Title: Effects of simulation education on oral care practices – a randomized controlled trial

ABSTRACT

Background: Implementation of evidence-based oral care protocols, nurse education programs and assessment tools may reduce the risk of developing ventilator-associated pneumonia by increasing critical care nurses' knowledge and skills in adhering to current oral care recommendations.

Aims: To evaluate the longitudinal effects of single-dose simulation education with structured debriefing and verbal feedback on critical care nurses' knowledge and skills in adhering to current oral care recommendations.

Design: A randomized controlled trial with repeated measurements.

Method: The data for the study was collected in a single academic centre in a 22-bed adult, mixed, medical-surgical intensive care unit in Finland from February 2012 to March 2014. The effectiveness of simulation education was evaluated through the validated Ventilator Bundle Questionnaire and Observation Schedule at the baseline (n = 30) and 24 months (n = 17) after simulation education. Data were analysed using a linear mixed model and intention-to-treat analyses.

Results: During the study period, the average knowledge score in the intervention group increased significantly (44.0% to 56.0% of the total score) in the final postintervention measurement ($p_t = 0.51$, $p_g = 0.002$, $p_{t*g} = 0.023$). However, single-dose simulation education with structured debriefing and verbal feedback had no impact on critical care nurses' skill scores.

Conclusion: Single-dose simulation education had only a minimal effect on critical care nurses' knowledge and skills in adhering to current oral care recommendations. Despite of increased awareness, there was no significant difference in oral care practices between the study groups after simulation education.

Relevance for clinical practice: The need for regularly repeated educational sessions with theoretical training and practical exercises and direct feedback is evident. Certain aspects of oral care, such as prevention of microaspiration of oropharyngeal secretions and moistening of oral mucosa and lips, require more reinforcement than others.

INTRODUCTION

Critical care nurses plays a crucial role in maintaining and assessing oral health among invasively ventilated critically ill patients. Comprehensive oral care, using either chlorhexidine oral rinse or gel and toothbrush together with preventing microaspiration of oropharyngeal secretions may reduce the risk of developing ventilator-associated pneumonia (VAP) in these patients (AACN, 2010; Conley *et al*., 2013; Hillier *et al*., 2013).

BACKGROUND

Implementation of evidence-based oral care protocols, nurse education programs and assessment tools may reduce the risk of developing VAP by increasing critical care nurses' knowledge and skills in adhering to current oral care recommendations (Garcia *et al*., 2009; Ames *et al*., 2011; Hillier *et al*., 2013). However, institutional policies and procedures related to oral care are not consistent and do not always reflect current recommendations (DeKeyser *et al*., 2009; Feider *et al*., 2010; Perrie and Scribante, 2011; Soh *et al*., 2011; Hillier *et al*., 2013). In addition, critical care nurses' knowledge of oral diseases (Azodo *et al*., 2013) and recommended oral care practices (Jordan *et al*., 2014) is insufficient. Most, however, reported positive attitude toward the importance of oral care (Rello *et al*., 2007; DeKeyser *et al*., 2009; Feider *et al*., 2010; Perrie and Scribante, 2011; Soh *et al*., 2011; Chan *et al*., 2012; Gatell *et al*., 2012; Orlandinia and Lazzarib, 2012; Azodo *et al*., 2013; Javadinia *et al*., 2014; Lin *et al*., 2014).

Previous single center studies have demonstrated significant improvements in oral assessment scores and the quality of oral care immediately after educational interventions (e.g., 1–5 hours training/teaching sessions, 20–30 minute structured educational sessions including reminders, repeated 60-minute training sessions, theoretical training and practical exercises, direct feedback and implementation of oral assessment guide and storyboards) (Cutler and Davis, 2005; Ross and Rumple, 2007; Meherali *et al*., 2011). However, the effectiveness of previous multidisciplinary and multifaceted approaches have mainly measured in single group pre-test post-test designs without a control group and a comprehensive follow-up time. In addition, the effectiveness of advanced, high-fidelity teaching methods in improving oral care practices on nursing education is still largely unknown (Jansson *et al*., 2014a).

DESIGN AND METHODS

Aim and objectives

This randomized controlled trial with repeated measurements was conducted to evaluate the longitudinal effects of single-dose simulation education with structured debriefing and verbal feedback on critical care nurses' knowledge and skills in adhering to current oral care recommendations.

Hypotheses

It was hypothesised that critical care nurses who received a simulation education with structured debriefing and verbal feedback would demonstrate a higher level of knowledge and skills than those who did not receive it.

