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(ESAT©): An exploratory sequential mixed methods study**

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**Psychometric Testing of the
Endotracheal Suction Assessment Tool[®] (ESAT[®]):
An exploratory sequential mixed methods study**

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Bachelor of Science (Nursing)

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This thesis by publication submitted for the degree of Doctor of Philosophy 2018

Statement of Authorship

I affirm that this thesis contains no material previously published or written by another person, except where due reference is made in the thesis, and that it contains no work which the student has previously presented for an award of the University or any other educational institution.

Contributions by others to the articles that make up the body of this thesis are listed on page *xii*.

Kylie Davies

July 31, 2018

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Abstract

Background

Endotracheal tube (ETT) suction is a common nursing procedure performed in paediatric intensive care settings. Significant side effects of this procedure can dramatically affect the stability of the critically ill ventilated paediatric patient. The lack of clear standards for determining when the procedure is warranted, especially in paediatrics, can present challenges for the inexperienced paediatric intensive care nurse when assessing a patient's need for ETT suction.

Previous research underpinned the development of an Endotracheal Suction Assessment Tool[®] (ESAT[®]) to guide inexperienced nurses through the decision making process to determine suction requirements. The aim of the ESAT[®] is to improve patient health outcomes through improved nursing practice for patients with an artificial airway (endotracheal tube) in situ.

Aim

To evaluate the psychometric properties of the ESAT[®] for the clinical setting, namely content validity and the scale level content validity index, criterion-related (construct) validity and test-retest (stability) reliability.

Design

A five-phase sequential mixed method study using standard psychometric testing principles was performed. Phase one comprised an integrative literature review to determine the clinical indicators used to establish the original format of the ESAT[®]. In phase two, a clinical audit was performed to establish the link between current clinical practice and the clinical indicators within the ESAT[®]. Phase three established scale level content validity index of the ESAT[®] using “expert” paediatric intensive care nurses' opinion (n=9) and developed clinical scenarios (n=10) with predetermined outcomes. In phase four, criterion-related (construct) validity testing of the ESAT[®] was undertaken by comparing clinical scenario outcomes between expert, “inexperienced” and “experienced” paediatric intensive care nurses. In phase five, test-retest (stability) reliability of the ESAT[®] was performed where the

previously developed scenarios were presented at two time points to the same groups of inexperienced and experienced paediatric intensive care nurses.

Results

All items met the a-priori criteria for content validity. Content validity index (0.8-1.0) and scale content validity index (0.9-1.0) scores were high for all items. Construct validity was established as no differences were observed between endotracheal tube suction decisions made by expert (n=9), inexperienced (n=14) and experienced (n=12) nurses using clinical scenarios. There were no differences observed between groups for endotracheal tube suction decisions at T1 and T2 confirming test-retest reliability.

Conclusion and significance

To the best of our knowledge this study is the first to provide an assessment tool to guide decisions about endotracheal tube suction. Originally designed for nurses, the ESAT[®] could potentially be used by other healthcare professionals. Using clinical scenarios, the tool proved to be valid, user-friendly and useful for inexperienced nurses. Further testing is required in the clinical setting.

List of Publications Included in this Thesis

This thesis consists of the following published articles:

1. Davies K, Monterosso L, Bulsara M, Ramelet AS. (2015). Clinical indicators for the initiation of endotracheal tube suction in children: An integrated review. *Australian Critical Care*, 28(1), 11-18. doi:10.1016/j.aucc.2014.03.001
2. Davies, Monterosso L, Bulsara M, Ramelet AS. (2015). Audit of Endotracheal Tube Suction in a Pediatric Intensive Care Unit. *Clinical Nursing Research*, 26(1), 68-81. doi:10.1177/1054773815598272
3. Davies K, Bulsara M, Ramelet AS, Monterosso L. (2018). Content validity testing of the ESAT[®]: A decision aid tool for performing endotracheal suction in children. *Australian Critical Care*, 31(1), 23-30. doi: 10.1016/j.aucc.2017.01.006
4. Davies K, Bulsara M, Ramelet AS, Monterosso L. (2018). Reliability and criterion-related validity testing (construct) of the Endotracheal Suction Assessment Tool (ESAT[®]). *Journal of Clinical Nursing*. 27(9-10). 1891-1900. doi: org/10.1111/jocn.14269

These four articles formulate the body of this dissertation and have been published in peer reviewed journals during the researcher's PhD candidacy. The articles establish the literature relating to the topic, theoretical underpinnings of the research and methodological approaches used in the psychometric testing procedures. The publications had the benefit of expert peer review and feedback where suggestions to improve the quality of each the article were integrated prior to publication. Since the articles form chapters within this dissertation, North American spelling was used in some manuscripts to meet journal requirements. To avoid self-plagiarism the researcher has included only sufficient previously published material necessary for the reader to understand context and the purpose for inclusion. Where feasible, all of the author's own words cited have been included in a minimum number of paragraphs, with the inclusion of a citation for relevant sentences. Abstracts for each article have been provided in PDF format at the commencement of the relevant chapter.

Other Publications and Conference Presentations Related to this Thesis

Publication

Davies K, Monterosso L, Leslie G. (2011). Determining standard criteria for endotracheal suctioning in the paediatric intensive care patient: An exploratory study. *Intensive and Critical Care Nursing*, 27(2), 85-93. doi:10.1016/j.iccn.2011.01.002

Clinical Presentation

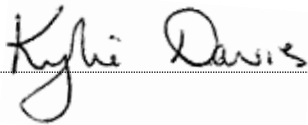
“Why Research?” Presentation of PhD overview to the Post Graduate Nurses Community Practice at Children’s and Adolescent Health Service. July 2017.

