Approaches and adjuncts used by physiotherapists when suctioning adult patients who are intubated and ventilated in intensive care units in Australia and New Zealand: a cross-sectional survey

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Abstract

Background: Suctioning is an integral component of care for patients who are intubated and ventilated in an intensive care unit (ICU). There appears to be no published data of physiotherapy suctioning practices in Australia or New Zealand.

Objective: To describe suctioning practices and the factors which have shaped these practices, of experienced physiotherapists working with adults who are intubated and ventilated in an ICU across Australia and New Zealand. Areas of investigation focused on: (i) suctioning approach (i.e. open vs. closed system); (ii) use of adjuncts to suctioning such as hyperoxygenation, hyperinflation and saline lavage; (iii) use of subglottic suctioning and; (iv) factors influencing suctioning practices.

Methods: Electronic surveys were emailed to experienced physiotherapists working in ICUs across Australia and New Zealand which had the capacity to intubate and ventilate adult patients for ≥ 24 hours.

Results: The participation rate was 84.8% (112/132). Closed suction system was used in most ICUs (97/112, 86.6%). Hyperoxygenation was commonly performed on 'all' or 'most' patients *before* suctioning (71/112, 63.4%), but less frequently *after* suctioning (38/112, 33.9%). Hyperinflation was infrequently performed on 'all' or 'most' patients *before* (22/112, 19.6%) or *after* suctioning (22/112, 19.6%). Saline lavage and subglottic suctioning were infrequently performed on 'all' or 'most' patients (3/112, 2.7%; 17/112, 15.2%, respectively). 'Personal experience' and 'established practice in the ICU' had the greatest influence on suctioning practices.

Conclusions: Most ICUs in Australia and New Zealand are equipped for closed system suctioning. As hyperoxygenation minimises desaturation during suctioning, there may be scope for a larger proportion of physiotherapists to use this adjunct. The practice of hyperinflation before and after suctioning was uncommon despite the emerging evidence for improved lung compliance with this procedure. Subglottic suctioning was infrequently available as a choice for physiotherapists despite the strong evidence, which suggests an evidence-practice gap.

Keywords: Endotracheal; Health care surveys; Intensive care; Physiotherapy; Suction

1. Introduction

Suctioning is a procedure that involves the use of negative pressure to remove secretions from the airway.[1, 2] It is an integral component of care for patients who are intubated and ventilated in an intensive care unit (ICU).[1] Nevertheless, it is often a painful and distressing experience and places the patient at risk of oxygen desaturation, reduced lung compliance, infection, and untoward cardiovascular responses.[2-5] Various approaches and adjuncts to suctioning have been trialed to mitigate these risks. Regarding approaches, both the open suction system (OSS) and closed suction system (CSS) may be available to use in an ICU. An OSS approach involves either completely disconnecting the patient from the ventilator to introduce the suction catheter into the airway, or introducing the suction catheter into the airway through a self-sealing port which assists in preserving positive end-expiratory pressure.[1] In contrast, a CSS approach or 'in-line' suctioning, involves using a suction catheter in an enclosed plastic sleeve, which is integrated into the ventilatory circuit. These suction catheters, enclosed in their sleeves, are often left in place for up to 72 hours.[1, 6] There is emerging evidence that, compared with OSS, CSS reduces the risk of ventilator-associated pneumonia (VAP)[7] but does not influence oxygenation, duration of mechanical ventilation, length of ICU stay, or mortality.[1, 6-9]

In addition to different suctioning approaches, adjuncts such as the use of hyperoxygenation, hyperinflation and saline lavage, are available to mitigate risk and/or optimise sputum yield. There is strong evidence that hyperoxygenation performed before, during and after suctioning helps to minimise desaturation after suctioning.[1, 10, 11] Hyperinflation implemented before and after suctioning has been shown to improve lung compliance following suctioning,[1] and there is some evidence that saline lavage will increase sputum yield, although it is unclear whether or not it increases the incidence of VAP.[12, 13] Regarding equipment, some ICUs facilitate subglottic suctioning, which involves removing secretions that have pooled above the cuff of the endotracheal tube, through the use of a specially designed endotracheal tube with a separate dorsal lumen that opens directly above the endotracheal tube cuff.[1, 14] There is evidence that subglottic suctioning reduces the risk of VAP, duration of mechanical ventilation, and length of ICU stay.[14, 15]

To date, there appears to be no published data of the approach and adjuncts to suctioning used by physiotherapists working in ICUs across Australia or New Zealand (NZ). As such, it is difficult to ascertain whether evidence is shaping current suctioning practices, so that safety and effectiveness of the procedure are optimised. Therefore, the aim of this study was to report the current suctioning practices of experienced physiotherapists working with adult patients who are intubated and ventilated in an ICU in Australia or NZ. The scope of this investigation was limited to: (i) the use of OSS vs. CSS; (ii) the use of adjuncts to suctioning such as hyperoxygenation, hyperinflation and saline lavage; (iii) the use of subglottic suctioning and; (iv) factors that have shaped suctioning practices.

2. Materials and methods

2.1. Study design

A cross-sectional observational study was conducted across Australia and NZ with data collection taking place between January 2014 and March 2014. Ethical approval was obtained from the Human Research Ethics Committee at xxx.

2.2. Setting and eligibility criteria

A list of ICUs in Australia and NZ were identified via the Australian and NZ Intensive Care Society Centre for Outcome Resource Evaluation database[16] and the National Health Performance Authority of Australia website.[17] Hospitals from this list with the capacity to intubate and ventilate adult patients for ≥ 24 hours were eligible for inclusion. Hospitals were excluded if the ICU accommodated primarily a neonatal or paediatric case mix. Staff at each hospital were contacted via telephone to confirm that their ICU met the eligibility criteria.

For hospitals that met the study criteria, the manager of the Physiotherapy Department was contacted either via telephone or email, and asked to provide the contact details of the physiotherapist with the most experience in this clinical area who maintained a clinical caseload in the ICU. This physiotherapist was then invited to participate in this study and provided with a participant information sheet via email. Each physiotherapist was asked to complete an electronic survey within two weeks. Return of the completed survey was implied as consent to participate in the study. Participants were

informed that on completion of data collection, prior to analysis, data would be saved in a de-identified format.

2.3. Optimising the participation rate

A modified Dillman approach was used to optimise participation rate,[18] as this has been demonstrated to be effective in other studies.[19, 20] Reminder emails were sent every two weeks until such time as the survey had been completed. A maximum of three reminders were sent to the physiotherapist, followed by one reminder email to the manager of the Physiotherapy Department as a last attempt to facilitate participation.

2.4. Survey format and variables

An electronic (i.e. online) survey was developed using the Qualtrics survey software program (see online supplement for a copy of the survey).[21] In order to optimise readability and face validity, the survey was piloted by five experienced cardiopulmonary physiotherapists prior to use. The final survey comprised four sections and a total of 44 questions. Sections 1 and 2 included questions pertaining to the characteristics of the ICU and physiotherapists who completed the survey, respectively. Section 3 focused on the factors that shaped the suctioning practices (entry level training, textbooks, established practice in ICU, published journal articles, personal experience, professional development and postgraduate education). Section 4 included questions pertaining to OSS vs. CSS, adjuncts (hyperoxygenation, hyperinflation and saline lavage) and whether or not subglottic suctioning was available to the physiotherapist. The responses to most questions were in the format of a 5-point Likert scale (e.g. 'All patients', 'Most patients', 'Some patients', 'A few patients' or 'None of the patients'). A small proportion of questions were in the format of multiple choice or open-ended responses.

