORCID iD

Elyse Ladbrook [iD] https://orcid.org/0000-0001-7219-8253
Ana Hutchinson [iD] https://orcid.org/0000-0002-0014-689X

References

Alcan AO, Korkmaz FD and Uyar M (2016) Prevention of ventilator-associated pneumonia: use of the care bundle approach. *American Journal of Infection Control* 44: e173–e176.

Alp E, Cookson B, Erdem H and Rello J; Survey Group (2019) Infection control bundles in intensive care: an international cross-sectional survey in low- and middle-income countries. *Journal of Hospital Infection* 101(3): 248–256.

Australian College for Critical Care Nurses (2003) ACCCN ICU Staffing Position Statement (2003) on Intensive Care Nursing Staffing. Available at: http://www.cicm.org.au/CICM_Media/CICMSite/CICM-website/Resources/Professional%20Documents/IC-1-Minimum-Standards-for-Intensive-Care-Units.pdf (accessed 18 Feburary 2019).

Australian Commission on Safety and Quality in Health Care 2008, *Reducing harm from healthcare associated infection: the role of surveillance*. Available at: https://www.safetyandquality.gov.au/wp-content/uploads/2008/01/Reducing-Harm-to-Patient-Role-of-Surveillance1.pdf (accessed 18 February 2019).

Australian Commission on Safety and Quality in Health Care 2012, *National Safety and Quality Health Service Standards*. Available at: https://www.safetyandquality.gov.au/wp-content/uploads/2011/09/NSQHS-Standards-Sept-2012.pdf (accessed 18 Feburary 2019).

Australian Commission on Safety and Quality in Health Care 2017, *Standard 3 Preventing and Controlling Healthcare Associated Infections. Safety and Improvement Guide*. Available at: https://www.safetyandquality.gov.au/wp-content/uploads/2017/11/Preventing-Controlling-Healthcare-Associated-Infection.pdf (accessed 18 Feburary 2019).

Balas MC, Burke WJ, Gannon D et al. (2013) Implementing the awakening and breathing coordination, delirium monitoring/management, and early exercise/mobility bundle into everyday care: opportunities, challenges, and lessons learned for implementing the ICU Pain, Agitation, and Delirium Guidelines. *Critical Care Medicine* 41(9 Suppl 1): S116–S127.

Borgert MJ, Goossens A and Dongelmans DA (2015) What are effective strategies for the implementation of care bundles on ICUs: a systematic review. *Implementation Science* 10(119): 1–11.

Centres for Disease Control and Prevention (2009) *The direct medical costs of healthcare-associated infections in U.S hospitals and the benefit of prevention*. Available at: https://www.cdc.gov/hai/pdfs/hai/scott_costpaper.pdf (accessed 18 Feburary 2019).

Chamberlain D, Pollock W and Fulbrook P; ACCCN Workforce Standards Development Group (2018) ACCCN Workforce Standards for Intensive Care Nursing: Systematic and evidence review, development, and appraisal. *Australian Critical Care* 31(5): 292–302.

College of Emergency Nursing Australasia (2014) Position statement mechanical ventilation. Available at: http://cena.org.au/wp-content/uploads/2014/10/CENA_Position_Statement_Mechanical_Ventilation.pdf (accessed 18 Feburary 2019).

Cutler LR and Sluman P (2014) Reducing ventilator-associated pneumonia in adult patients through high standards of oral care: A historical control study. *Intensive and Critical Care Nursing* 30(2): 61–68.

Dudley-Brown S, White KM and Terhaar MF (2015) *Translation of evidence into nursing and health care*. New York, NY: Springer Publishing Company.

Eom JS, Lee M-S, Chun H-K et al. (2014) The impact of a ventilator bundle on preventing ventilator-associated pneumonia: a multicentre study. *American Journal of Infection Control* 42(1): 34–37.

Fernandez PG, Loftus RW, Dodds TM et al. (2015) Hand hygiene knowledge and perceptions among anesthesia providers. *Anesthesia and Analgesia* 120(4): 837–843.

Hellyer T, Ewan V, Wilson P and Simpson AJ (2016) The Intensive Care Society recommended bundle of interventions for the prevention of ventilator-associated pneumonia. *Journal of Intensive Care Society* 17(3): 238–234.

Hugonnet S, Villaveces A and Pittet D (2007) Nurse staffing level and nosocomial infections: empirical evaluation of the case-crossover and case-time-control designs. *American Journal of Epidemiology* 165(11): 1321–1327.

Infection Prevention Society (2017) High impact interventions care processes to prevent infection. Available at: https://www.ips.uk.net/files/6115/0944/9537/High_Impact_Interventions.pdf (accessed 3 Feburary 2019)

Institute for Healthcare Improvement (2012) How-to guide: prevent ventilator-associated pneumonia. Available at: http://www.ihi.org/resources/Pages/Tools/HowtoGuidePreventVAP.aspx (accessed 18 Feburary 2019)

Klompas M, Branson R, Eichenwald E et al. (2014) Strategies to prevent ventilator-associated pneumonia in acute care hospitals: 2014 Update. *Infection Control and Hospital Epidemiology* 35(8): 915–936.

Maxwell M, Murphy K and McGettigan M (2018) Changing ICU Culture to reduce catheter-associated urinary tract infections. *Canadian Journal of Infection Control* 33(1): 39–43.

Melnyk BM, Fineout-Overholt E, Gallagher-Ford L and Kaplan L (2012) The state of evidence-based practice in US nurses. *Journal of Nursing Administration* 42(9): 410–417.

Micik S, Besic N, Johnson N et al. (2013) Reducing risk for ventilator associated pneumonia through nursing sensitive interventions. *Intensive and Critical Care Nursing* 29(5): 261–265.

National Health and Medical Research Council 2010, *Australian guidelines for the prevention and control of infection in healthcare*. Available at: https://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/cd33_infection_control_healthcare_140616.pdf (accessed 18 Feburary 2019).

Parisi M, Gerovasili V, Dimopoulous S et al. (2016) Use of a ventilator bundle and staff education to decrease ventilator-associated pneumonia in intensive care patients. *Critical Care Nurse* 36(5): e1–e7.

Rashnou F, Toulabu T and Hasanvand S (2017) Barriers to the management of ventilator-associated pneumonia: A qualitative study of critical care nurses' experiences. *World Family Medicine* 15(8): 174–182.

Rello J, Afonso E, Lisboa T et al. (2012) A care bundle approach for prevention of ventilator-associated pneumonia. *Clinical Microbiology and Infection* 19(4): 363–369.

Resar R, Griffin F, Haraden C and Nolan TW (2012) Using care bundles to improve health care quality; IHI innovation series white paper. Available at: http://www.ihi.org/resources/Pages/IHIWhitePapers/UsingCareBundles.aspx (accessed 18 Feburary 2019).

Russo P, Cheng A, Richards M et al. (2015) Healthcare-associated infections in Australia: time for national surveillance. *Australian Health Review* 39(1): 37–43.

Stavor DC, Zedreck-Gonzalez J and Hoffmann RL (2017) Improving the use of evidence-based practice and research utilisation through the identification of barriers to implementation in a critical access hospital. *Journal of Nursing Administration* 47(1): 56–61.

van Buijtene A and Foster D (2018) Does a hospital culture influence adherence to infection prevention and control and rates of healthcare associated infection? A literature review. *Journal of Infection Prevention* 20(1): 5–17.

Wagh H and Acharya D (2009) Ventilator Associated pneumonia – an overview. *British Journal of Medical Practitioners* 2(2): 16–19.