Intensive Care Nurses' Knowledge and Practice of Evidence-Based Recommendations for Endotracheal Suctioning: A Multisite Cross-Sectional Study in Changsha China

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Abstract

Background: Endotracheal suctioning is one of the most frequently operated invasive procedures by intensive care nurses. Nurses should have adequate knowledge and skills to perform endotracheal suctioning based on the best evidence. Litter is known about intensive care nurses' knowledge and practice of evidence-based endotracheal suctioning in Chinese hospitals. The purpose of this study is to investigate intensive care nurses' knowledge and practice of the evidence-based recommendations regarding endotracheal suctioning. Specifically, the study aims to examine 1) intensive care nurses' awareness of and adherence to the endotracheal suctioning guideline; and 2) their influencing factors.

Methods: The cross-sectional online questionnaire survey was distributed to 310 intensive care nurses working in intensive care units of five tertiary hospitals in Changsha, China.

Results: 281 nurses completed and returned the survey (response rate= 90.6%). Participants' awareness of and adherence to the evidence-based guideline was at a poor to moderate level. There was a significant difference regarding the awareness of the guideline between experienced and inexperienced nurses. Nurses who worked 6-15 years in intensive care units had a higher awareness of evidence-based endotracheal suctioning practices than nurses who worked within five years and over 16 years. Nurses with endotracheal suctioning training demonstrated significantly higher awareness of endotracheal suctioning recommendations and higher adherence levels than those untrained nurses.

Conclusion: There are considerable evidence-practice gaps in ETS among Chinese intensive care practice. further research should emphasis on revealing barriers and facilitators of implementing the evidence-based endotracheal suctioning practices, developing context-suitable interventions for the guideline implementation. We suggest a systematic training of the ETS guidelines along with innovative implementation strategies from implementation science to promote the ETS practice changes.

1 Background

Endotracheal suctioning (ETS) is the insertion of an endotracheal tube and removal of accumulated secretion from the tracheobronchial tree, using a mechanical suction device (Zeb et al., 2017). The purpose of this procedure is to maintain the patient airway, to optimize ventilation and oxygenation, and to prevent the respiratory tract infection from lodgment of secretion (Zeb et al., 2017). It is among the most frequently conducted invasive procedures in the Intensive Care Unit (ICU) for mechanically ventilated patients (Negro, Ranzani, Villa, & Manara, 2014).

As a crucial procedure in maintaining airway patency, if ETS is not performed with correct techniques, it will lead to numerous adverse effects, such as tracheobronchial edema, ulceration, and denudation of epithelium (Favretto et al., 2012; Pedersen, Rosendahl-Nielsen, Hjermind, & Egerod, 2009; Sole, Bennett, & Ashworth, 2015). These areas of mucosal damages increase the risk of infection and bleeding (Leddy & Wilkinson, 2015). Moreover, ETS is considered as an extremely distressing and painful experience for ICU patients (Patak, Gawlinski, Fung, Doering, & Berg, 2004). Study findings showed that performing ETS by well-educated health care professionals based on the best evidence can diminish its side effects (Ansari, Alavi, Adib-Hajbagheri, & Afazel, 2012; Ntoumenopoulos et al., 2018). It is, therefore, very essential for healthcare professionals to have

updated knowledge on the evidence-based practices of ETS so that they can perform the procedures scientifically to reduce patients' complications and potential risks (Heidari & Shahbazi, 2017).