2.5. Data analysis

Categorical data were expressed in terms of count, frequency and proportions. Free text was analysed by development of themes and reported qualitatively. To facilitate interpretation of data

obtained in Section 4 of the survey, responses of 'all' and 'most' were collapsed and reported together. This is because a response of 'all' and most' to any question in this section indicated that the physiotherapist applied the approach in the majority of patients. As this study was descriptive and did not test any hypotheses, no sample size calculations were undertaken.

3. Results

3.1. Pilot study

In response to piloting of the survey, eight questions were changed to improve the face validity and two questions were altered to improve the readability.

3.2. Participation rate

Results of the screening process and final participation rate are summarised in Fig. 1. Briefly, 136 hospitals were identified as meeting the eligibility criteria. However, on four occasions, one physiotherapist covered two hospitals. This occurred where the publically- and privately-funded hospitals were covered by the same experienced physiotherapist. Therefore, participation from 132 physiotherapists would have provided information on suctioning practices at 136 hospitals. In total, 112 surveys were completed, resulting in a participation rate of 84.8% (112/132).

3.3. Characteristics of ICUs

The representation of ICUs across Australia and NZ is shown in Table 1. Responses showed that the highest proportion of ICUs had between one and 10 ventilator-capable beds (67/112, 59.8%) and the lowest proportion of ICUs had more than 30 ventilator-capable beds (5/112, 4.5%). There were 30 ICUs with between 11 and 20 ventilator-capable beds (30/112, 26.8%), and 10 ICUs with between 21 and 29 ventilator-capable beds (10/112, 8.9%). The majority of ICUs (58/112, 51.8%) provided daytime physiotherapy services only, while 36 (36/112, 32.1%) provided daytime physiotherapy services in conjunction with on call services in the evening and overnight. Only one ICU provided a 24-hour physiotherapy service (1/112, 0.9%).

3.4. Characteristics of physiotherapists who participated in the survey

Most physiotherapists had more than five years of experience with a cardiopulmonary caseload (84/112, 75.0%). A large proportion of physiotherapists had a bachelor degree or an entry level diploma as their highest level of qualification (86/112, 76.8%). The remaining physiotherapists had a post-graduate physiotherapy degree (15/112, 13.4%), a doctorate degree (4/112, 3.6%) or an Australian Physiotherapy Association titled cardiopulmonary physiotherapy qualification or equivalent specialisation in cardiopulmonary physiotherapy (7/112, 6.3%). The majority of physiotherapists (94/112, 83.9%) had worked in two or more ICUs.

3.5 Open vs. closed system approach

A large proportion of physiotherapists indicated that their ICU predominantly used CSS (97/112, 86.6%). Of the 97 physiotherapists who primarily used CSS, 63 did not use the OSS for any of their patients (63/97, 64.9%). For those physiotherapists who occasionally used OSS, the reasons given were medical team decision (8/18, 44.4%) and if the endotracheal tube was too small for CSS (4/18, 22.2%). For those who used OSS, 35 (35/63, 55.6%) used a sterile technique and 28 (28/63, 44.4%) used a clean technique.

3.6. Adjuncts to suctioning

The proportion of patients for which physiotherapists used adjuncts to suctioning are outlined in Table 2. The reasons for performing and not performing these adjuncts to suctioning are summarised in Table 3.

Hyperoxygenation *before* suctioning was performed on ‘all’ or ‘most’ patients by approximately two-thirds of physiotherapists (71/112, 63.4%). Hyperoxygenation *after* suctioning was performed on ‘all’ or ‘most’ patients by approximately one-third of physiotherapists (38/112, 33.9%). The most common duration for hyperoxygenation was one to two minutes (49/112, 43.8%). Hyperoxygenation was less frequently performed for 30 to 60 seconds (20/112, 17.9%), more than two minutes (19/112, 17.0%) or for one to 30 seconds (10/112, 8.9%).

Hyperinflation was not commonly performed on ‘all’ or ‘most’ patients *before* (22/112, 19.6%) or *after* suctioning (22/112, 19.6%). Different methods of hyperinflation were used: manual hyperinflation (MHI) (50/112, 44.6%); ventilator hyperinflation (VHI) (25/112, 22.3%) and both techniques (18/112, 16.0%).

Saline lavage was infrequently used on ‘all’ or ‘most’ of the patients (3/112, 2.7%).

3.7. Subglottic suctioning

Subglottic suctioning was performed on ‘all’ or ‘most’ of the patients by a small proportion of physiotherapists (17/112, 15.2%).

3.8. Factors shaping suctioning practices

The two most commonly reported factors that shaped suctioning practices in the ICU by ‘a lot’ or ‘very much’ were ‘personal experience’ and ‘established practice in the ICU'. ‘Text books’ and ‘entry level training’ were factors that were considered to have the least influence on their suctioning practices. The data are shown in Fig. 2.

4. Discussion

This is the first study to describe the suctioning practices (i.e. approach and use of adjuncts) by physiotherapists working in ICUs across Australia and NZ. This information will allow physiotherapists to benchmark their practices with that of others in Australia and NZ. The novel findings of this study are: (i) CSS was predominantly used in the ICUs (86.6%); (ii) hyperoxygenation was commonly performed on ‘all’ or ‘most’ patients *before* suctioning (63.4%); but less frequently *after* suctioning (33.9%); (iii) hyperinflation was not commonly performed on ‘all’ or ‘most’ patients *before* (19.6%) or *after* suctioning (19.6%); (iv) the use of saline lavage (2.7%) and subglottic suctioning (15.2%) were infrequently performed on ‘all’ or ‘most’ patients and; (v) ‘personal experience’ and ‘established practice in the ICU’ had the greatest influence on suctioning practices.

4.1. Open vs. closed system approach

The use of CSS is recommended for adults with high oxygen requirements or high risk for lung de-recruitment, as it facilitates continuous mechanical ventilation and oxygenation during the suctioning event.[3, 20] Prior to 2010, three meta-analyses had pooled data from between five and 11 trials to compare outcomes between OSS and CSS approaches and demonstrated no differences in terms of the incidence of VAP, oxygenation, length of ICU stay and mortality.[1, 6, 8] These data are consistent with individual randomised studies published after 2010 which also reported that the incidence of VAP was similar between CSS and OSS.[22, 23] Nevertheless, a large meta-analysis published in 2015 which included data from 16 randomised studies (n=1,929), demonstrated that CSS reduced the risk of VAP compared with OSS (relative risk 0.69, 95% confidence interval 0.54 to 0.87), but did not change the duration of mechanical ventilation or mortality.[7] Data collected in the current study demonstrated that ICUs in Australia and NZ predominantly utilise the CSS approach.