Oral Conferences Paper

Davies. K. Content validity testing of the ESAT[®]: A decision aid tool for performing endotracheal suction in children. School of Nursing and Midwifery Inaugural Higher Degree Research Student and Staff Research Symposium. Fremantle, 3 June, 2016. (Abstract: See Appendix A).

Statement of Contributors

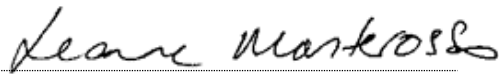
I declare I am the first author on all articles and was responsible for all phases of thesis development: literature searching and reviews; study design; clinical audit; content validity, test-retest and construct validity testing procedures; data entry and transcription; analyses of quantitative and qualitative data; and creation of the first and subsequent drafts of all articles and thesis chapters.



Kylie Davies

PhD Student

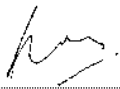
Professor Leanne Monterosso was principal supervisor and provided invaluable and supportive guidance, research methodology and statistical expertise, scholarly writing advice and editorial oversight.



Professor Leanne Monterosso

Principal Supervisor

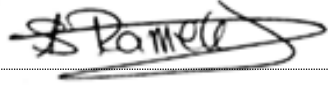
Professor Max Bulsara was co supervisor and provided methodological and biostatistical expertise and editorial support.



Professor Max Bulsara

Co-supervisor & Biostatistician

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Professor Anne-Sylvie Ramelet

Associate Supervisor

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*“The only way to get better is to surround yourself
with people who believe in you”*

(Anonymous)

Definition of Terms

For the purpose of this study, the following definitions were used throughout the literature review and subsequent chapters.

Assessment tool	A tool to assist in the appraisal or evaluation of a patient's clinical condition.
Biofilm	An organised layer of microorganisms that forms on a surface.
Clinical	Pertaining to direct bedside medical or nursing care.
Clinical indicator	A measure, process or outcome used to judge a particular clinical situation.
Complication	A negative result or reaction associated with the underlying disease or process.
Concurrent validity	The determination of how well an item or test compares with a pre-existing indicator that is already judged as valid.
Construct	An abstract or concept that is deliberately created (constructed) by researchers for a scientific purpose.
Construct validity	The degree to which an instrument measures the construct under investigation.
Content validity	True reflection of the concept.
Convergent validity	A type of validity measurement for multiple indicators based on the idea that indicators of one construct will act alike or converge.
Criteria	A set of standard or expected behaviours, conditions, or circumstances established as a basis for making judgements. The term is used interchangeably with "item" within the thesis, particularly in reference to the clinical indicators within the Endotracheal Suction Assessment Tool (ESAT) [©] .
Criterion validity	How well one measure predicts an outcome for another measure.

Criterion-related validity	The degree to which scores on an instrument are correlated to an external criterion.
Criterion-related construct validity	The degree to which scores on an instrument correlate and measure the construct under investigation.
Endotracheal tube	A large bore catheter inserted into the airway within or through the tracheal (windpipe) space enabling delivery of oxygen when ventilation must be totally controlled.
Experienced paediatric intensive care nurse (EPICN)	A nurse working within a Paediatric Intensive Care Unit for three or more years, or, a nurse who has completed a graduate nursing Paediatric Intensive Care qualification.
Experts	Clinical nurse educators, clinical development nurses, clinical nurse consultants or clinical nurse researchers with more than five years' PIC nursing experience and directly involved in the delivery of education to PIC nurses.
Face validity	A type of measurement validity in which an indicator "makes sense" as a measure of a construct in the judgement of others.
Inexperienced paediatric intensive care nurse (IPICN)	Nurses with less than three years PIC clinical experience.
Instrument	The device or technique that a researcher uses to collect data.
Observation	The act of watching carefully and attentively, inspection of the patient.
Predictive validity	Measurement validity that relies on a pre-existing and already accepted measure to verify the indicator of a construct.
Psychometric assessment	An evaluation of the quality of an instrument, based primarily on evidence of its reliability and validity.

Psychometrics	The theory underlying principles of measurement, and the application of the theory in the development of measuring tools.
Reliability	The degree of consistency or dependability with which an instrument measures the attribute it is designed to measure.
Respiration	The process of gaseous exchange between an organism and its environment.
Respiratory	Of or pertaining to respiration.
Secretions	A substance such as saliva and mucous secreted within the airway.
Suction (ing)	The process of aspirating fluid and/or other material from an area.
Technique	The systematic procedure by which a complex or scientific task is accomplished.
Test-retest reliability	Assessment of the stability of an instrument by correlating the scores obtained on repeated administration.
Validity	An indication of the extent to which a measure is a true indicator of what it purports to measure.
Ventilation	The passage of air into and out of the respiratory tract. Includes the use of a ventilator to maintain or support the breathing movements of the patient.

(Neuman, 2011; Oxford, 2015; Polit & Hungler, 2013)

Chapter One

Introduction

1.1 Background

Endotracheal tube (ETT) suction, a nursing procedure to remove mucous secretions from within an ETT, is commonly performed in patients who are intubated and ventilated within the paediatric intensive care (PIC) setting. A comprehensive literature review confirmed there are significant clinical side effects associated with the procedure that can dramatically affect the stability of the critically ill ventilator-dependent paediatric patient (Curley & Moloney-Harmon, 2001; Davies, 2009; Hazinski, 2013). Effects range from changes in alveolar ventilation to altered cardiac perfusion (Curley & Moloney-Harmon, 2001; Dougherty Wrightson & Askin, 1999; Gilbert, 1999; Godfrey, 2004; Hazinski, 2013). Justification for performing this procedure however is not clearly defined within the identified literature. Further, a review of the literature failed to establish clear standards for determining when the procedure is warranted, especially within the paediatric patient population. In paediatric nursing limited evidence-based guidelines exist that can be used to guide paediatric nursing practice. Hence, research that enhances clinical knowledge and practice is considered important for nurses of this patient group when attempting to improve patient care and outcomes. As an experienced PIC nurse and educator, it is evident from clinical experience that inexperienced nurses working within the PIC environment require expert guidance and support to develop skills and competence for procedures such as ETT suction that carry inherent risks for the patient. Of equal importance, the critically ill paediatric patient requires individualised nursing care that responds quickly and appropriately to his/her changing physiological needs (Jakimowicz & Perry, 2015) to promote optimal patient-sensitive outcomes.