Clinical practice guidelines are "systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances" (Institute of Medicine, 1990). As a type of high-level evidence in the evidence hierarchy, guidelines provide clinicians trustworthy recommendations and can be used to reduce inappropriate practice variations and promote the delivery of high quality care (Institute of Medicine, 1990; Leddy & Wilkinson, 2015). Several ETS guidelines have been developed in recent years by authoritative organizations. For example, in 2010, the American Association of Respiratory Care (AARC) released the AARC Clinical Practice Guidelines on endotracheal suctioning of mechanically ventilated patients with artificial airway (American Association of Respiratory Care, 2010). Despite the enormous efforts taken in developing those guidelines, there continues to be large discrepancies between evidence and the actual practice on ETS. Researchers in countries such as Canada (Leddy & Wilkinson, 2015), and Italy (Negro et al., 2014) analyzed the application of guidelines for endotracheal suctioning among intensive care nurses. Both studies revealed that nurses were often not aware of the existence of those guidelines, and there was a lack of relevant knowledge regarding the ETS.

In China, intensive care nurses are responsible for performing the ETS in ICUs. In 2018, Hu et al. (Hu et al., 2019) developed an adapted guideline on ETS for adult patients with artificial airway, by synthesizing and evaluating seven evidence documents including the AARC Guidelines. This was the only evidence-based ETS guideline designated for mechanically ventilated patients in China. There was no investigation on the gaps between evidence and the clinical practice on ETS performed by Chinese intensive care nurses. Considering nurses' important roles in performing ETS procedures to maintain patients airway, especially during the pandemic of COVID-19 where lots of COVID patients were ventilated and required ETS frequently (Xie et al., 2020), it is well-needed to investigate intensive care nurses' knowledge of ETS guidelines in Chinese ICUs and the differences between their current ETS practices and the evidence-based procedures. Therefore, this study aims to investigate intensive care nurses' knowledge and practice of evidence-based recommendations regarding ETS. Specifically, our objectives are to examine 1) intensive care nurses' awareness of and adherence to the ETS guideline; and 2) their influencing factors.

2 Method

2.1 Study design

A multisite cross-sectional online survey was employed.

2.2 Setting and sampling

Convenient sampling was applied to recruit intensive care nurses from ICUs (i.e., general surgery, cardiothoracic surgery, neurological, respiratory, emergency department ICU, coronary care unit, etc.) in five tertiary hospitals in Changsha, the second-most populous city in the central southern part of China. We included 1) registered nurses who worked in these ICUs and provided direct care for adult patients with artificial airway at the time of investigation, and 2) nurses had at least one year working experience in the ICU. To warrant the anonymity of participants, we disseminated the electronic survey through a WeChat group that was set up specifically for this study and could accommodate up to 500 participants.

2.3 Questionnaire survey

We formulated the questionnaire based on recommendations from the adapted endotracheal suctioning (ETS) guideline (Hu et al., 2019). The development of this guideline was guided by the ADAPTE framework (ADAPTE Collaboration, 2009). The guideline contained 26 key recommendations in three procedural phases and 17 points of care (Hu et al., 2019). We also referred to questionnaires or checklists that have been used to assess ETS knowledge or practice of nurses in other countries such as the US and Australia (Leddy & Wilkinson, 2015; Mwakanyanga, Masika, & Tarimo, 2018; Negro et al., 2014; Rn et al., 2007). The questionnaire involved three domains: 1) demographic data, 2) nurses' awareness of, and 3) adherence to the ETS guideline. Demographic characteristics included nine items: age, gender, the highest level of educational degree, Length of nursing employment and ICU experience, type of ICU, job title, number of patients per nurse on duty, and training experience. The second domain included 26 items which were directly extracted from the ETS guideline. We organized the items as 1) practice prior to suctioning (n = 5), such as clinical indicators, patient communication, catheter size, knowledge, and skills; 2) procedure of ETS (n = 18), includes the ETS approach, aseptic technique, humidification, insertion depth, suction pressure, time length and frequency of ETS, suction intervals, hyperinflation, pre-oxygenation, ventilation; 3) evaluation after ETS (n = 2) includes monitoring and adverse effects. The third domain included 16 items, which were also organized as prior (n = 3), during (n = 12), and after suctioning (n = 1). Two self-rating scales were applied to rate the second and third domains, respectively: 1) whether you are aware of the recommendation (Yes/No)? 2) whether you adhere to the recommendation in the clinical work (Yes/No)?