4.2. Adjuncts to suctioning

The American Association for Respiratory Care Clinical Practice Guidelines recommend hyperoxygenation *before* suctioning if the patient has a clinically important reduction in oxygen saturation with suctioning.[24] Systematic reviews and meta-analyses have shown that hyperoxygenation is effective in maintaining oxygenation levels, as it elevates the partial pressure of oxygen in arterial blood.[1, 10] This technique was associated with no adverse effects[1, 10] and therefore, experts recommend that hyperoxygenation be performed before suctioning.[25] Data collected in this study indicated that only just over half of the physiotherapists (63.4%) frequently performed hyperoxygenation *before* suctioning, and less than half of the physiotherapists commonly used this adjunct *after* suctioning (33.9%). Given that hyperoxygenation is both a low cost and low risk adjunct to suctioning, and desaturation is a common outcome of suctioning patients in the ICU,[26-28] there may be scope to increase its utilisation among physiotherapists.

Hyperinflation was not commonly performed *before* or *after* suctioning despite the emerging evidence that it may improve lung compliance.[1, 29, 30] Although barotrauma has been suggested to be an associated risk of hyperinflation,[4, 25] it was not reported in this study as one of the reasons physiotherapists were not utilising this adjunct. Rather, ‘lack of evidence’ and ‘ICU policy’ were more

commonly reported reasons for not using this adjunct. A knowledge translation strategy that highlights the emerging evidence for hyperinflation as an adjunct to suction may be needed to increase utilisation of this technique.

Saline lavage was not commonly performed in ICUs in Australia and NZ, with 83.0% of physiotherapists (93/112) using it on 'a few' or 'none' of the patients. This is consistent with the results of an earlier study that reported 94.7% (18/19) of experienced physiotherapists in NZ used saline lavage for 'under 50% of patients' or 'never used' this technique in patients who were intubated and ventilated.[31] Although there is minimal evidence that saline lavage will increase sputum weight,[10] a survey of respiratory physiotherapists in the United Kingdom revealed that they perceived saline lavage was indicated prior to suctioning when there was persistent retention of thick or tenacious secretions which were affecting ventilatory status, such as the presence of atelectasis or the obstruction of the endotracheal tube/tracheostomy.[32] It is unclear whether or not saline lavage leads to unfavourable outcomes such as VAP and hemodynamic changes.[13, 33] Overall, the lack of clear evidence for saline lavage suggests that this technique should not be used routinely during suctioning.[3, 13, 25, 33] Responses to the open-ended questions revealed that physiotherapists were aware of the lack of high quality evidence for this technique.

4.3. Subglottic suctioning

Subglottic suctioning was infrequently available as a choice for most physiotherapists, with the main reasons identified as 'a lack of appropriate endotracheal tubes' and 'current practice in the ICU'. This highlights the fact that, unlike the use of adjuncts such as hyperoxygenation, hyperinflation and saline lavage which physiotherapists may choose to use at the bedside, the capacity for physiotherapists to utilise subglottic suctioning is contingent on the availability of suitable equipment, which reflects usual practice within the organisation rather than a personal choice. A meta-analysis established that subglottic suctioning was associated with a reduced risk of VAP, shorter duration of mechanical ventilation (two days), and decreased length of ICU stay (three days).[14] Five recent studies, which were not included in the meta-analysis, also reported a significant reduction in the incidence of VAP with the use of subglottic suctioning.[15, 22, 34-36] Further studies which present an economic analysis

of weighing the cost of purchasing and using the appropriate equipment against the benefit in reducing the incidence of VAP may assist in the increased utilisation of this adjunct.

4.4. Factors shaping suctioning practices

Current suctioning practices were shaped largely by historical precedent, as 'personal experience' and 'established practice in the ICU' were most commonly ranked as the two strongest influencing factors of suctioning practices in the ICU. This is perhaps not surprising as ICUs often have a well-established local culture for common interventions, such as suctioning. Successful behaviour change is difficult to achieve. Given the evidence for subglottic suctioning, the limited uptake of this approach would appear to be an evidence-practice gap. For ICUs to increase the use of subglottic suctioning, a four-step framework may be used, which involves: (i) identifying who needs to do what differently; (ii) using the Theoretical Domains Framework[37] to understand determinants of behaviour which serve as barriers to or enablers to increase the availability of subglottic suctioning; (iii) selecting specific behaviour change techniques to overcome modifiable barriers and enhance enablers and; (iv) developing a method to assess the behavior change.[38] Recent work indicates that there is increased familiarity with the Theoretical Domains Framework amongst healthcare professionals working in the area of implementation science[39] and its use in future research would facilitate a systematic approach to identifying determinants of behaviour which underpin suctioning practices.

4.5. Strengths and limitations

This is the first study to report current suctioning practices related to approaches and adjuncts, and the factors that have shaped these practices amongst experienced physiotherapists working in ICUs across Australia and NZ. The high participation rate coupled with wide geographical representation suggests that these data are highly representative of current practice in Australia and NZ. By informing the participants that their responses would be stored in a de-identified format, we were likely to have minimised social desirability bias. Nevertheless, the survey sought responses from one experienced physiotherapist working in each of the ICUs and therefore the results may not be

reflective of the suctioning practice by others in the ICU. Further, although these data were collected more than two years ago, it is likely that they are reflective of current practice as: (i) suctioning practices were largely shaped by historical precedent (which is established over several years) and; (ii) there has been no significant change in the equipment available for suctioning over the last two years.

5. Conclusion

Data collected in this study demonstrated that ICUs in Australia and NZ predominantly utilise the CSS approach. There may be scope to increase utilisation of specific suctioning adjuncts such as hyperoxygenation and hyperinflation by physiotherapists working in ICUs across Australia and NZ. There was limited availability of equipment to facilitate subglottic suctioning and this appears to be an evidence-practice gap. To address this issue, consideration should be given to identify what factors influence the uptake of subglottic suctioning and other evidence-based suctioning practices.

Conflict of interest

None.

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References

1 Overend TJ, Andersen CM, Brooks D, et al. Updating the evidence base for suctioning adults patients: A systematic review. *Can Respir J*. 2009;**16**(3):6-17.

2 Brooks D, Anderson CM, Carter MA, et al. Clinical practice guidelines for suctioning the airway of the intubated and nonintubated patient. *Can Respir J*. 2001;**8**(3):163-181.

3 Chaseling W, Bayliss S-L, Rose K, et al. Agency for Clinical Innovation NSW Government. Suctioning an adult ICU patient with an artificial airway. *Agency for Clinical Innovation NSW Government*. 2014. Available at: https://www.aci.health.nsw.gov.au/__data/assets/pdf_file/0010/239554/ACI14_Suction_2-2.pdf. Accessed November 5, 2016.

4 Pedersen CM, Rosendahl-Nielsen M, Hjermind J, Egerod I. Endotracheal suctioning of the adult intubated patient- What is the evidence? *Intensive and Criti Care Nurs*. 2009;**25**(1):21-30.

5 Thompson L. Suctioning adults with an artificial airway: a systematic review. *The Joanna Briggs Institute for Evidence Based Nursing and Midwifery*. 2000;**9**(1):1-95.

6 Jongerden IP, Rovers MM, Grypdonck MH, Bonten MJ. Open and closed endotracheal suction systems in mechanically ventilated intensive care patients: A meta-analysis. *Crit Care Med*. 2007;**35**(1):267-270.