1.2 Development of the Endotracheal Suction Assessment Tool©

The Endotracheal Suction Assessment Tool© (ESAT©) was developed as the basis of the researcher's Master's thesis (Appendix B) to support inexperienced nurses working with intubated and ventilated paediatric patients (Davies, 2009). The ESAT© was purposefully designed for the inexperienced nurse to systematically

guide the assessment of clinical indicators used in decision making for the ETT suction procedure. A four-phase mixed methods design guided development of the original ESAT[®] (Davies, 2009; Davies, Monterosso, & Leslie, 2011). Given the fundamental importance of this work which underpins the current PhD thesis, a brief overview will now be provided giving an historical perspective under which the original tool was developed.

Phase One

Phase one comprised a comprehensive literature review to identify the clinical indicators most commonly reported and used by nurses during assessment for ETT suction (Davies et al., 2011). Forty-nine criteria (items) were identified as clinical indicators used to initiate ETT suction and were categorised into one of three broad sub categories: “Clinical considerations”, “Assessment of respiratory status” and “Assessment of ventilation status”. General consensus from authors indicated that ETT suction should only be performed when clinically warranted due to the potential serious complications associated with the procedure; however there was lack of agreement regarding which clinical indicators should be assessed prior to the procedure (Ahrens & Sona, 2003; Baun, 1984; Blackwood, 1999; Carhuapoma & Williams, 1999; Carroll, 2003; Chang, 1995; Charland & Rouleau, 1999; Cook et al., 2000; Copnell & Fergusson, 1995; Curley & Thompson, 1990; Day, Wainwright, & Wilson-Barnett, 2001; Dougherty Wrightson & Askin, 1999; Durand, Sangha, Cabal, Hoppenbrouwers, & Hodgman, 1989; Dyhr, Bonde, & Larsson, 2003; Gilbert, 1999; Hodge, 1991; Knox, 1993; Kondo & Horiuchi, 1999; Moore, 2003; Oh & Seo, 2003; Page, Giehl, & Luke, 1998; Place & Fell, 1998; Pritchard, Flenady, & Woodgate, 2003; Runton, 1992; Swartz, Noonan, & Edwards-Beckett, 1996; Tolles & Stone, 1990; Wainwright & Gould, 1996; Walsh, Vanderwarf, Hoscheit, & Fahey, 1989; Wood, 1998).

Phase Two

Following examination of the literature, the next logical phase was to survey contemporary PIC nurses in order to determine their personal perceptions regarding the importance and clinical relevance of the clinical indicators previously identified in the literature (Davies et al., 2011). Since no suitable validated survey instrument was available, the Endotracheal Suction Questionnaire’ (ESQ) was developed for this purpose (Appendix C). The ESQ was based on the previously identified clinical

indicators and designed to survey experienced PIC nurses in Australia and New Zealand. Prior to use the content validity of the ESQ was established using Lynn's (1986) framework for determining and quantifying the content validity of an instrument (Davies et al., 2011).

The ESQ comprised seven demographic questions, 15 likert-type questions to determine how *frequently* criteria (clinical indicators) were used to determine the need for ETT suction and 15 likert-type questions to determine the respondent's perceived rating of *importance* for each criterion. To add rigour and depth, one open ended question was included requesting respondents to describe a recently performed ETT suction event to enable the researcher to identify any other criteria used by PIC nurses during clinical assessment but not listed in the ESQ.

Phases Three and Four

The ESQ was administered to a target group of PIC nurses (n = 104) in Australia and New Zealand in May 2007 (Davies et al., 2011). Spearman rank order correlation coefficient analyses of ESQ data showed a positive correlation between the perceived *importance* and *frequency of use* of each criterion during clinical assessment of the need to perform ETT suction. If a criterion was rated highly as a clinical indicator for *importance* when initiating ETT suction, it also rated high for *frequency of use*. Similarly, if the criterion was rated low for *importance*, it was also rated low for *frequency of use* (Davies, 2009; Davies et al., 2011).

Analysis of qualitative data from the open-ended question identified six criteria not previously described within the literature: clinical diagnosis; clinical history; previous response to ETT suction; clinical stability; current artificial ventilation mode and preparation of a ventilated paediatric patient for transport. This important finding suggested that clinical assessment of the ventilated PIC patient's requirement for ETT suction is dependent upon a number of interrelated clinical indicators and cannot be defined by a single criterion (Davies, 2009). Notably, ETT suction should only be performed in response to the patient's clinical condition and requirements, rather than routinely as per standardised PIC unit policies or guidelines (e.g. strictly three hourly since the previous ETT suction event).