The questionnaire was reviewed by five ICU nurse managers who were not part of the investigation team. They provided suggestions and feedbacks on the wording accuracy and understandability of these items. Then, it was pretested among 12 nurses working in a general ICU from a tertiary hospital, which was not one of the five participating hospitals in our study. Based on the review and pretest, we revised the wording of four items in the second domain and six items in the third domain for clarity. No items were added or removed. To determine the test-retest reliability of the revised questionnaire, we invited five other intensive care nurses to fill out the questionnaire twice with an interval of two weeks, and the correlation coefficient of scores of two tests was calculated by 89%.

2.4 Data collection

We conducted the questionnaire survey through the WeChat. WeChat is the most commonly used social networking application in China and has been widely used in health care studies for professional education, health care intervention, and questionnaire collection (Peng & Ye, 2018). After obtaining the required authorization from the nursing department and ICU nurse managers of the five hospitals for distributing the questionnaire, participants were recruited by research assistants under the supervision of the first Author. The research assistants were nurses working in those participating hospitals. Those intensive care nurses agreed to participate were added to a WeChat group. After giving their informed consent, 310 nurses from the five tertiary hospitals were invited to join the WeChat group. Then, a study invitation with a hyperlink to the online survey was sent to the WeChat group. The participants could choose to use a mobile device or desktop to complete the survey. Each IP address only allowed participants to complete the survey once. Data was collected automatically upon submission. No personal data or information on the participants was collected.

2.5 Ethical Issues

Research Ethics Committee approval was obtained at the Xiangya Nursing School of Central South University. Before data collection, the aim of the study was explained to nurses by research assistants together with informed consent from participating hospitals. The questionnaires were nameless, not coded, and confidential. Participant response bias and any possible enforcement participation were diminished since there was no way to identify the participants.

2.6 Statistical analysis

Software Package Statistical Analysis (SPSS) Version 23.0 was applied for data analysis (IBM Corp., 2013). Demographic data were analyzed using descriptive statistics. They were also used as independent variables to understand the influencing factors for the awareness of and adherence to ETS guideline.

We applied descriptive statistics methods to record numbers and percentage of participants rate Yes/No to each item of the two scales. The quality of performance was categorized into three levels based on the percentage of "Yes" to each item: good (76–100%), moderate (50–75%), and poor (< 50%). For statistical inference, each item was measured at a binary level (i.e., No 0, Yes 1), then the average score of each scale was calculated using mean and standard deviation (mean ± SD). T-test or one-way ANOVA was used to identify the significance in the observed differences in awareness and adherence of ETS scores by the independent variables such as gender, years of working in ICU, and ETS training, considering statistically significant at a p-value less than 0.05. All results assumed a two-tailed distribution with an alpha level of 5%.

3 Result

3.1 Demographic Characteristics

The survey was conducted from July 2018 to August 2018. Of the 310 intensive care nurses who joined the study's WeChat groups, 281 completed and returned the questionnaire (response rate = 90.6%). As showed in Table 1, 85.77% (n = 241) of the intensive care nurses were female nurses, and one in three (n = 186) were aged 20 to 30. Over three-quarters of them (n = 234) had a bachelor's degree, and only one with a Ph.D. The majority of them had work experiences in ICU (n = 238) less than ten years. Over half of them (n = 154) had senior nurse job titles. 60.14%(n = 169) of nurses worked in a general ICU, 16.73% (n = 47) in a Neurosurgical ICU, and only three from Cardiothoracic ICU. 70.46% (n = 198) took care of three to four patients in their practices. 68.68% (n = 193) received ETS training before.