Setting and sample

The data for the study was collected in a single academic centre in a 22-bed adult, mixed, medical-surgical intensive care unit (ICU) in Finland from February 2012 to March 2014. Randomly selected critical care nurses were invited via letter and electronic mail between December 2011 and January 2012. Inclusion criteria were to holding a degree qualification as a registered nurse and being a direct care provider. Before this study, the hospital didn't have a policy for oral care.

Sample size determination

The sample size was determined through power analysis, which revealed that a sample size of 32 participants was required to detect a 20% difference between means (mean difference = 2.74, SD = 2.66 points [alpha=0.05 and power=0.90]). Further, we anticipated a 20% drop-out rate, which led to a sample size of 20 nurses per group (40 participants in total).

Randomization and blinding

Participants were randomly allocated to intervention (n = 20) and control (n = 20) groups by the biostatistician using a computer-generated randomization list (allocation ratio of 1:1). Randomization was stratified into two age-based strata according to the median age of the study population (≤35 and >35 years). Due to the nature of intervention, unfortunately, blinding was not possible. However, the biostatistician and research assistant who analysed and collected the data were blinded to group assignment.

Intervention

The high-fidelity, human patient simulation education and its evaluation process began with a brief (20 min.) introduction to the simulation center (SimLab, Oulu University of Applied Science) and mannequin (HAL, Gaumard, Miami, FL) capabilities followed by an actual simulated scenario (10 min.). Post-scenario, only the intervention group participated in a structured and standardized debriefing session (60 min.) and received verbal feedback. The debriefing took place immediately after simulated scenario and was led by two facilitators who were specialised in simulation pedagogy and key areas. The debriefing consisted of a standardized Powerpoint slide show and didactic lecture covering the scope (e.g., definition, epidemiology and etiology, risk factors, clinical and economic outcomes of VAP) and the management of the problem (e.g., recommended oral care practices). In addition, facilitators provided constructive feedback in accordance with best practice. During the debriefing, participants were encouraged to discuss, analyse and summarize the experience to enhance their learning.

Data collection tools and methods

Identical repeated measurements were taken for intervention and control groups by the same trained and experienced observers; the procedural flowchart for the data collection is shown in Figure 1, in compliance with CONSORT guidelines. The baseline (initially before the intervention) and initial post-intervention (3 months after the intervention) measurements (e.g., knowledge and skills) were conducted in the high-fidelity simulation setting (follow-up I). In addition, the final follow-up measurements (6 and 24 months after the intervention) were conducted in clinical practice (follow-ups II and III). After the study protocol, however, the control group received a traditional didactic lecture, carried out by the principal author.

The level of participants' knowledge was evaluated at the end of each simulated scenarios using a validated Ventilator Bundle Questionnaire (VBQ). The VBQ contained 5 questions related to the recommended oral care practices (e.g., brush teeth every 12 hours, provide water-based oral moisturizing to oral mucosa and lips every 2–4 hours and as needed) and interventions aimed at reducing the microbiological colonization of the lower airways (e.g., clean the oral cavity and pharynx every 2–4 hours and as needed, use chlorhexidine oral rinse or gel). The method was guided by a blinded research assistant, who arranged an appropriate time and venue to gather the responses. If participant answered correctly, they scored one point, yielding a knowledge score range from 0 to 5 (Jansson *et al*., 2014b).

The level of participants' skills were evaluated while managing adult, invasively ventilated patients using a direct, non-participatory method of observation. Controlled method of observation was conducted during the morning shift (07:00–15:00) in simulation setting and clinical practice. The method was guided by a validated, highly structured Ventilator Bundle Observation Schedule (VBOS) that contained 13 items related to the recommended oral care practices (e.g., brush teeth and tongue with toothbrush, brush approximately 1–2 minutes, use oral chlorhexidine rinse or gel, clean the oral cavity and pharynx every 2–4 hours and as needed, provide water-based oral moisturizing to oral mucosa and lips every 2–4 hours and as needed, rotate position of ETT regularly) and interventions aimed at reducing the microbiological colonization of the lower airways (e.g., elevate the head-of-bed, verify suction pressure and ETT cuff inflation prior to and post oral care, oro- and nasopharyngeal suctioning). Identical measurements were taken for the intervention and control groups by the same trained and experienced observers. If participants adhered to a recommended practice, they were assigned one point, yielding a skill score range from 0 to 13 (Jansson *et al*., 2014b). Discrepancies between the observers were resolved through consensus.