Findings supported the need for a brief, systematic, clinical assessment instrument based on empirically derived clinical indicators that could be used as a decision aid by the inexperienced paediatric intensive care nurse (IPICN). It was anticipated that use of an instrument such as the Endotracheal Suction Assessment Tool[®] (ESAT[®]) could potentially improve nursing practice and care of ventilated paediatric patients by the IPICN (Davies, 2009; Davies et al., 2011). The previously described subheadings used to categorise ETT suction clinical indicators (*clinical considerations*, *assessment of respiratory status* and *assessment of ventilation status*) were used as the structural framework of the ESAT[®]. During the ESAT[®] design process the most highly ranked clinical indicators were then assigned to each subheading. This was considered the most practical approach to designing such a tool for use in the clinical setting (Appendix B). The rationale underpinning use of these subheadings was to prompt the IPICN (assessor) to assess criteria according to the order of their appearance in the instrument. The ESAT[®] was designed to streamline the assessment process by applying the most significant and frequently used criteria in a simplified user-friendly format for the inexperienced nurse working in a PIC setting.

1.3 Next Steps

The foundation of this PhD thesis was to establish scale level content validity index, criterion-related (construct) validity and test-retest reliability of the ESAT[®] in the clinical setting using established psychometric principles (De Vet, Terwee, & Bouter, 2003; Imle & Atwood, 1988; Lynn, 1986; Polit, 2014; Polit & Beck, 2006; Polit, Beck, & Owen, 2007; Polit & Hungler, 2013; Streiner & Kottner, 2014; Streiner & Norman, 2005). A brief overview of psychometrics is presented to provide context for the remainder of the thesis.

Overview of Psychometrics

Psychometrics is defined as the determination of the reliability and validity of an instrument and historically has its roots in psychological measurements such as establishing personality traits and mental capacity (De Von et al., 2007; Hummel, 2017; Mayo, 2015; Souza, Alexandre, & Brito Guirardello, 2017). Psychometrics is concerned with the scientific approach to testing the theory, design and formation of an instrument (De Von et al., 2007; Hummel, 2017; Mayo, 2015). Fundamentally, psychometrics is testing the design, credibility and validation of a measurement

instrument and in the case of this research, the reliability and validity of the ESAT[®] using established psychometric research principles (De Von et al., 2007; Hummel, 2017; Mayo, 2015). Validity and reliability, while separate entities, are concerned with establishing whether an instrument reliably measures the attributes of the construct (validity) being measured and whether it produces authenticated outcomes repeatedly and consistently over time (reliability and stability) (De Von et al., 2007; Hummel, 2017; Mayo, 2015). In the context of the research presented reliability means the instrument is dependable and can consistently reproduce the same outcomes under identical or similar conditions (Neuman, 2011), while validity reflects how truthfully the instrument measures the reality of the construct under assessment (Neuman, 2011). Decision making related to the most suitable psychometric test for instrument testing is dependent upon the purpose and type of instrument being evaluated. The rationale for the tests used in this study (content validity, criterion-related (construct) validity and test-retest reliability) will be explained in the methodology section of Chapter Three.

1.4 Study Purpose

The overall purpose of this five-phase study is to use standard psychometric testing principles to establish: a) content validity and the scale level content validity index by establishing “clarity”, “apparent internal consistency” and “content validity index”; b) criterion-related (construct) validity; and c) test-retest (stability) reliability of the ESAT[®].

1.5 Research Objectives

1. To determine the currency of the clinical indicators originally used to develop the ESAT[®] by undertaking an updated integrated review of literature published between January 2012- December 2017 (phase one).
2. To establish whether the clinical indicators used to develop the ESAT[®] are directly linked to current ETT suction nursing practice (phase two).
3. To establish the content validity and scale level content validity index of the ESAT[®] using “expert” PIC nurses’ opinion (phase three).
4. To develop ETT Suction Clinical Scenarios and Clinical Assessment Guidelines for the purpose of establishing criterion-related (construct) validity and test retest reliability (phase three).
5. To establish criterion-related (construct) validity of the ESAT[®] (phase four).
6. To establish test retest (stability) reliability of the ESAT[®] (phase five).

1.6 Research Process

Prior to undertaking the psychometric testing procedures two steps were considered necessary to ensure current relevance of this research. First, literature published from 1980 to 2012 describing criteria used by PIC nurses' to perform ETT suction within the PIC environment was reviewed using integrative literature review principles (Davies, Monterosso, Bulsara, & Ramelet, 2015b).

Second, a comprehensive clinical audit of intubated and ventilated patient medical records (n=292) from the sole tertiary PIC clinical setting in Western Australia was undertaken to verify and establish a *real-time* link between clinical indicators listed as criteria within the ESAT[®] to those used in current PIC clinical nursing practice (Davies, Monterosso, Bulsara, & Ramelet, 2015a). As per the Definitions of Terms of this thesis (page xv), the terms “criteria” and “item” are used interchangeably when discussing the clinical indicators within the ESAT[®].

Psychometric testing of the instrument, as described above, was then conducted to establish the content validity, scale level content validity index, criterion-related (construct) validity and test-retest (stability) reliability of the ESAT[®] (K Davies, M Bulsara, AS Ramelet, & L. Monterosso, 2018b).

1.7 Significance

The ESAT[®] psychometric testing processes undertaken during this study formed the basis for this doctoral thesis by publication. Psychometric testing to establish scale level content validity index, criterion-related (construct) validity and test-retest (stability) reliability of the ESAT[®] in the paediatric clinical setting builds on previous research undertaken to develop a gold standard endotracheal suction assessment instrument (tool) for inexperienced PIC nurses (Davies et al., 2011). This research will have the potential to improve patient care, contribute to patient-sensitive health outcomes and standardise nursing practice within the PIC environment. This is the first published research related to the paediatric endotracheal suction procedure, and, importantly is the first known research to develop and test an evidence-based clinical assessment instrument for ETT suction performed by PIC nurses. The establishment of evidence-based practice for nurses enables the benchmarking of endotracheal clinical practice by all nurses irrespective

of the level of experience or expertise. Evaluation of content validity and the scale level content validity index, criterion-related (construct) validity, and, test-retest reliability (stability) of the ESAT[®] makes a contribution to PIC nursing theory and practice. Practice implications of this research focus on the delivery of evidence-based (McGrath, 2012) paediatric intensive nursing care that is individualised, person-centred and potentially improves patient-sensitive health outcomes (Jakimowicz & Perry, 2015).