7 Kuriyama A, Umakoshi N, Fujinaga J, Takaada T. Impact of closed versus open tracheal suctioning systems for mechanically ventilated adults: a systematic review and meta-analysis. *Intensive Care Med*. 2015;**41**(3):402-411.

8 Subirana M, Solà I, Benito S. Closed tracheal suction systems versus open tracheal suction systems for mechanically ventilated adult patients. *Cochrane Database of Syst Rev*. 2007.

9 Favretto DO, Silveira RCdCP, Canini SRMdS, et al. Endotracheal suction in intubated critically ill adult patients undergoing mechanical ventilation: a systematic review. *Rev Lat-Am Enferm*. 2012;**20**(5):997-1007.

10 Oh H, Seo W. A meta-analysis of the effects of various interventions in preventing endotracheal suction-induced hypoxemia. *J Clin Nurs*. 2003;**12**(6):912-924.

11 Demir F, Dramali A. Requirement for 100% oxygen before and after closed suction. *J Adv Nur*. 2005;**51**(3):245-251.

12 Caruso P, Denari S, Ruiz SAL, et al. Saline instillation before tracheal suctioning decreases the incidence of ventilator-associated pneumonia. *Crit Care Med*. 2009;**37**(1):32-38.

13 Paratz JD, Stockton KA. Efficacy and safety of normal saline instillation: A systematic review. *Physiotherapy*. 2009;**95**(6):241-250.

14 Dezfulian C, Shojania K, Collard HR, et al. Subglottic secretion drainage for preventing ventilator-associated pneumonia: A meta-analysis. *AM J Med*. 2005;**118**(1):11-18.

15 Gujadhur R, Helme BW, Sanni A, Dunning J. Continuous subglottic suction is effective for prevention of ventilator associated pneumonia. *Interact Cardiovas Thorac Surg*. 2005;**4**(2):110-115.

16 Australia and New Zealand Intensive Care Society (ANZICS) Centre for Outcome and Resource Evaluation (CORE) Annual Report 2010-2011. Melbourne: 2013 1-876980-68-0. Available at: http://www.anzics.com.au/Downloads/ANZICS%20CORE%20Annual%20Report%202011.pdf. Accessed March 9, 2013.

17 National Health Performance Authority. My hospitals-intensive care unit. Sydney, Australia: Commonwealth of Australia 2014; 2014. Available at: http://www.myhospitals.gov.au/search-service/results?searchTerm=Intensive care unit. Accessed March 9, 2013.

18 Dillman D. Mail and internet surveys: the tailored design method. 2nd ed. New York: John Wiley & Sons Inc; 2000.

18 Cavalheri V, Jenkins S, Hill K. Physiotherapy practice patterns for patients undergoing surgery for lung cancer: a survey of hospitals in Australia and New Zealand. *Intern Med J*. 2013;**43**(4):394-401.

20 Harth L, Stuart J, Montgomery C, et al. Physical therapy practice patterns in acute exacerbations of chronic obstructive pulmonary disease. *Can Resp J*. 2009;**16**(3):86-92.

21 Qualtrics Provo, Utah, USA. 2014. Available at: http://www.qualtrics.com/. Accessed April 8, 2013.

22 Hamishekar H, Shadvar K, Taghizadeh M, et al. Ventilator-associated pneumonia in patients admitted to intensive care units, using open or closed endotracheal suctioning. *Anesth Pain Med*. 2014;**4**(5):e21649.

23 Hlinková E, Nemcová J, Bielená K. Closed versus open suction system of the airways in the prevention of infection in ventilated patients. *Cent Eur J Nurs Midwifery*.2014;**5**(2):63-71.

24 American Association for Respiratory Care. AARC clinical practice guidelines- endotracheal suctioning of mechanically ventilated patients with artificial airways 2010. *Respir Care*. 2010;**55**(6):758-764.

25 Hanekom S, Berney S, Morrow B, et al. The validation of a clinical algorithm for the prevention and management of pulmonary dysfunction in intubated adults - a synthesis of evidence and expert opinion. *J Eval Clin Pract*. 2010;**17**(4):801-810.

26 Gosselink R, Bott J, Johnson M, et al. Physiotherapy for adult patients with critical illness; recommendations of the european respiratory society and european society of intensive care medicine task force on physiotherapy for critically ill patients. *Intensive Care Med.* 2008;**34**(7):1188-1199.

27 Maggiore S, Lellouche F, Pigeot J, et al. Prevention of endotracheal suctioning-induced alveolar derecruitment in acute lung injury. *Am J Respir Crit Care Med*. 2003;**167**(9):1215-1224.

28 Sakuramoto H, Shimojo N, Jesmin S, et al. Repeated open endotracheal suctioning causes gradual desaturation but does not exacerbate lung injury compared to closed endotracheal suctioning in a rabbit model of ARDS. *BMC Anesthesiology*. 2013;**13**(1):47.

29 Lemes DA, Zin WA, Guimaraes FS. Hyperinflation using pressure support ventilation improves secretion clearance and respiratory mechanics in ventilated patients with pulmonary infection: A randomised crossover trial. *Aust J Physiother*. 2009;**55**(4):249-254.

30 Stiller K. Physiotherapy in intensive care: an updated systematic review. *Chest.* 2013;**144**(3):825-847.

31 Reeve JC, Davies N, Freeman J, O'Donovan B. The use of normal saline instillation in the intensive care unit by physiotherapists: a survey of practice in New Zealand. *New Zeal J Physiotherapy*. 2007;**35**(3):119-125.

32 Roberts F. Consensus among physiotherapists in the United Kingdom on the use of normal saline instillation prior to endotracheal suction: a Delphi study. *Physiotherap Can.* 2009;**61**(2):107-115.

33 Caparros AS, Forbes A. Mechanical ventilation and the role of saline instillation in suctioning adult intensive care unit patients. *Dimens Crit Care Nurs*. 2014;**3**3(4):246-253.

34 Bouza E, Pérez MJ, Muñoz P, et al. Continuous aspiration of subglottic secretions in the prevention of ventilator-associated pneumonia in the postoperative period of major heart surgery. *Chest*. 2008;**134**(5):938-946.

35 Juneja D, Javeri Y, Singh O, et al. Comparing influence of intermittent subglottic secretions drainage with/without closed suction systems on the incidence of ventilator associated pneumonia. *Indian J Crit Care Med*. 2011;**15**(3):168-172.

36 Safdari R, Yazdannik A, Abbasi S. Effect of intermittent subglottic secretion drainage on ventilator-associated pneumonia: a clinical trial. *Iran J Nurs Midwifery Res*. 2014;**19**(4):376-380.

37 Cane J, O'Connor D, Michie S. Validation of the theoretical domains framework for use in behaviour change and implementation research. *Implement Sci*. 2012;**7**(37):1-17.

38 French SD, Green SE, O'connor DA, et al. Developing theory-informed behaviour change interventions to implement evidence into practice: a systematic approach using the Theoretical Domains Framework. *Implement Sci*. 2012;**7**(1):38:1-8.