Table 1
Demographic Characteristics of intensive care nurses

Characteristic	Group	Frequency	Percentage (%)
Gender	Male	40	14.23
	Female	241	85.77
Age	≤ 20	3	1.07
	20–30	186	66.19
	31–40	80	28.47
	41–50	12	4.27
Highest Level of Education	Associate degree	26	10.94
	Bachelor's Degree	234	77.10
	Master's Degree	20	10.94
	PhD	1	0.29
Years of work of nurses	1–5	110	39.15
	6–10	109	38.79
	11–15	37	13.17
	16–20	13	4.63
	20	12	4.27
Years of work in ICU	1–5	135	48.04
	6–10	103	36.65
	11–15	27	9.61
	16–20	10	3.56
	20	6	2.14
Type of ICU	General	169	60.14
	Cardiothoracic	3	1.07
	Neurological	47	16.73
	Respiratory	8	2.85
	Emergency (department)	6	2.14
	Coronary	20	7.12
	Others	28	9.96
Job Title	Nurse	40	14.24
	Senior Nurse	154	54.8

Characteristic	Group	Frequency	Percentage (%)
	Supervisor Nurse	81	28.83
	Co-Chief Nurse	5	1.78
	Chief Nurse	1	0.36
Number of Patients Per Nurse on Duty	1	6	2.14
	2	47	16.73
	3	101	35.94
	4	97	34.52
	≥ 5	30	10.68
ETS training	Yes	193	68.68
	No	88	31.32

3.2 Participants' awareness of endotracheal suctioning

Participants' awareness level regarding 21 out of the 26 recommendations was at a moderate level (50–75%). While 66.19% (n = 186) intensive care nurses reported that they didn't know the comparison between closed and open suction systems (item 7); 55.87% (n = 157) and 50.89% (n = 143) didn't know the pros and cons of using hyperinflation (item 18 and 19). 55.52% (n = 156), and 50.53% (n = 142) of them didn't know the rules of using the suction catheters (item 3), and the frequency of performing the suctioning, respectively (item 16) (Table 2).

Table 2
Intensive care nurses' awareness of the ETS Guidelines

Practices prior to, during, and post ETS event		Items (n = 26)	Variables	Awareness No. of nurses rate yes/no (%)
Preparation before Endotracheal suctioning	Clinical indicators	1. Suctioning should only be done when a thorough assessment of the patient establishes the need for such a procedure and not be dictated by routine	Yes	191(67.97)
			No	90(32.03)
	Patient communication	2. If patients are able to cough up their own secretions, they should be encouraged to do so	Yes	192(68.33)
			No	89(31.67)
	Catheter size	3. Suction catheters should be as small as possible, yet large enough to facilitate secretion removal	Yes	125(44.48)
			No	156(55.52)
		4. The size of the suction catheter should occlude no more than half of the internal diameter of the artificial airway to avoid greater negative pressures in the airway and to potentially minimize falls in PaO2	Yes	175(62.28)
			No	106(37.72)
	Knowledge and Skills	5. I possess required procedural skill and gentleness when suctioning because of the potential associated hazards	Yes	193(68.68)
			No	88(31.32)
The procedure of Endotracheal suctioning	Suction Approach	6. The use of a closed suction system is suggested for adults with high FIO2 or PEEP, or at risk for acute lung injury	Yes	170(60.50)
			No	111(39.50)
		7. The closed or open suction system is not superior to the other in terms of oxygen saturation, cardiovascular instability, secretion removal, environmental contamination, and cost	Yes	95(33.81)
			No	186(66.19)
	Aseptic Technique	8. Aseptic technique should be considered an essential component of the suctioning procedure for hospitalized patients with artificial airways, including handwashing and use of gloves because endotracheal suctioning is an invasive procedure that may lead to contamination of the lower airways	Yes	192(68.33)
			No	89(31.67)
	Humidification	9. Routine use of normal saline instillation prior to endotracheal suction should not be performed	Yes	164(58.36)
			No	117(41.64)
		10. Ensuring patients are adequately hydrated is the way health care providers can facilitate	Yes	189(67.26)