The National Safety and Quality Health Service (NSQHS) standards set by the Australian Commission on Safety and Quality in Health Care are deemed essential for ensuring patient safety and quality of care in Australia (Australian Council on Healthcare Standards, 2015). In accordance with Standard One (S1) “Governance for Safety and Quality in Health Service Organisations” clinical care for patients should be appropriate no unwarranted variations to patient care. The ESAT[®] will potentially assist nurses’ compliance with this standard as it provides a validated tool to direct standardised patient care for the intubated paediatric patient. It complies with Section 1 point 1.27 which requires the provision of evidence-based care to improve the quality and standard of patient care. Accordingly, NSQHS Standard Nine (S9) “Recognising and Responding to Clinical Deterioration in Acute Health Care” point 8.4, stipulates provision of appropriate and timely care is key in providing quality care that is individualised. The ESAT[®] will potentially contribute to provision of individualised timely care as it provides direction for individual patient assessment and subsequent responsive nursing care (Australian Council on Healthcare Standards, 2015).

With regard to the ESAT[®]’s contribution to the nursing profession, it has the potential to provide clinical guidance for the inexperienced PIC nurse. This could likely be achieved through improved and effective decision making at the bedside regarding the ETT suction procedure by both inexperienced and experienced nurses caring for the intubated paediatric patient. Such improvements to practice would provide the means to guide clinical teaching around assessment of the intubated patient’s need for ETT suction and encourage use of evidence-based care to improve patient care, patient sensitive health outcomes and encourage reflective practice within the clinical setting (De Pedro-Gomez et al., 2011; Melnyk, 2017). It is anticipated that following future implementation and testing for reliability and efficacy in the clinical setting with patients, the ESAT[®] will be recognised as a

reliable and valid instrument to guide the inexperienced PIC nurse's in clinical practice. Further the ESAT[®] complies with national quality and safety standards. The true test of any instrument is the ease of implementation and use within the reality of the clinical setting, and, the reliability of the instrument to guide practice across diverse patient ages and diagnostic groups. Validation of any newly developed instrument should be an ongoing process that builds on the ground work of early developmental research and adjusts as new insights emerge from the tool's use within the clinical setting.

1.8 Overview of Chapters in this Thesis

This initial chapter has provided the introduction, study purpose, research objectives, research process and significance of this study.

Chapter Two presents the original literature review, in which the published literature related to clinical indicators for endotracheal tube (ETT) suction is discussed and critically analysed. This chapter also provides an updated review related to the first publication of this thesis (Davies et al., 2015b).

Chapter Three provides an overview of the conceptual framework and methodology underpinning this thesis.

Chapter Four presents the second publication for this thesis entitled "Audit of Endotracheal Tube Suction in a Paediatric Intensive Care Unit" (Davies et al., 2015a) and explores the link between the ESAT[®] and current clinical practice .

Chapter Five presents the third publication "Content validity testing of the ESAT[®]: A decision aid tool for performing endotracheal suction in children" (K Davies, M Bulsara, AS Ramelet, & L Monterosso, 2018a) and is a pivotal article that describes the scale level content validity index process that was undertaken.

Chapter Six provides the final published article for this thesis "Reliability and criterion-related validity testing (construct) of the endotracheal suction assessment tool (ESAT[®])" (Davies et al., 2018b), presenting the final psychometric procedures undertaken.

Chapter Seven comprises the discussion for this study, including the limitations, future prospects and recommendations for the instrument and the conclusion.

Chapter Two

Publication One: Literature Review

“Clinical indicators for the initiation of endotracheal tube suction in children: An integrated review.”

Davies K, Monterosso L¹, Bulsara M², Ramelet AS³

Publication One, prepared with advice and editorial support from each member of the supervisory team, describes the available evidence surrounding clinical indicators for endotracheal suction published between the years 1980 and 2012. This work provides the foundation for the research and the rationale for providing clinical guidance for inexperienced nurses in the paediatric intensive care (PIC) setting when performing the endotracheal tube suction procedure. An updated integrative literature review (January 1st 2012– 31st of December 2017) is then presented in section 2.1 to review the evidence published since completion of the original article.

Reference:

Davies K, Monterosso L, Bulsara M, Ramelet AS. (2015). Clinical indicators for the initiation of endotracheal tube suction in children: An integrated review. *Australian Critical Care*, 28(1), 11-8. doi:10.1016/j.aucc.2014.03.001

¹ Professor L Monterosso is the principal supervisor of this study and provided content direction, review and editorial advice for this article.

² Professor M Bulsara is the co-supervisor of this study and provided biostatistical and editorial advice for this article.

³ Professor A-S Ramelet is the associate supervisor of this study and provided content guidance and editorial advice for this article.



Clinical indicators for the initiation of endotracheal suction in children: An integrative review



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ABSTRACT

Background: Critical decisions and interpretation of observations by the nurse caring for the paediatric intensive care (PIC) patient can have dramatic and potential adverse impact on the clinical stability of the patient. A common PIC procedure is endotracheal tube (ETT) suction, however there is inconsistent evidence regarding the clinical indicators to guide and support nursing action. Justification for performing this procedure is not clearly defined within the literature. Further, a review of the literature has failed to establish clear standards for determining if the procedure is warranted, especially for paediatric patients. **Objective:** The objective of the review is to identify current clinical indicators used in practice to determine why ETT suction should be performed.