39 Phillips CJ, Marshall, AP, Chaves NJ, et al. Experiences of using the Theoretical Domains Framework across diverse clinical environments: a qualitative study. *J Multidiscip Healthc*. 2015;**8**(1):139-146

Figure captions

Fig. 1. Flow chart illustrating the process of screening and determining the participation rate.

Fig. 2. Factors influencing suctioning practices of physiotherapists in Australian and New Zealand intensive care unit.

Table 1.

Representation of intensive care units across Australia and New Zealand in the survey results

Location	No. of eligible ICUs	No. of eligible publically-funded ICUs	No. of eligible privately-funded ICUs	No. of ICUs included in survey n (%)
NSW*	45	34	11	33 (73.3%)
VIC	25	15	10	23 (92.0%)
QLD*	22	13	9	20 (90.9%)
SA*	10	7	3	10 (100.0%)
WA	7	3	4	6 (85.7%)
ACT	4	2	2	4 (100.0%)
TAS	3	2	1	3 (100.0%)
NT	2	0	2	2 (100.0%)
NZ	18	18	0	15 (83.3%)
Total	136	94	42	116 (85.2%)

ACT=Australian Capital Territory, ICU=intensive care unit, NSW=New South Wales, NT=Northern Territory, NZ=New Zealand, QLD=Queensland,

SA=South Australia, TAS=Tasmania, VIC=Victoria, WA=Western Australia.

[*] In four instances, there were two hospitals covered by the same physiotherapist. This occurred where the publically-funded and privately-funded hospitals were covered by the same physiotherapist. In NSW, there were 45 eligible hospitals and responses were obtained from 33 physiotherapists who reported data across 34 hospitals. In QLD, there were 22 eligible hospitals and responses were obtained from 19 physiotherapists who reported data across 22 hospitals. In SA, there were 10 eligible hospitals and responses were obtained from nine physiotherapists who reported data across 10 hospitals. In total, data pertaining to 116 ICUs were obtained, but only 112 surveys completed.

Table 2.

Proportion of patients for which physiotherapists used hyperoxygenation, hyperinflation, saline lavage, subglottic suctioning and lubricating gel

n=112 (%) Adjuncts	All patients, n (%)	Most patients, n (%)	Some patients, n (%)	A few patients, n (%)	None of the patients, n (%)	Not applicable, n (%)
Hyperoxygenation before suctioning	43 (38.3%)	28 (25.0%)	19 (16.9%)	16 (14.2%)	6 (5.3%)	0 (0.0%)
Hyperoxygenation during suctioning	38 (33.9%)	26 (23.2%)	16 (14.2%)	19 (16.9%)	13 (11.6%)	0 (0.0%)
Hyperoxygenation after suctioning	27 (24.1%)	11 (9.8%)	21 (18.7%)	41 (36.6%)	12 (10.7%)	0 (0.0%)
Hyperinflation before suctioning	6 (5.3%)	16 (14.2%)	30 (26.7%)	29 (25.8%)	31 (27.6%)	0 (0.0%)
Hyperinflation after suctioning	10 (8.9%)	12 (10.7%)	20 (17.8%)	28 (25.0%)	42 (37.5%)	0 (0.0%)
Use of saline lavage before suctioning	2 (1.7%)	1 (0.8%)	16 (14.2%)	45 (40.1%)	48 (42.8%)	0 (0.0%)
Subglottic suctioning	10 (8.9%)	7 (6.2%)	10 (8.9%)	27 (24.1%)	58 (51.7%)	0 (0.0%)
Use of lubricating gel during open suction	0 (0.0%)	4 (3.5%)	3 (2.6%)	12 (10.7%)	35 (31.2%)	58 (51.7%)

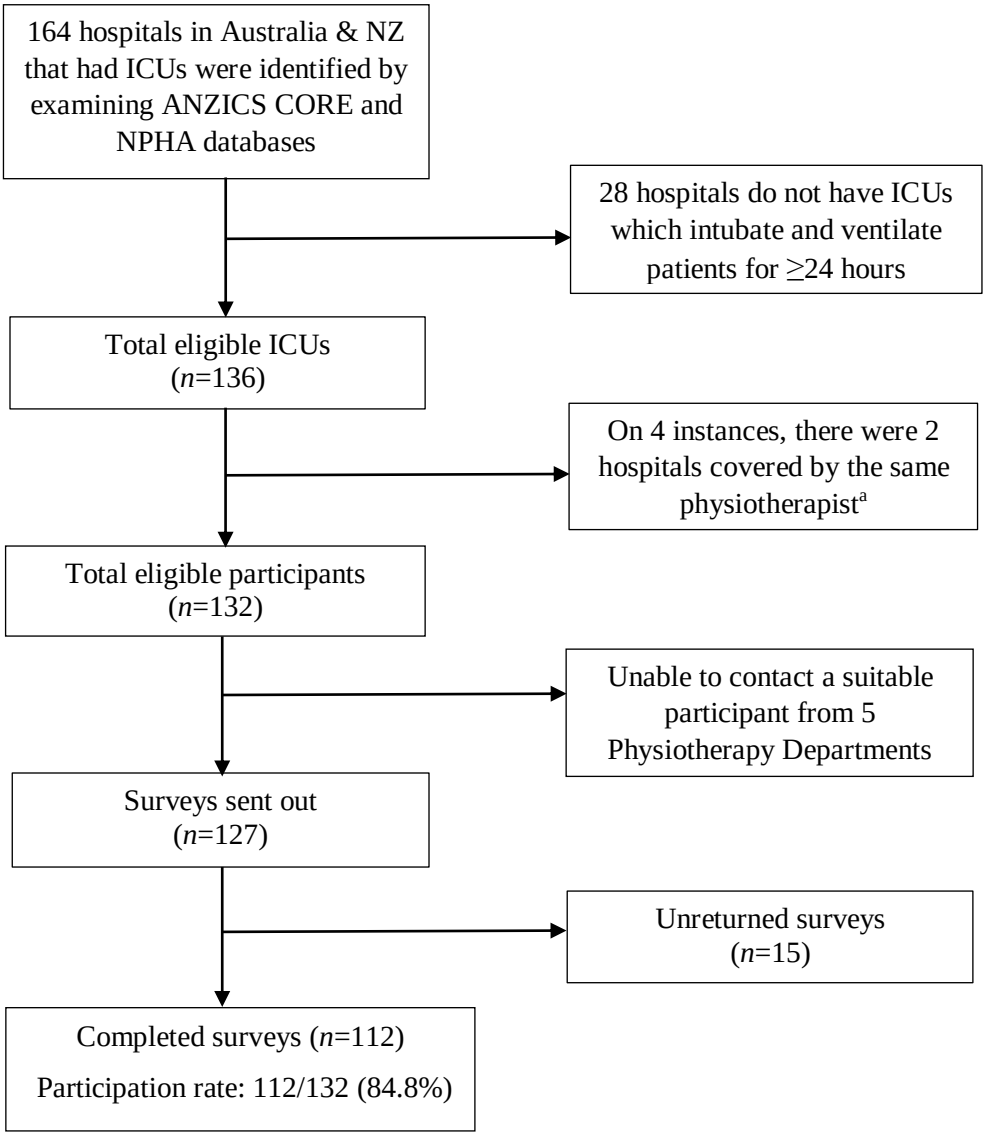
Table 3.