Validity and reliability

Simulation education and its evaluation process were pilot tested among a single cohort of 10 randomly selected critical care nurses in January 2012. The face and content validities of the VBOS and VBQ were evaluated using an expert panel. The item-level content validity indexes (CVIs) ranged from 0.91 to 1.0 while the average scale-level CVIs ranged from 0.99 to 1. In addition, all the items, questions and response alternatives met the chosen clarity criteria (Jansson *et al*., 2014b).

The intraclass correlation coefficient (ICC), including a 95% confidence interval (CI), and the Cohen kappa coefficient (κ) of each item and the average scale score (VBOS) were tested using a second observer during the data collection. The ICC of the average scale score was 0.99 (95% CI 0.98–1.0). In addition, the Cohen κ coefficient of each item varied from 0.65 to 1.0, demonstrating an acceptable level of inter-rater reliability (Jansson *et al*., 2014b).

Data analysis

The statistical analysis was performed using SPSS 18.0 for Windows (SPSS INC., Chicago, IL). The repeatedly measured data was analysed using a linear mixed model with a covariance pattern model (continuous variables) or by generalised linear mixed model (categorical/dichotomous variables). *P* values reported for repeatedly measured data are as follows: p-time (p_t), the overall change over time; p-group (p_g), the average between-group difference; and p-time*group (p_{t*g}), the interaction between time and group. All participants were included in the groups to which they were originally assigned (intention-to-treat analysis). An independent samples t-test was used to compare the median delta scores (baseline score minus final post-intervention score) between the study groups. A two-tailed *P* value less than 0.05 was considered statistically significant.

Ethical considerations

According to the Medical Research Act (488/1999 and amendments 295/2004), the approval of the local ethics committee is not required for studies focusing on healthcare staff. However, the study protocol was approved by the relevant academic centre in the autumn of 2011 and 2013. In addition, written informed consent from participants was obtained prior to inclusion in the study (Declaration of Helsinki 2013).

RESULTS

Thirty (*n* = 30) out of forty (*n* = 40) initially randomized critical care nurses enrolled in the baseline measurements (15 participants per group), of whom seventeen (*n* = 17) completed all the study procedures (Figure 1). Most of the participants were female (70.0%), often with a bachelor's degree (96.7%) and permanent employment (66.7%). Fifty-three per cent of participants' had a less than five years of working experience. There were no significant differences in the baseline characteristics between the study groups. However, the withdrawal rate between the study groups varied from 26.7% (intervention group) to 60.0% (control group). After baseline measurement, the reasons for withdrawal from the intervention group were sudden illness (*n* = 1), job transfer (*n* = 1), declining to participate (*n* = 1) and not known (*n* = 1). The main reasons for withdrawal from the control group were declining to participate (*n* = 3), sudden illness (*n* = 2), other reason (*n* = 2), and job transfer (*n* = 2).

Knowledge

In the baseline measurement, the average knowledge score was 2.2 out of 5 points (SD 0.6) in the both study groups (44.0% of the total score). Majority of participants had poor knowledge of existing oral care protocol (73.3%). However, all of them knew that teeth should be brushed every 12 hours (100.0%). In addition, majority (93.3%) of them knew that oral decontamination using chlorhexidine oral rinse or gel reduces the risk of VAP. However, none of them knew that oral cavity and pharynx should be cleaned and oral mucosa and lips should be moisturized every 2–4 hours and as needed (Table 1).

Twenty-four months after simulation education, the average knowledge score was 2.8 out of 5 points (SD 1.5) in the intervention group (56.0% of the total score) and 1.8 out of 5 points (SD 0.4) in the control group (36.0% of the total score). Significant group ($p_g = 0.002$) and time-group interactions ($p_{t*g} = 0.023$) were identified in the average knowledge scores between the study groups (Table 1). After simulation education, however, the level of knowledge related to oropharyngeal clearance (30.0%) and water-based oral moistening (40.0%) remained low. The median delta knowledge score were 0.0 (25^{th}–75^{th} pct. -1.0–2.0) in the intervention group compared to 0.0 (25^{th}–75^{th} pct. -1.0–0.25) in the control group ($p = 0.43$).

Skills

In the baseline measurement, the average skill score was 5 out of 13 points (SD 1.0) in the intervention group (38.5% of the total score) and 4.9 out of 13 points (SD 2.1) in the control group (37.7% of the total score). In the baseline measurement, majority (78.6%) of patients had their teeth brushed (median duration 16.1 [SD 9.3] seconds), had swab cleaning (92.9%), and had oral decontamination using chlorhexidine oral rinse or gel (64.3%). None of them, however, received water-based oral moisturizer to oral mucosa or lips (Table 2).