Method: An integrative review using a systematic approach to summarise the empirical and theoretical evidence within the literature as it relates to clinical practice was used.

Results: Consensus of opinion indicates that ETT suctioning should only be performed when clinically indicated. There is no general consensus regarding which clinical indicators should be measured and used to guide the decision to perform ETT suctioning.

Conclusion: Research is required to identify the clinical indicators that could be used to design a valid and clinically appropriate tool to use to assist in the decision making process to perform ETT suction.

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1. Introduction

In recent years the role of the paediatric critical care nurse has evolved in response to advances in technology, quality control, accountability, documentation and evidence-based practice.^{1–6} Complexities in critical care arise from differing disease processes and fundamental differences in the physiological and co-morbidities between neonatal, paediatric and adult critical care patients.^{7–13} In particular, compared with adults, neonatal and paediatric patients have immature respiratory and cardiovascular

systems affecting compensatory mechanisms. The neonatal and paediatric airway is still developing until around eight years of age. Further, high chest wall compliance impedes counter traction recoil of the lungs producing lower lung volumes at end expiration and decreased respiratory reserve; combined with increased metabolic and oxygen requirements these patients are also prone to muscle fatigue resulting in respiratory failure.^{7,8,10}

The care of the critically ill child therefore is complex, multidimensional and must be coordinated by a multidisciplinary team.^{7,8} As with neonatal and adult critical care, there is an expectation from the health profession and family, that paediatric critical care nurses demonstrate highly developed clinical and communication skills, accountability, the ability to practice independently and deliver care that meets established standards of quality care.^{3,14} The need to provide education and support to nurses in critical care areas to ensure safe care is delivered according to best practice norms

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The complete PDF version of the manuscript was presented in Appendix D for examination purposes only.

2.1 Introduction

In recent years the role of the paediatric critical care nurse has evolved in response to advances in technology, quality and safety control, accountability, documentation and evidence-based practice (American Association of Respiratory Care, 2010; Bolton, Donaldson, Rutledge, Bennett, & Brown, 2006; Brett, 2011; Mantzoukas, 2008; McGrath, 2010). Complexities in critical care arise from diverse disease processes and fundamental physiological differences and co-morbidities experienced by neonatal, paediatric and adult critical care patients (Adewale, 2009; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Khilnani, 2011; Sims & Johnson, 2011; Sims & von Ungern-Sternberg, 2012; Sunder, Haile, Farrell, & Sharma, 2012). Compared with adults, neonatal and paediatric patients have immature respiratory and cardiovascular systems affecting compensatory mechanisms. The neonatal and paediatric airway is still developing until around eight years of age. Further, high chest wall compliance impedes counter traction recoil of the lungs producing lower lung volumes at end expiration and decreased respiratory reserve; combined with increased metabolic and oxygen requirements these patients are also prone to muscle fatigue resulting in respiratory failure (Curley & Moloney-Harmon, 2001; Hazinski, 2013; Sims & Johnson, 2011).

The care of the critically ill child therefore is complex, multidimensional and must be coordinated by a multidisciplinary team (Curley & Moloney-Harmon, 2001; Hazinski, 2013). As with neonatal and adult critical care, there is an expectation from the health profession and family that paediatric critical care nurses demonstrate highly developed clinical and communication skills, accountability, the ability to practice independently and deliver care that meets established standards of quality care (Australian Nursing & Midwifery Council, 2006; Commonwealth Department of Education Science and Training, 2001). From a workforce perspective, the need to provide education and support to nurses in critical care areas to ensure appropriate and safe care is delivered according to best practice norms is now more important than ever (Australian Council on Healthcare Standards, 2015). Further, the importance of clear and accurate documentation to fulfil legal, professional and social requirements cannot be underestimated (Austin, 2011).

The focus of this review is to identify the decision processes used by critical care nurses when assessing the requirement for endotracheal suction in the paediatric intensive care unit (PICU). Airway management is a core component of multidisciplinary care within the PICU, and a critical component and responsibility of PIC nursing care. Mechanical ventilation for PICU patients can range from 17% to 65% of admissions, and is dependent upon the type of critical care services provided and the diagnostic group admitted within individual PICUs (Namachivayam et al., 2010; Ramelet, 2006; Rischbieth, 2006; Turner & Cheifetz, 2011). The decision to perform endotracheal tube (ETT) suction in a critically ill child can have major implications and should only be performed after assessment and due consideration including mitigation of any known potential side effects if possible.

There are a number of significant clinical side effects associated with ETT suction that can seriously affect the clinical stability of the critically ill ventilated patient that are well documented (Curley & Moloney-Harmon, 2001; Gilbert, 1999; Hazinski, 2013; Knox, 1993; Landsman, 2004)(Table 2.1). The most significant complications relate to the respiratory stability of the patient and include changes in lung volume, lung compliance and oxygen and carbon dioxide gas exchange (Hazinski, 2013). These alterations in respiratory dynamics can cause hypoxaemia, which in turn can adversely affect the cardiac output of the patient, altering blood flow and oxygen delivery at a cellular level; hence ETT suction can adversely affect the clinical stability of the patient. More serious but less common complications associated with ETT suction include cardiac arrest and sudden death (Curley & Moloney-Harmon, 2001; Curley & Thompson, 1990; Hazinski, 2013). The range and complexity of situations and potentially hazardous outcomes make it essential that ETT suction be performed only when clinically indicated. These complications are dependent upon the clinical stability and underlying pathophysiology of the disease process for each individual patient. Some common problems associated with the ETT suction procedure may be directly linked to a respiratory disease. For example, a patient diagnosed with pulmonary hypertension is more likely to experience alteration in oxygen saturations following endotracheal suction than a patient suffering from renal dysfunction (Curley & Moloney-Harmon, 2001; Hazinski, 2013).