Reasons for performing or not performing hyperoxygenation, hyperinflation, saline lavage and subglottic suctioning

Suctioning adjunct	Most frequently reported reasons given for performing (n, %)	Most frequently reported reasons given for not performing (n, %)
Hyperoxygenation before suctioning	Poor oxygen saturation levels (27/59, 45.7%) Prevention of desaturation (18/59, 30.5%)	ICU policy (2/6, 33.3%) Lack of evidence (2/6, 33.3%) A perceived lack of clinical need (1/6, 16.6%)
Hyperoxygenation after suctioning	Significant desaturation with oxygen level not returning to pre-suctioning values (58/69, 84.0%)	A perceived lack of clinical need (5/10, 10.0%) Lack of evidence (4/10, 40.0%) Nursing staff role (1/10, 10.0%)
Hyperinflation before suctioning	Collapse/consolidation on chest x-ray (34/72, 47.2%) Hyperinflation forms part of treatment (8/72, 11.1%) ICU policy (7/72, 9.7%)	ICU policy (16/29, 55.1%) Lack of evidence (4/29, 13.7%) Lack of training (3/29, 10.3%)
Hyperinflation after suctioning	If clinically indicated (16/57, 28.0%) Oxygen desaturation post-suctioning (14/57, 24.5%) Hyperinflation forms part of treatment (9/57, 15.7%) Sputum retention (6/57, 10.5%)	ICU policy (18/36, 50.0%) Lack of evidence (4/36, 11.1%) A perceived lack of clinical indication (3/36, 8.3%)

Saline lavage	Thick tenacious secretions that were difficult to clear (59/59, 100.0%)	Lack of evidence (13/31, 41.9%) ICU policy (12/31, 38.7%)
Subglottic suctioning	Nil	Lack of appropriate endotracheal tubes (31/54, 57.4%) Current practice in the ICU (15/54, 27.7%) Nursing staff role (8/54, 14.8%)

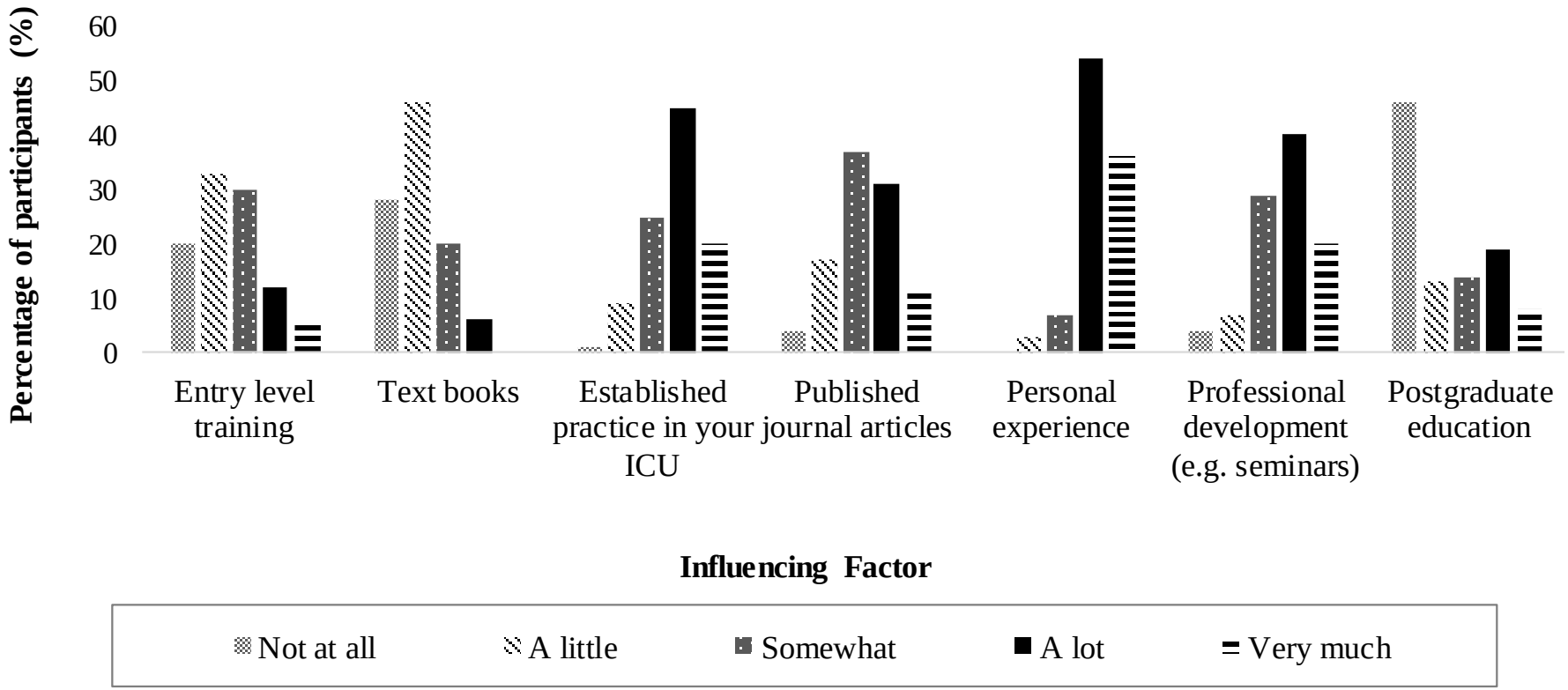
ICU= intensive care unit



ANZICS CORE=Australian and New Zealand Intensive Care Society Centre for Outcome Resource Evaluation, ICU=intensive care unit, NHPA=National Health Performance Authority of Australia, NZ=New Zealand.

[*]On four instances, there were two hospitals covered by the same physiotherapist. This most commonly occurred where the publically funded and privately funded hospitals were covered by the same physiotherapist. There were 136 eligible ICUs and data were sought from 132 physiotherapists.

Fig. 2.


Percentage of participants (%)
60
50
40
30
20
10
0
Entry level training
Text books
Established practice in your ICU
Published journal articles
Personal experience
Professional development (e.g. seminars)
Postgraduate education
Influencing Factor
Not at all
A little
Somewhat
A lot
Very much

SURVEY

Dear _____

Thank you for agreeing to participate in this study. Your time is very much appreciated.

The questionnaire relates to suctioning practices of adult patients who are intubated and ventilated in the intensive care unit in which you currently work. It does not relate to the suctioning of paediatric patients or those who are not intubated and ventilated.

There are four sections. Please read the information that has been embedded into each section prior to completing the questions in each section. Please complete each question unless instructed otherwise. We estimate that it will take no longer than 15 minutes of your time to complete the following questionnaire.

SECTION 1: INTENSIVE CARE UNIT CHARACTERISTICS

Section 1 comprises 5 questions pertaining to the characteristics of the intensive care unit (ICU) that you work in.