Twenty-four months after simulation education, the average skill score was 5.3 out of 13 points (SD 1.5) in the intervention group (40.8% of the total score) and 5.2 out of 13 points (SD 1.7) in the control group (40.0% of the total score). No significant time ($p_t = 0.35$) and group ($p_g = 0.15$) differences or time-group interactions ($p_{t*g} = 0.11$) were identified between the study groups in the average skill scores (Table 2). However, the intervention group had higher skill scores over the whole study period ($p_g = 0.03$). After simulation education, the level of skills related to verification of ETT cuff inflation prior to oral care (30.0%), teeth brushing (45.5%) and water-based oral moistening (9.1%) remained low. The median delta skills score were 0.0 (25^{th}–75^{th} pct. -1–1) in the intervention group compared to 0.0 (25^{th}–75^{th} pct. -2.0–1.0) in the control group ($p = 0.85$).

DISCUSSION

The aim of the study was to evaluate the longitudinal effects of single-dose simulation education with structured debriefing and verbal feedback on critical care nurses' knowledge and skills in adhering to current oral care recommendations. It was hypothesized that the participants who received a simulation education would demonstrate a higher level of knowledge and skills than those who did not receive it. However, the results did not support this experimental hypothesis: 24 months after simulation education, the average knowledge score in the intervention group increased significantly in the final postintervention measurement. However, single-dose simulation education education with structured debriefing and verbal feedback had no impact on critical care nurses' skill scores.

In the baseline measurement, critical care nurses' knowledge and skills in adhering to current oral care recommendations were unacceptably poor, consistent with past literature (DeKeyser *et al*., 2009; Perrie and Scribante 2011; Meherali *et al*., 2011; Chan *et al.*, 2012; Gatell *et al.*, 2012; Javadinia *et al*., 2014; Lin *et al*., 2014). In this study, majority of participants had less than five years working experience, which may partly explain these low baseline values; in the past literature, the level of ICU experience (≥7 years, senior registered nurses, team leaders) have been associated with higher scores. Similarly, age (>30 years), gender (male), the type of ICU and the level of education (bachelor's degree) have been associated with higher scores (Feider *et al*., 2010; Jordan *et al*., 2014; Lin *et al*., 2014).

Unfortunately, poor knowledge leads to uninformed choice of equipment and techniques in oral care. Contrary to recommendations, for example, chlorhexidine oral rinse was diluted with sterile water and toothbrushes were replaced with oral swabs, which may reduce their effectiveness. In our study, however, patients' teeth were brushed and chlorhexidine oral rinse or gel was used more frequently than reported in other studies (Cutler and Davis, 2005; Jordan *et al*., 2014; Lin *et al*., 2014). In Croatia, only 58.1% of critical care nurses decontaminate patients' mouths with chlorhexidine (Jordan *et al*., 2014) even it has been associated with a 40% reduction in the odds of developing VAP (Shi *et al*., 2013). In addition, only 45.2% of them use toothbrushes and toothpaste, which are similar results to those obtained by Lin *et al*. (2014).

Similarity to Gatell *et al.* (2012), significant discrepancies were observed in critical care nurses' knowledge and skills in preventing microaspiration of oropharyngeal secretions which is the primary pathway for VAP (e.g., head-of-bed positioning, verification ETT cuff inflation prior to and post oral care, oro- and nasopharyngeal suctioning). In addition, moistening of the oral mucosa and lips were very rarely observed while in the United States they are used more frequently (Binkley *et al*., 2004).

Similarity to Bingham *et al*. (2010), unit-level education had only a minimal effect on critical care nurses' knowledge and skills in adhering to current oral care recommendations. Despite of increased awareness, there was no significant difference in oral care practices between the study groups after simulation education. However, we found some non-significant improvements in the head-of-bed positioning (60.0% vs. 90.9%), rotate positioning of ETT tube (0% vs. 30%) and verification of ETT cuff inflation post oral care (28.6% vs. 60.0%). In addition, the median duration of teeth brushing increased from 16.1 (SD 9.3) to 32.0 (SD 13.4) seconds in the final post-intervention measurement. During the study, unfortunately, other practices remained unchanged or even decreased.