Table 2.1 Adverse Effects of Airway Suctioning

Respiratory Effects	Haemodynamic Effects
1. Altered pulmonary compliance (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow, Futter, & Argent, 2004; Morrow, Futter, & Argent, 2008)	1. Anxiety (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)
2. Bleeding (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)	2. Cardiac arrest (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)
3. Bronchospasm and bronchial constriction (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)	3. Cerebral blood flow alterations (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Gilbert, 1999; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)
4. Contamination of airway, infection and sepsis (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)	4. Cyanosis (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)
5. Decrease in arterial oxygenation (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)	5. Dysrhythmias (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Gilbert, 1999; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)
6. Hypoxaemia (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)	6. Haemodynamic compromise (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Inselman, 2001; Morrow et al., 2004; Morrow et al., 2008)
7. Increased airway resistance (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)	7. Heart rate alterations (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)
8. Laryngospasm (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)	8. Hypertension (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)
9. Microatelectasis (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Gilbert, 1999; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)	9. Hypotension (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)

Respiratory Effects	Haemodynamic Effects
10. Mucosal damage (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Gilbert, 1999; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)	10. Increased intrathoracic pressure (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)
11. Necrotising tracheobronchitis (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)	11. Oxygen consumption changes altering haemodynamics (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)
12. Negative intra-pulmonary pressures (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)	12. Oxygen saturation changes (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Gilbert, 1999; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)
13. Paroxysmal coughing (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)	13. Pallor (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)
14. Perforation (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)	14. Stressing of patient during procedure (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)
15. Pneumothorax (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)	15. Sudden death (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)
16. Pulmonary haemorrhage (Godfrey, 2004)	16. Vagal stimulation causing hypotension (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)
17. Tissue damage (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)	17. Trauma (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)
18. Tube blockage (American Association of Respiratory Care, 2010; Curley & Moloney-Harmon, 2001; Hazinski, 2013; Morrow et al., 2004; Morrow et al., 2008)	

This table is taken from the integrative review article (Davies et al., 2015b)

2.2 Problem Formulation

Advances in patient care delivery and the increased reliance on technology within the health care setting, particularly in intensive care units has led to changes in the knowledge base, skills and standards of nursing care required to effectively care for the critically ill patient (Baggot, Hensinger, Parry, Valdes, & Zaim, 2005; Commonwealth Department of Education Science and Training, 2001). Critically ill paediatric patients have complex problems that are often associated with changes in the child's clinical condition such as the deterioration from an initial diagnosis of aspiration pneumonia to multi-organ failure, which can in turn lead to multi-morbidities (Baggot et al., 2005; Commonwealth Department of Education Science and Training, 2001; Ryan, Hills, & Webb, 2004). As a specialty area, the PICU is faced with complex care issues requiring both clinical and technical expertise. The accurate assessment of ventilation and oxygenation of the ventilated critically ill patient is fundamental to the care of the patient in the intensive care setting (Curley & Moloney-Harmon, 2001; Hazinski, 2013). A review of medical and nursing literature about competency in respiratory assessment skills identified a number of inadequacies including poor assessment skills; errors in physical diagnosis and poor quality of nursing judgement in making a respiratory assessment (Day, Farnell, Haynes, Wainwright, & Wilson-Barnett, 2002; Epstein & Hundert, 2002). Compounding these issues was inadequate knowledge of protocols and practices that directly impacted on the quality of patient care (Cousins & Power, 1999; Day et al., 2001; Jacobe, Denessen, & Postma, 2004; Lester & Tritter, 2001; Mangione & Nieman, 1997; McGlynn & Brook, 2003; Moore, 2003).

In 2006, Bolton and colleagues (2001) published a review article from their evaluation of a systematic review and meta-analysis of published articles relating to nursing interventions and patient outcomes in acute care settings. One aspect of the review indicated that quality of nurse staffing is strongly linked to patient care outcomes such as adverse events, though the limitations of available evidence impaired the author's ability to establish a direct association between nursing interventions and patient outcomes. The authors recommended that research undertaken to standardise assessment tools, integral to nursing interventions, would add to the understanding of the effect nursing interventions had on patient outcomes. This report supports the premise that ETT suction should only be performed when

clinically indicated in order to limit adverse events. Furthermore, the expertise of the nursing staff providing care impacts on the quality of care delivered for the patient. Chlan and colleagues (2011) suggested that competence and intensive care skills for the ventilated patient require specific education strategies and support. Further, nurses who engage in evidence-based practice and research at the PICU level can contribute to improving outcomes for the mechanically ventilated patient (Mantzoukas, 2008).

These issues, together with the potential complications associated with ETT suction, add further support to the identification of clinical indicators for ETT. The aim of this integrative review is to identify current clinical indicators used in practice by PIC nurses to determine why ETT suction should be performed. For the purpose of this review, “clinical indicators” are defined as specific observable “criteria” relating to airway assessment, such as “visible secretions” or “changes in ventilator peak pressure”.

2.3 Method

This integrative review uses a systematic approach to summarise the empirical and theoretical evidence within the literature as it relates to clinical practice (Neuman, 2011; Whittemore & Knafl, 2005). The advantage of this approach over a systematic review is that it provides a more comprehensive or in-depth evaluation of the issue under investigation, including both advantages and disadvantages of each article reviewed (Whittemore & Knafl, 2005). As recommended by Whittemore and Knafl (2005) this integrative review encompassed five stages: problem identification and formulation (as presented above), literature search, data evaluation, data analysis and presentation.