1) Which category does your hospital belong to? (tick one)

- ○ Public
- ○ Private
- ○ Other, please specify: _____

2) How many ventilator-capable staffed beds are there in the ICU that you work in? (tick one)

- ○ 0-10
- ○ 11-20

- ○ 21-30
- ○ 30+
- ○ Other, please specify: _____

3) Which areas of specialty are managed in the ICU that you work in? (tick all that apply)

- ○ General medical/surgery
- ○ Neurosurgery
- ○ Cardiothoracic surgery
- ○ Transplant
- ○ Trauma
- ○ Spinal
- ○ Burns
- ○ Paediatrics
- ○ Other, please specify: _____

4) How many full-time equivalent physiotherapists work clinically in your ICU on weekdays, during usual working hours (e.g. 8am-5pm)? (tick one)

- ○ 0.5
- ○ 1
- ○ 1.5
- ○ 2
- ○ 2.5
- ○ 3
- ○ 4
- ○ 5

- ○ 5+

5) During the week, when does the ICU that you work in have access to physiotherapy services? (tick one)

- ○ Daytime only (e.g. 8am-5pm)
- ○ Daytime + evening
- ○ Daytime + evening + on call services overnight
- ○ Daytime + on call services in the evening
- ○ Daytime + on call services in the evening and overnight
- ○ 24 hours

SECTION 2: PHYSIOTHERAPIST CHARACTERISTICS

Section 2 comprises 6 questions regarding your physiotherapy qualifications:

6) How long ago did you complete your initial (entry-level) qualification in physiotherapy? (tick one)

- ○ Less than 1 year
- ○ Between 1 and 5 years
- ○ Between 6 and 10 years
- ○ 10+ years

7) Where did you complete your initial qualification in physiotherapy? (tick one)

- ○ Australian Capital Territory
- ○ New South Wales
- ○ Queensland
- ○ South Australia

- ○ Victoria
- ○ Western Australia
- ○ New Zealand
- ○ Other, please specify: _____

8) What is your highest qualification in physiotherapy? (tick one)

- ○ Diploma
- ○ Entry level physiotherapy degree (Bachelor's Degree or Post-graduate Master's degree)
- ○ Post-graduate physiotherapy degree
- ○ Doctorate
- ○ Australian Physiotherapy Association (APA) Titled Cardiorespiratory Physiotherapist or equivalent specialisation in Cardiorespiratory Physiotherapy

9) How many years of experience do you have in treating cardiopulmonary patients? (tick one)

- ○ Less than 1 year
- ○ Between 1 and 5 years
- ○ Between 6 and 10 years
- ○ 10+ years

10) How many different ICUs have you worked in as a clinician (including the current one that you are working at)? (tick one)

- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5

- ○ 5+

11) How many full-time equivalent physiotherapists are employed in your hospital? (tick one)

(Please ask the Manager of your Physiotherapy Department if you are unsure)

- ○ 0 to 20
- ○ 21 to 40
- ○ 41 to 60
- ○ 60+

SECTION 3: FACTORS THAT INFLUENCE YOUR SUCTIONING PRACTICES

Section 3 pertains to the factors that influence your decisions regarding the suctioning practices that you perform on intubated and ventilated adult patients in the ICU.

12) Use the table below to indicate the extent to which each factor has influenced how you currently suction intubated and ventilated adult patients in the ICU. Please tick one frequency category for each 'influencing factor' listed in the table below.

	Frequency				
Influencing factor	**Not at all**	**A little**	**Somewhat**	**A lot**	**Very much**
Entry level training (Diploma/Undergraduate degree)					
Text books					
Established practice in your hospital					
Published journal articles					

Personal experience					
Professional development (workshops, seminars etc.)					
Postgraduate education					
Other, please specify:_____					

SECTION 4: INFORMATION PERTAINING TO PHYSIOTHERAPY PRACTICES REGARDING SUCTIONING IN THE ICU

Section 4 comprises 6 separate parts, each of which pertain to the different approaches or strategies that you may perform before, during or after suctioning an intubated and ventilated adult patient in the ICU.

Part 1: HYPEROXYGENATION

Hyperoxygenation is defined as the practice of increasing the fraction of inspired oxygen for a short time period above the current level that the patient is receiving via a mechanical ventilator.

13) On average, do you provide hyperoxygenation BEFORE suctioning? (tick one)

- ○ For all patients (Go to Question 16)
- ○ For most patients
- ○ For some patients
- ○ For a few patients
- ○ For none of the patients (Go to Question 15)

14) If you do NOT provide hyperoxygenation for ALL patients BEFORE suctioning, briefly describe the criteria you use to select patients for hyperoxygenation?

- _____

15) If you NEVER provide hyperoxygenation for patients BEFORE suctioning, briefly explain why.

- _____

16) On average, do you provide hyperoxygenation DURING suctioning? (tick one)

- For all patients (Go to Question 19)
- For most patients
- For some patients
- For a few patients
- For none of the patients (Go to Question 18)

17) If you do NOT provide hyperoxygenation for ALL patients DURING suctioning, briefly describe the criteria you use to select patients for hyperoxygenation?

- _____

18) If you NEVER provide hyperoxygenation for patients DURING suctioning, briefly explain why.

- _____

19) On average, do you provide hyperoxygenation AFTER suctioning? (tick one)

- For all patients (Go to Question 22)
- For most patients
- For some patients
- For a few patients

- ○ For none of the patients (Go to Question 21)

20) If you do NOT provide hyperoxygenation for ALL patients AFTER suctioning, briefly describe the criteria you use to select patients for hyperoxygenation?

- ○ _____

21) If you NEVER provide hyperoxygenation for patients AFTER suctioning, briefly explain why.

- ○ _____

22) If you provide hyperoxygenation before, during or after suctioning to the patient on average, how long is it provided for? (tick one)

- ○ Not applicable/Do not use
- ○ Between 1-30 seconds
- ○ Between 30 seconds-1 minutes
- ○ Between 1-2 minutes
- ○ 2+ minutes
- ○ Other, please specify: _____

Part 2: HYPERINFLATION

Hyperinflation is defined as the process of increasing the patient's tidal volume.

Manual hyperinflation is defined as a technique whereby the patient is disconnected from the ventilator and a manual circuit is used to increase the patient's tidal volume.

Ventilator hyperinflation is defined as a technique whereby the ventilator settings are manipulated to increase the patient's tidal volume.

23) As part of your average suctioning practice, do you perform manual or ventilator hyperinflation BEFORE suctioning? (tick one)

- ○ For all patients (Go to Question 26)
- ○ For most patients
- ○ For some patients
- ○ For a few patients
- ○ For none of the patients (Go to Question 25)

24) If you do NOT perform manual or ventilator hyperinflation for ALL patients BEFORE suctioning, briefly describe the criteria you use to select patients for hyperinflation?

- ○ _____

25) If you NEVER perform manual or ventilator hyperinflation for patients BEFORE suctioning, briefly explain why.

- ○ _____

26) On average, do you perform manual or ventilator hyperinflation AFTER suctioning? (tick one)

- ○ For all patients (Go to Question 29)
- ○ For most patients
- ○ For some patients
- ○ For a few patients
- ○ For none of the patients (Go to Question 28)

27) If you do NOT perform manual or ventilator hyperinflation for ALL patients AFTER suctioning, briefly describe the criteria you use to select patients for hyperinflation?