The variability of findings among the published studies might be the result from the lack of robust evidence and a universal method for outcome measurement (e.g., variations in the research designs, lack of standardized instruments, measurement, and follow-up times). Previous studies have showed that oral care practices have improved significantly (from 33% to 97%) after multidisciplinary and multifaceted approaches (e.g., repeated training sessions including theoretical training and practical exercises, assessment in conjunction with education, encouraging self-learning, reminders, direct feedback), indicating that these approaches may be the best ways to improve learning and clinical outcomes (Cutler and Davis, 2005; Sona *et al.*, 2009; Arroliga *et al.*, 2012; Gatell *et al.*, 2012; Lin *et al*., 2014). Currently critical nurses' oral care knowledge has been learned during their basic nursing education, which is inadequate to respond to the needs of invasively ventilated critically ill adult patients. These global results emphasizes the need for continuing education in this area. For example, only 66–77% of Asian and European nurses perceived that they have adequate oral care training (Rello *et al.*, 2007; Chan *et al.*, 2012). Similarly, the majority of nurses have had some formal training in oral care, but would appreciate an opportunity to improve their knowledge and skills (Rello *et al.*, 2007; Perrie and Scribante 2011; Javadinia *et al*., 2014).

The lack of significant enhancement may also have been attributable to the lack of motivation and self-regulation, which often enhances practioners' learning, performance and transfer of training (Bauer *et al.*, 2016, Orsini *et al.*, 2016). In health professions education, motivation is known to be influenced by education and also by other factors such as work environment (e.g., safety culture, leadership, learning culture, peer support, opportunity to use learned skills) and intra- (e.g., gender, age, personality traits, self-efficacy and expectancy, goal-orientation) and interpersonal (e.g., autonomy-supportive learning climate, timely and constructive feedback, assessment, social pressure) factors (Martin 2010; Orsini *et al.*, 2016). However, getting evidence into practice and implementing clinical guidelines are dependent upon more than practioners' motivation. According to past literature, the main self-reported barriers toward guideline adoption and implementation have been nurse- (e.g., lack of knowledge and skills, limited education, attitudes, beliefs, suspicions and perceptions), environmental- (e.g., lack of time, staff, supplies, guidelines and equipment, workload) and patient-related (e.g., confused or uncooperative patients) factors (Perrie and Scribante 2011; Chan and Ng 2012; Jordan *et al.*, 2014; Javadinia *et al*., 2014) that are likely to be equally influential (Forsner *et al.*, 2010).

Limitations

The lack of significant enhancement of oral care practices may have been attributable to the low statistical power (because of low sample size, small effects or both) which may undermine the reliability of the study findings. The withdrawal rate was higher in the control group compared with the intervention group which may lead to attrition bias. However, the level of skills in the baseline measurement did not differed between participants who completed the entire clinical trial according to the protocol and those who dropped out (data not shown). Due to the lack of baseline characteristics (e.g., years of experience in critical care, qualification), randomization was stratified into two age-based strata to enhance the sample's representativeness. In addition, random sampling, random assignment and use of the control group were used to enhance the external validity of the study. However, the results may not be applicable to different populations, settings or situations.

CONCLUSION

Single-dose simulation education had only a minimal effect on critical care nurses' knowledge and skills in adhering to current oral care recommendations. Despite of increased awareness, there was no significant difference in oral care practices between the study groups after simulation education. Comprehensive oral care programs that improve both the efficiency and efficacy of critical care services should be carefully developed, implemented and regularly evaluated in order to ensure consistency and a high quality of standardized care.

IMPLICATIONS FOR PRACTICE

In clinical practice, certain aspects of oral care (e.g., verify ETT cuff inflation prior to and post oral care, brush teeth approximately 1–2 minutes, clean the oral cavity and pharynx every 2–4 hours and as needed, provide water-based oral moisturizing to oral mucosa and lips every 2–4 hours and as needed), require more reinforcement than others. The need for regularly repeated multidisciplinary and multifaceted educational approaches, updated policies and regular auditing in conjunction with direct feedback is evident. In addition, comprehensive oral care procedures should be incorporated as part of units' orientation to ensure consistency and quality of care.

IMPACTS

What is known about this topic?

- Oral care plays a crucial role in preventing ventilator-associated pneumonia.
- Critical care nurses' knowledge and skills in adhering to current oral care recommendations is insufficient.

What this paper adds?

- Nurse education programs may reduce the risk of developing ventilator-associated pneumonia by increasing critical care nurses' knowledge and skills in adhering to current oral care recommendations.
- Single-dose simulation education with structured debriefing and verbal feedback had only a minimal effect on critical care nurses' knowledge and skills in adhering to current oral care recommendations.
- The need for regularly repeated educational sessions with theoretical training and practical exercises and direct feedback is evident.