Practices prior to, during, and post ETS event		Items (n = 26)	Variables	Awareness No. of nurses rate yes/no (%)
		the removal of respiratory secretions	No	92(32.74)
	Insertion Depth	11. The suction catheter should be inserted to the carina and then retracted 1–2 cm before suctioning is performed, or the length of the suction catheter is estimated by measuring an identical endotracheal tube	Yes	169(60.14)
			No	112(39.86)
		12. Deep suctioning is necessary for patients with large amounts of secretions in the lower airways	Yes	186(66.19)
			No	95(33.81)
	Suction Pressure	13. Using the lowest possible suction pressure during endotracheal suctioning, usually 80–120 mmHg	Yes	152(54.09)
			No	129(45.91)
	Time Length of Suction Procedure	14. The suctioning procedure should last no longer than 15 seconds	Yes	193(68.68)
			No	88(31.32)
	Frequency of Suction Procedure	15. There should not be more than two consecutive suction procedures	Yes	171(60.85)
			No	110(39.15)
	Suction Intervals	16. Perform suctioning at least every 8-hour to reduce the risk of partial occlusion of the endotracheal tube and the accumulation of secretions	Yes	139(49.47)
			No	142(50.53)
	Hyperinflation	17. Using volumes of hyperinflation that is indexed to the size of the patient may assist in minimizing potential difficulties	Yes	160(56.94)
			No	121(43.06)
		18. Tidal volumes should no more than 900 cc during hyperinflation because patients may feel dyspneic	Yes	124(44.13)
			No	157(55.87)
		19. If hyperinflation is used in the patients before suctioning, caution should be employed because it may be associated with increases in mean arterial blood pressure	Yes	138(49.11)
			No	143(50.89)
	Pre-oxygenation	20. Pre-oxygenation by the delivery of 100% oxygen for at least 30 seconds prior to and after the suctioning procedure is recommended to prevent a decrease in oxygen saturation, especially when the patient has a clinically important reduction in oxygen saturation with suctioning	Yes	188(66.90)
			No	93(33.10)
		21. Combining hyperoxygenation and hyperinflation prior to suctioning can minimize suctioning-induced hypoxemia	Yes	143(50.89)
			No	138(49.11)
	Ventilation	22. A ventilator should be used rather than a manual resuscitation bag to provide	Yes	151(53.74)

Practices prior to, during, and post ETS event		Items (n = 26)	Variables	Awareness No. of nurses rate yes/no (%)
		hyperventilation/hyperoxygenation prior to suctioning to reduce hemodynamic alterations	No	130(46.26)
		23. Suctioning through an adaptor is preferred to preserve oxygenation in mechanically ventilated patients	Yes	164(58.36)
			No	117(41.64)
		24. A washout time of up to two minutes can be required when hyperoxygenation is being delivered via some ventilators to allow time for the increased oxygen percentage to come through the ventilator tubing and reach the patient	Yes	183(65.12)
			No	98(34.88)
Evaluation after Endotracheal suctioning	Monitoring	25. The following should be monitored prior to, during, and after the procedure, if indicated and available: breath sounds, oxygen saturation, respiratory rate and pattern, hemodynamic parameters, sputum characteristics, cough characteristics, intracranial pressure, and ventilator parameters	Yes	187(66.55)
			No	94(33.45)
	Adverse Effects	26. Endotracheal suctioning, unless managed appropriately, can lead to various adverse events (tracheal trauma, hypoxemia, hypertension, cardiac arrhythmias, and raised intracranial pressure) and increase mortality and morbidity rates	Yes	186(66.19)
			No	95(33.81)

3.3 Adherence to ETS recommendations during practice

The adherence of participants' practice to the recommendations was at a moderate level (50–75%). Yet approximately half of them did not apply 80–120 mmHg suction pressure and perform ETS at least every 8-hour, and 49.82% of them still using normal saline instillation routinely before ETS (Table 3).