- _____

28) If you NEVER perform manual or ventilator hyperinflation for patients AFTER suctioning, briefly explain why.

- _____

29) If you perform hyperinflation, which method is your preference? (tick one)

- Not applicable/Do not use
- Manual hyperinflation
- Ventilator hyperinflation
- Varies according to patient's needs
- No preference

Part 3: SALINE LAVAGE

30) On average, do you use saline lavage before suctioning? (tick one)

- For all patients (Go to Part 4)
- For most patients
- For some patients
- For a few patients
- For none of the patients (Go to Question 32)

31) If you do NOT use saline lavage for ALL patients, briefly describe the criteria you use to select patients for saline lavage?

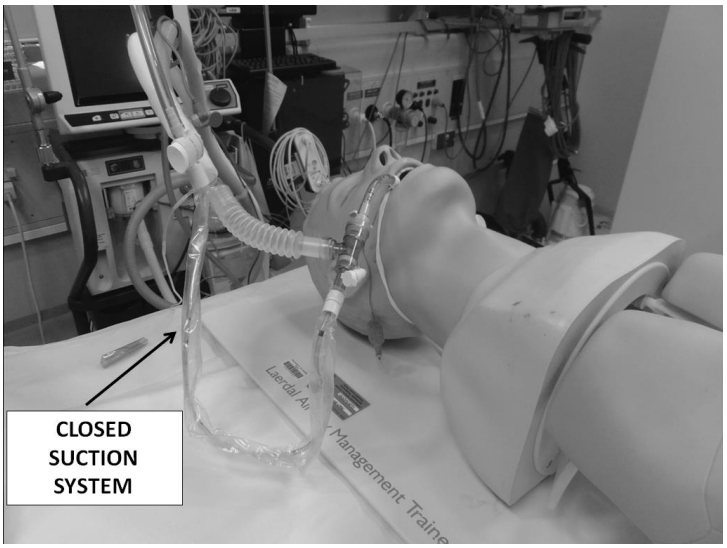
- _____

32) If you NEVER use saline lavage for patients before suctioning, briefly explain why.

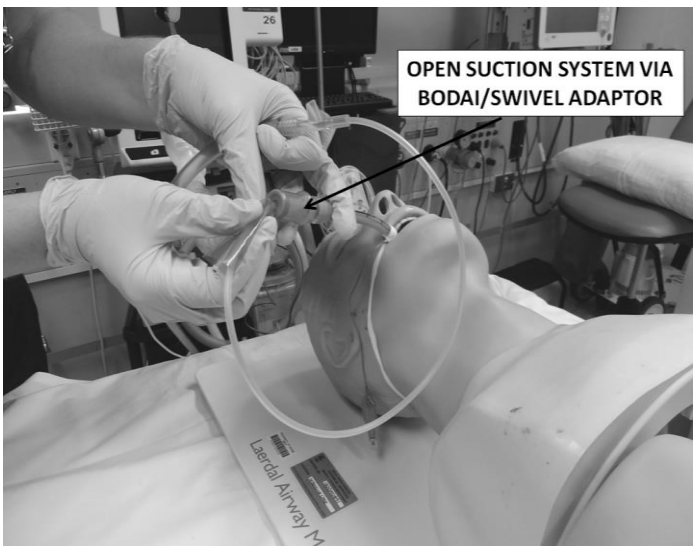
- _____

Part 4: TYPE OF SUCTION SYSTEM

Closed suction system or 'in-line' suctioning is defined as the insertion of a suction catheter that is enclosed in a plastic sleeve, into a endotracheal tube (ETT) or tracheostomy without the need for disconnection of the patient from the ventilator circuit.



Open suction system is defined as the use of a single-use suction catheter after a complete or partial disconnection (via the use of an adaptor) of the patient from the ventilator circuit.



33) Which type of suction system is predominantly used in the ICU that you work in? (tick one)

- ○ Closed suction system (Please skip Question 37)
- ○ Open suction system (Please skip Questions 33 & 34)

34) Which type of suction system is predominantly used in the ICU that you work in?

- ○ Closed suction system
- ○ Open suction system

35) On average, what percentage of patients who are intubated and ventilated are suctioned using an open suction system? (tick one)

- ○ 0%
- ○ 1-10 %
- ○ 11-25%
- ○ 26-50%
- ○ 51-75%
- ○ 76-100%

36) What criteria do you use to select an open suction system for intubated and ventilated patients? (tick all that apply)

- ○ Not applicable/Do not use
- ○ When an angled tipped catheter is required
- ○ When the closed suction system is inadequate (difficult to insert or maneuver the catheter via the plastic sleeve)
- ○ Other, please specify: _____

37) If you perform open suction, which type of technique do you use for intubated and ventilated patients? (tick all that apply)

- ○ Not applicable/Do not use
- ○ Sterile (i.e. surgical gloves, sleeved catheter approach)
- ○ Clean (i.e. regular gloves)
- ○ Other, please specify: _____

38) If you perform open suction, do you routinely use lubricating gel? (tick one)

- ○ Not applicable (i.e. Use of closed suction system only)
- ○ For all patients
- ○ For most patients
- ○ For some patients
- ○ For a few patients
- ○ For none of the patients

39) If you predominantly perform open suction, what criteria do you use for selecting a closed suction system for intubated and ventilated patients?

- ○ Not applicable/Do not use
- ○ Predicted length of stay >24 hours
- ○ Infection control
- ○ Other, please specify: _____

Part 4: SUBGLOTTIC SUCTIONING

Subglottic suctioning is defined as the removal of secretions that have pooled above the cuff of the ETT in the subglottic space, through the use of a specially designed ETT with a separate lumen that opens directly above the ETT cuff.

40) On average, how many of the ICU patients undergo subglottic suctioning? (tick one)

- ○ All patients (Go to Question 42)
- ○ Most patients (Go to Question 42)
- ○ Some patients (Go to Question 42)
- ○ A few patients (Go to Question 42)
- ○ None of the patients

41) If you NEVER perform subglottic suctioning on ICU patients, briefly explain why.

- ○ _____

Part 6: PROCEDURE & EQUIPMENT

42) On average, how often is the catheter for the closed suction system replaced at the ICU that you work in? (tick one)

- ○ Not applicable/Do not use
- ○ Less than or equal to 24 hours
- ○ Every 25-48 hours
- ○ Every 49-72 hours
- ○ Unsure
- ○ Other, please specify: _____

43) On average, for what percentage of intubated and ventilated patients do you use an angled tip catheter during suctioning? (tick one)

- ○ 0%
- ○ 1-10 %
- ○ 11-25%
- ○ 26-50%

- ○ 51-75%
- ○ 76-100%

44) If you use an angled tip catheter, briefly describe the criteria that you use to select patients for this approach?

- ○ _____

45) On average, what type of infection control measures do you routinely use when suctioning intubated and ventilated patients? (tick all that apply)

- ○ Gloves
- ○ Gown/Apron
- ○ Protective eyewear
- ○ Faceshield
- ○ Other, please specify: _____

Thank you very much for completing this survey. Your time is greatly appreciated.

If you are interested in the results of this survey, we will send you a summary of the findings once the study has been completed. Please fill in your contact email below to request a summary.

_____