REFERENCES

AACN Practice Alert (2010). Oral care for patients at risk for ventilator-associated pneumonia. http://www.aacn.org/wd/practice/docs/practicealerts/oral-care-patients-at-risk-vap.pdf?menu=aboutus Accessed 22 March 2016.

Ames NJ, Sulima P, Yates JM, McCullagh L, Gollins SL, Soeken K, Wallen GR. (2011). Effects of systematic oral care in critically ill patients: A multicenter study. *American Journal of Critical Care*; **20**: e103–e114.

Arroliga AC, Pollard CL, Wilde CD, Pellizzari SJ, Chebbo A, Song J, Ordner J, Cormier S, Meyer T. (2012). Reduction in the incidence of ventilator-associated pneumonia: a multidisciplinary approach. *Respiratory Care*; **57**: 688–696.

Azodo CC, Ezeia EB, Ehizele AO, Ehigiator O. (2013). Oral assessment and nursing interventions among Nigerian nurses-knowledge, practices and educational needs. *Ethiopian Journal of Health Sciences*; **23**: 265–270.

Bauer KN, Orvis KA, Ely K, Surface EA. (2016). Re-examination pf motivation in learning contexts: Meta-analytically Investigating the role type of motivation plays in the prediction of key training outcomes. *Journal of Business and Psychology*; **31**: 33–50.

Bingham M, Ashley J, De Jong M, Swift C. (2010). Implementing a unit-level intervention to reduce the probability of ventilator-associated pneumonia. *Nursing Research*; **59**: S40–S47.

Binkley C, Furr LA, Carrigo R, McCurren C. (2004). Survey of oral care practices in US intensive care units. *American Journal of Infection Control*; **32**: 161–169.

Cason CL, Tyner T, Saunders D, Broome L. (2007). Centers for Disease Control and Prevention. Nurses Implementation of guidelines for ventilator-associated pneumonia from the Centers for Disease Control and Prevention. *American Journal of Critical Care*; **16**: 28–36.

Chan E-Y, IH-L Ng. (2012). Oral care practices among critical care nurses in Singapore: a questionnaire survey. *Applied Nursing Research*; **25**: 197–204.

Conley P, McKinsey D, Graff J, Ramsey AR. (2013). Does an oral care protocol reduce VAP in patients with a tracheostomy? *Nursing*; **43**: 18–23.

Cutler CJ & Davis N. (2005). Improving oral care in patients receiving mechanical ventilation. *American Journal of Critical Care*; **14**: 389–394.

Feider LL, Mitchell P, Bridges E. (2010). Oral care practices for orally intubated critically ill adults. *American Journal of Critical Care*; **19**: 175–183.

Forsner T, Hansson J, Brommels M, Wistedt AÅ, Forsell Y. (2010) Implementing clinical guidelines in psychiatry: a qualitative study of perceived facilitators and barriers. *BMC Psychiatry* **10**: 8.

DeKeyser G F, Fink NF, Raanan O, Asher M, Bruttin M, Nun MB, Benbinishty J. (2009). ICU Nurses' Oral-Care Practices and the Current Best Evidence. *Journal of Nursing Scholarship*; **4**: 132–138.

Garcia R, Jendersky L, Colbert L, Bailey A, Zaman M, Majumder M. (2009). Reducing ventilator-associated pneumonia through advanced oral-dental care: a 48-month study. *American Journal of Critical Care*; **18**: 523–532.

Gatell MRJ, Roig MS, Vian OH, Santin EC, Duaso CT, Moreno IF, Daunis JV. (2012). Assessment of a training programme for the prevention of ventilator-associated pneumonia. *Nursing in Critical Care*; **6**: 285–292.

Hillier B, Wilson C, Chamberlain D, King L. (2013). Preventing ventilator-associated pneumonia through oral care, product selection, and application method. A literature review. *AACN Advanced Critical* Care; **24**: 38–58.

Jansson MM, Kyngäs HA, Kääriäinen MS. (2014a). Effectiveness of human patient simulation education in improving infection control practices – A systematic review. *Journal of Nursing Education and Practice*; **4**: 12–18.

Jansson MM, Ala-Kokko TI, Syrjälä HP, Kyngäs HA. (2014b). Development and psychometric testing of Ventilator Bundle Questionnaire and Observation Schedule. *American Journal of Infection Control*; **42**: 381–384.