Table 3
Adherence of intensive care nurses' practice to the ETS Guidelines

Practices prior to, during, and post ETS event		Items (n = 16)	Variables	Adherence No. of nurses rate yes/no (%)
Preparation before Endotracheal suctioning	Clinical indicators	1. I assessed the need for endotracheal suctioning as a routine part of the patient/ventilator system assessment	Yes	187(66.55)
			No	94(33.45)
	Patient communication	2. I encouraged patients to cough up their own secretions if they are able to	Yes	192(68.33)
			No	89(31.67)
	Catheter size	3. I used the suction catheter occlude less than half of the internal diameter of the artificial airway	Yes	167(59.43)
			No	114(40.57)
The procedure of Endotracheal suctioning	Suction Approach	4. I used a closed suction system suggested for adults with high FIO2, or PEEP, or at risk for acute lung injury	Yes	156(55.52)
			No	125(44.48)
	Aseptic Technique	5. I washed my hands before and after suctioning and wore gloves during suctioning	Yes	190(67.62)
			No	91(32.38)
	Humidification	6. I did not perform normal saline instillation routinely before endotracheal suction	Yes	141(50.18)
			No	140(49.82)
	Insertion Depth	7. I inserted the suction catheter to the carina and then retracted 1–2 cm before suctioning or measured an identical endotracheal tube to estimate the length of the suction catheter.	Yes	158(56.23)
			No	123(43.77)
		8. I performed deep suctioning for patients with large amounts of secretions in the lower airways	Yes	180(64.06)
			No	101(35.94)
	Suction Pressure	9. I used 80–120 mmHg suction pressure during endotracheal suctioning	Yes	145(51.60)
			No	136(48.40)
	Time Length of Suction Procedure	10. I performed each suctioning procedure less than 15 seconds	Yes	191(67.97)
			No	90(32.03)
	Frequency of Suction Procedure	11. I performed less than three consecutive suction procedures each time	Yes	175(62.28)
			No	106(37.72)
	Suction Intervals	12. I performed suctioning for each patient at least every 8-hour	Yes	146(51.96)

Practices prior to, during, and post ETS event		Items (n = 16)	Variables	Adherence No. of nurses rate yes/no (%)
			No	135(48.04)
	Pre-oxygenation	13. I performed pre-oxygenation by delivering 100% oxygen for at least 30 seconds prior to and after the suctioning procedure.	Yes	184(65.48)
			No	97(34.52)
	Ventilation	14. I used a ventilator instead of a manual resuscitation bag to provide hyperventilation/hyperoxygenation prior to suctioning to reduce hemodynamic alterations	Yes	143(50.89)
			No	138(49.11)
		15. I performed suctioning through an adaptor to preserve oxygenation in mechanically ventilated patients	Yes	155(55.16)
			No	126(44.84)
Evaluation after	Monitoring	16. I monitored the following prior to, during, and after the procedure if indicated and available: breath sounds, oxygen saturation,	Yes	171(60.85)
			No	110(39.15)
Endotracheal suctioning		respiratory rate and pattern, hemodynamic parameters, sputum characteristics, cough characteristics, intracranial pressure, and ventilator parameters.		

3.4 Factors associate with intensive care nurses' awareness of and adherence to the guideline

As shown in Table 4, there was a significant difference between the awareness of the guideline between experienced and inexperienced nurses (p = 0.028). Nurses who worked for 6–15 years in ICUs had a higher awareness of evidence-based ETS practices than nurses who worked within five years and over 16 years. Nurses with ETS training demonstrated significantly higher awareness of ETS recommendations (p = 0.001), and their practices are more adherent to the recommendations than untrained nurses (P = 0.008) (see Table 5).