Javadinia SA, Kuchi Z, Saadathu A, Tabasi M, Adib-Hajbaghery M. (2014). Oral care in trauma patients admitted to the ICU: Viewpoints of ICU nurses. *Trauma Monthly*; **19**: e15110.

Jordan A, Badovinac A, Spalj S, Par M, Slaj M, Plancak D. (2014). Factors influencing intensive care nurses' knowledge and attitudes regarding ventilator-associated pneumonia and oral care practice in intubated patients in Croatia. *American Journal of Infection Control*; **42**: 1115–1117.

Lin HL, Yang LY, Lai CC. (2014). Factors related to compliance among critical care nurses with performing oral care protocols for mechanically ventilated patients in the intensive care unit. *American Journal of Infection Control*; **42**: 533–535.

Martin HJ. (2010). Workplace climate and peer support as determinants pf training transfer. *Human Resource Development Quarterly*; **21**: 87–104.

Meherali SM, Parpio Y, Ali TS, Javed F. (2011). Nurses' knowledge of evidence-based guidelines for prevention of ventilator-associated pneumonia in critical care areas: A pre and post test design. *Journal of Ayub Medical College Abbottabad*; **23**: 146–149.

Orlandinia GM, Lazzarib CM. (2012). Nursing staff's knowledge about oral care in critically ill patients. *Revista Gaucha Enfermagem*; **33**: 34–41.

Orsini C, Binnie VI, Wilson SL. (2016) Determinants and outcomes of motivation in health professions education: a systematic review based on self-determination theory. *Journal of Educational Evaluation for Health Professions*; **13:** 19.

Perrie H, Scribante J. (2011). A survey of oral care practices in South African intensive care units. *South African Journal of Critical Care*; **2**: 42–46.

Rello J, Koulenti D, Blot S, Sierra R, Diaz E, De Waele JJ, Macor A, Agbaht K, Rodriguez A. (2007). Oral care practices in intensive care units: a survey of 59 European ICUs. *Intensive Care Medicine*; **33**: 1066–1070.

Ross A, Crumpler J. (2007). The impact of an evidence-based practice education program on the role of oral care in the prevention of ventilator-associated pneumonia. Intensive and Critical Care Nursing; **23**: 132–136.

Shi Z, Xie H, Wang P, Zhang Q, Wu Y, Chen E, Ng L, Worthington HV, Needleman I, Furness S. (2013). Oral hygiene care for critically ill patients to prevent ventilator-associated pneumonia. Cochrane Database of Systematic Reviews; **8**: CD008367.

Soh KL, Soh KG, Japar S, Raman RA, Davidson PM. (2011). A cross-sectional study on nurses' oral care practice for mechanically ventilated patients in Malaysia. *Journal of Clinical Nursing*; **20**: 733–742.

Sona CS, Zack JE, Schallom ME, McSweeney M, McMullen K, Thomas J, Coopersmith CM, Boyle WA, Buchman TG, Mazuski JE, Schuerer DJ. (2009). The impact of a simple, low-cost oral care protocol on ventilator-associated pneumonia rates in a surgical intensive care unit. *Journal of Intensive Care Medicine*; **24**: 54–62.

Table 1. Critical care nurses' knowledge of recommended oral care practices before and after simulation education

Recommended practices	Baseline [1]		Follow-up I [1] (3 months after the intervention)		Follow-up II [2] (6 months after the intervention)		Follow-up III [2] (24 months after the intervention)		p_t [3]	p_g [4]	p_{t*g} [5]
	Intervention group (n = 15)	Control group (n = 15)	Intervention group (n = 13)	Control group (n = 12)	Intervention group (n = 13)	Control group (n = 10)	Intervention group (n = 11)	Control group (n = 6)			
Total score (range, 0–5)	2.2 (0.6)	2.2 (0.6)	3.2 (1.1)	1.92 (0.8)	3.0 (1.3)	1.8 (0.8)	2.8 (1.5)	1.8 (0.4)	0.51	0.002	0.023
1. Existing oral care protocol	4 (26.7)	3 (20.0)	8 (23.1)	3 (25.0)	6 (46.2)	0 (0.0)	4 (40.0)	1 (16.7)			
2. Brush teeth every 12 hours	15 (100.0)	13 (86.7)	10 (76.9)	9 (75.0)	11 (84.6)	7 (46.7)	8 (80.0)	4 (66.7)			
3. Clean the oral cavity and pharynx every 2 – 4 hours	0 (0.0)	1 (6.7)	4 (30.8)	2 (16.7)	5 (38.5)	1 (10.0)	3 (30.0)	0 (0.0)			
4. Use chlorhexidine oral rinse or gel	14 (93.3)	14 (93.3)	13 (100.0)	10 (83.3)	11 (84.6)	9 (90.0)	8 (80.0)	6 (100.0)			
5. Provide oral moisturizer every 2 – 4 hours	0 (0.0)	0 (0.0)	4 (15.4)	3 (25.0)	4 (30.8)	0 (0.0)	3 (30.0)	4 (66.7)			

[1] Simulation setting. [2] Clinical practice. NOTE. Values for total score are given as mean (SD). Values (valid percent) for knowledge are presented as n (%). P values reported for repeatedly measured data are as follows: [3] the overall change over time (p_t), [4] the average group difference (p_g), and [5] the interaction between time and group (p_{t*g}). A $P < 0.05$ is considered significant.

Table 2. Critical care nurses' oral care practices before and after simulation education

Practices	Baseline [1]		Follow-up I [1]* (3 months after the intervention)		Follow-up II [2]* (6 months after the intervention)		Follow-up III [2]* (24 months after the intervention)		p_t [3]	p_g [4]	p_{t*g} [5]
	Intervention group (n = 15)	Control group (n = 15)	Intervention group (n = 13)	Control group (n = 12)	Intervention group (n = 13)	Control group (n = 10)	Intervention group (n = 11)	Control group (n = 6)			
Total score (range, 0–13)	5.0 (1.0)	4.9 (2.1)	6.0 (1.2)	5.2 (0.8)	6.7 (1.3)	4.6 (1.9)	5.3 (1.5)	5.2 (1.7)	0.35	0.03	0.11
1. Elevate the head-of-bed	9 (60.0)	10 (66.7)	13 (100.0)	10 (83.3)	13 (100.0)	10 (100.0)	10 (90.9)	5 (83.3)			
2. Verify suction pressure	7 (50.0)	6 (42.9)	7 (53.8)	5 (41.7)	1 (8.3)	0 (0.0)	1 (11.1)	0 (0.0)			
3. Verify ETT cuff inflation prior to oral care	3 (21.4)	0 (0.0)	6 (46.2)	0 (0.0)	5 (38.5)	0 (0.0)	3 (30.0)	2 (40.0)			
4. Swab mouth and palate every 2 – 4 hours	13 (92.9)	8 (57.1)	10 (76.9)	5 (41.7)	11 (84.6)	7 (87.5)	8 (72.7)	4 (80.0)			
5. Brush teeth and tongue with toothbrush	11 (78.6)	11 (78.6)	11 (84.6)	12 (100.0)	12 (92.3)	5 (62.5)	5 (45.5)	2 (50.0)			
6. Brush for approximately 1 – 2 minutes	0 (0.0)	0 (0.0)	1 (9.1)	0 (0.0)	3 (23.1)	1 (12.5)	0 (0.0)	1 (50.0)			
7. Use oral chlorhexidine rinse or gel	9 (64.3)	7 (50.0)	4 (30.8)	4 (33.3)	12 (92.3)	7 (77.8)	6 (54.5)	5 (83.3)			
8. Perform oropharyngeal suctioning	13 (92.9)	14 (100.0)	13 (100.0)	12 (100.0)	13 (100.0)	9 (100.0)	11 (100.0)	6 (100.0)			
9. Perform nasopharyngeal suctioning	6 (42.9)	8 (53.3)	4 (30.8)	5 (41.7)	3 (23.1)	3 (33.3)	4 (36.4)	2 (33.3)			
10. Rotate position of ETT regularly	0 (0.0)	1 (14.3)	0 (0.0)	0 (0.0)	3 (23.1)	0 (0.0)	3 (30.0)	1 (16.7)			
11. Apply oral moisturizer to oral mucosa	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (9.1)	0 (0.0)			
12. Apply oral moisturizer to lips	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (23.1)	0 (0.0)	0 (0.0)	0 (0.0)			
13. Verify ETT cuff inflation post oral care	4 (28.6)	6 (42.9)	4 (26.7)	5 (41.7)	8 (61.5)	4 (50.0)	6 (60.0)	3 (60.0)			

[1] Simulation setting. [2] Clinical practice. NOTE. Values for total score are given as mean (SD). Values (valid percent) for knowledge are presented as n (%). P values reported for repeatedly measured data are as follows: [3] the overall change over time (p_t), [4] the average group difference (p_g), and [5] the interaction between time and group (p_{t*g}). A $P < 0.05$ is considered significant.