Table 4
Factors associated with intensive care nurses' awareness of the guideline

Factors	Variables	No. of nurses answered	Mean score (X ± SD)	T-test (t) or one-way ANOVA (F)	p-value
Years of work in ICU	1–5	135	14.86 ± 3.61	F = 2.759	0.028*
	6–10	103	15.95 ± 2.49		
	11–15	27	16.37 ± 2.73		
	16–20	10	14.10 ± 4.68		
	≥20	6	14.50 ± 5.96		
ETS training	Yes	193	15.89 ± 2.80	t = 3.488	0.001
	No	88	14.24 ± 4.01		

Table 5
Factors associated with the adherence of intensive care nurses' practice to the guideline

Factors	Variables	No. of nurses answered	Mean score (X ± SD)	T-test	P value
ETS training	Yes	193	9.69 ± 1.87	t = 2.702	0.008
	No	88	8.70 ± 3.20		

4 Discussion

Studies regarding the knowledge and practice of ETS among nurses have been conducted in several countries as ETS concerns the safety of mechanically ventilated patients (Beuret, Roux, Constan, Mercat, & Brochard, 2013; Gilder, Parke, & Jull, 2018; Leddy & Wilkinson, 2015; Negro et al., 2014). However, little is revealed from the Chinese ICUs. The results of this study show that intensive care nurses have poor to moderate awareness of evidence-based ETS practices. This result is inconsistent with studies of Negro et al. (Negro et al., 2014), Varghese and Moly (Varghese & Moly, 2016), Heidari and Shahbazi (Heidari & Shahbazi, 2017) where they revealed that nurses' knowledge of best ETS practices was in an moderate state.

In China, the poor to moderate level awareness of evidence-based ETS recommendations may be partly due to the inaccessibility of the guidelines by clinical nurses (Zhang & Yang, 2017). Even though several English ETS guidelines exit, there was no one in Chinese before the adapted guideline by Hu et al. (Hu et al., 2019). Many intensive care nurses in Chinese hospitals felt unable to access to those English guidelines due to language barriers (Zhang & Yang, 2017). In addition, insufficient training experiences may also explain this low to

moderate level of awareness and adherence (Gu, Shang, Jin, Zhou, & Wang, 2011). As showed in our study, nurses received training demonstrated significantly higher awareness and adherence than those who did not. Nevertheless, one third of the participants in our study have not taken any ETS training. As such, we recommend that frequent ETS training should be in place to disseminate the up-to-date ETS recommendations to the front-line intensive care practitioners.

In agreement with previous study (Endla, Kabdal, Sahai, & Masih, 2017; Negro et al., 2014), experienced intensive nurses (5–15 years of ICU work) in our study had better knowledge of the ETS than less experienced nurses (5 years of ICU work) and nurses who worked for over 15 years. This may be due to reasons. First, nurses who worked in ICU for 6–15 years had enough experience to know each feature of the ETS (Negrón et al., 2014). Second, they are usually the main force of ICU and have more opportunities to receive ETS training (China Social Welfare Foundation, 2017).

Our study findings showed that the majority of the nurses lack knowledge of certain aspects of the guideline. For example, almost two-thirds of the intensive care nurses were unaware of the insignificant differences between the open and closed suctioning on clinical outcomes (i.e., oxygen saturation, cardiovascular instability, secretion removal, environmental contamination, and cost). It was an unsurprising result as there were contradictory findings in the past two decades as to the comparisons of these two suctioning methods (Afshari, Safari, Oshvandi, & Soltanian, 2014). Some researchers found that the two suctioning methods differed in affecting the heart rate (Afshari et al., 2014; Zolfaghari, Nasrabadi, Rozveh, & Haghani, 2016), while it was the other way around in other investigations (Fernández, Piacentini, Blanch, & Fernández, 2004). However, the methodological flaws of some studies made their research findings less convincing and led to the failure of generating strong recommendations (American Association of Respiratory Care, 2010). Recommendations in our study were developed by incorporating the best available evidence (Hu et al., 2019). It, therefore, has the potential to be widely applied in the clinical ETS practices in China.

Likewise, over half of the nurses did not know the pros and cons of using hyperinflation (i.e., patients may feel dyspneic when the tidal volume is over 900 cc, the hyperinflation may relate to increases in mean arterial blood pressure, using volumes of hyperinflation that are indexed to the size of the patient may assist in minimizing potential difficulties). Elbokhary et al.(Elbokhary, Osama, & Al-Khader, 2015) had similar research findings that nurses retained poor knowledge regarding the adverse effects of hyperinflation. We suggested that ETS training programs should place particular emphasis on those 'low-awareness items' to change intensive care nurses' traditional views toward ETS and promote their acceptance of the evidence-based recommendations (Varghese & Moly, 2016).

We also found that almost one half of the participants' clinical practice differed from or contradicted the evidence-based recommendations, such as not routinely using normal saline, performing suctioning at least every 8-hour, and using 80–120 mmHg suction pressure during endotracheal suctioning. It revealed that considerable gaps exist between the evidence-based ETS practices and the current clinical practices (Graham & Logan, 2004). In order to bridge the evidence-practice gap, theoretical education or training alone may not be adequate to influence practice change (Ansari et al., 2012; Heidari & Shahbazi, 2017; Mwakanyanga et al., 2018). Routine training together with individual or group support like post-training follow-up, coaching, using of support documents like unit or hospital-level ETS regulations, web or mobile applications, checklists, reminders, user-friendly pictures, and pocket versions of the guideline could potentially elevate the knowledge level and practical

ETS skills of intensive care nurses (McKillop, 2004; Mwakanyanga et al., 2018; Straus, Tetroe, & Graham, 2013). Moreover, leader support alongside the guideline implementation is recommended, as leadership has been listed as one of the most important factors influencing knowledge translation in clinical practices (Chen et al., 2020; Hu & Gifford, 2018).

Strength and Limitation

Few studies described nursing practice regarding ETS in mainland China. We disclose in the present study the intensive care nurses' knowledge and practice of ETS in Chinese ICUs and propose recommendations for the current clinical nursing practices and training. Limitations existed in this study despite our efforts to minimize the defects during the research process. First, we did not conduct a systematic psychometric testing on the questionnaire. Although it was developed based on current ETS recommendations and underwent a brief test-retest reliability and face validity test before the final version, a lack of systematic psychometric testing may limit the comparability of our findings with others. Second, we used a questionnaire survey to investigate ICU nurses' adherence to ETS recommendations rather than the onsite shadowing. There might be a discrepancy between their perceptions and the actual practices on ETS.

Conclusion

Endotracheal suctioning (ETS) is one of the most commonly performed invasive procedures by nurses. It may cause serval consequences if performed incorrectly. The study findings revealed that Chinese intensive care nurses' knowledge of evidence-based ETS recommendations was at had a poor to an average level. It also showed that there were considerable gaps between ETS evidence and clinical practices. Further research should emphasis on revealing barriers and facilitators of implementing the evidence-based endotracheal suctioning practices, developing context-suitable interventions for the guideline implementation. We suggest a systematic training of the ETS guidelines along with innovative implementation strategies from implementation science to promote the ETS practice changes.

Abbreviations

AARC: American Association of Respiratory Care

ETS: Endotracheal suctioning

ICU: Intensive Care Unit

SPSS: Software Package Statistical Analysis

Declarations

Ethics approval and consent to participate

This research was approved by the Ethics institutional review board of the Xiangya Nursing School of Central South University (Ethics File Number: E201836), informed consent forms was received from all participants.

Consent for publication

The article does not contain any individual's details and consent for publication is not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

WC and JH conceptualized the study. WC led the data collection and analysis. WC and SH wrote the initial draft together. WC, XL, NW, PL, and KC contributed to participant recruitment and the development of data collection methods. WC, SH, and JZ were involved in manuscript revision. All authors have read manuscript drafts, provided input and refinements, and agreed to the final manuscript.

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