A primary search of Cinahl, Medline and Pubmed databases using Ovid and a secondary search based on the references of the available literature identified 52 relevant articles published over the last 30 years. This time frame was chosen due to the paucity of evidence regarding this topic. Primary search terms included “endotracheal”, “suction”, “suctioning”, “airway management”, “secretions”, “assessment tool”, “intubation”, “tracheobronchial”, “management”, “ventilated”, “patient”, “techniques”, “haemodynamic alterations”, “complications”, “paediatric”,

“pediatric”, “criteria”, “neonatal” and “clinical indicators”. Primary assessment of each article was based on the title, summary, and conclusion in relation to the contextual significance to the topic. These articles were identified and chosen for inclusion in the review because the key focus was the identification of specific clinical indicators that led to the decision to perform the ETT suction procedure. Clinical indicators listed included, “dyspnoea or signs respiratory distress”, “auscultation: (altered, diminished, abnormal air entry)”, “decreased oxygen saturation/cyanosis”, “visible or audible secretions”, “decreased tidal volume delivery”, “increasing end tidal carbon dioxide”, “increased peak pressure”, “haemodynamics (unexplained changes in heart rate/BP & ICP if applicable)”, “alteration in arterial blood gas results”, “coughing”, “altered chest movement”, “queried aspiration”, and “unexplained patient restlessness.” Excluded were articles relating to suction technique, saline instillation, neonatal and adult population, animal studies, physical assessment, tracheostomy, ventilator issues and airway physiology.

2.4 Data Evaluation Stage

Those articles meeting the selection criteria discussing identifying criteria used to rationalise ETT suction in the paediatric intensive care patient were retrieved and further assessed to determine the level of evidence, based on the characteristics of the articles (study purpose, research design, and sample size).

The “Hierarchy of Evidence for Intervention Studies”, as described by Stillwell, Fineout-Overholt, Melnyk and Williamson (2010) (Table 2.2) was used to assign the level of evidence provided by each article (Stillwell, Fineout-Overholt, Mazurek Melnyk, & Williamson, 2010).

Table 2.2 Hierarchy of Evidence for Intervention Studies

The original 'Hierarchy of Evidence' table was sourced from Searching for the Evidence, 2010, p. 43. (Stillwell et al., 2010). To view the original table please refer to this article.

2.5 Results

Details of the search results are outlined in Figure 2.1. As previously stated, the search identified 52 articles directly relating to the topic under review. Of these, 15 articles pertained directly to the paediatric intensive care setting and under further critique 11 articles were retained as pertinent to the subject under review (Table 2.3). Of the excluded articles, six related to the neonatal population, 30 to the adult intensive care setting and there was one animal study.

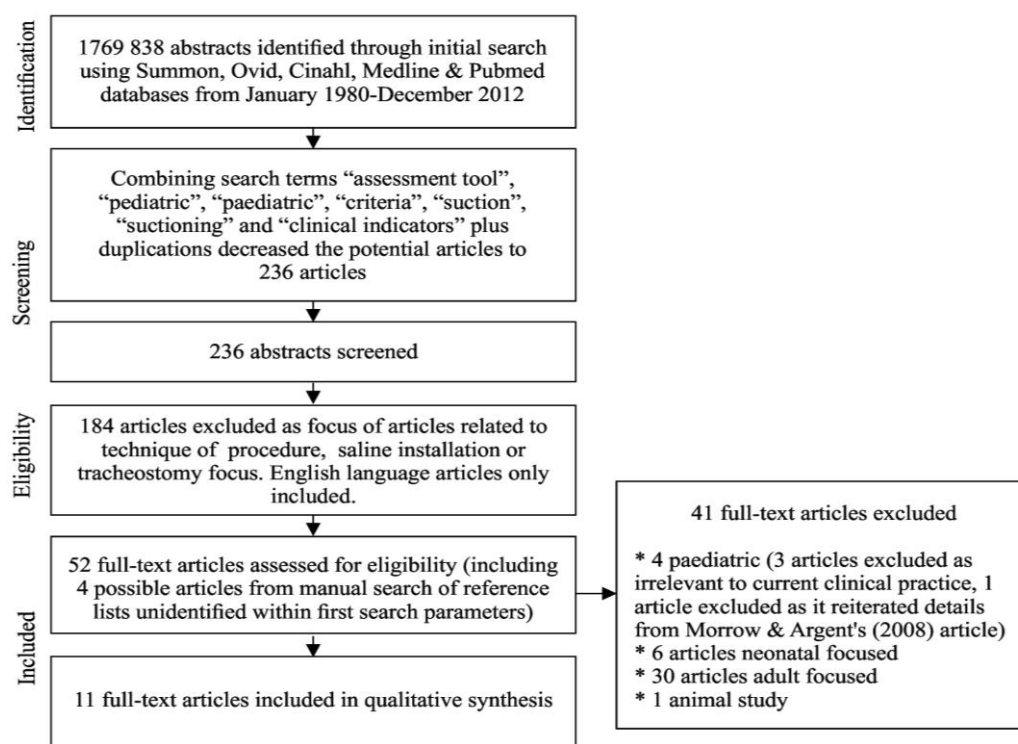


Figure 2.1 Flowchart of the literature search results (Davies et al., 2015b).

Although the general consensus from the current literature was that ETT suction should be performed according to the clinical condition and symptoms of the patient, there was wide discrepancy in the criteria used to determine if the procedure should be performed and what clinical guidance in prioritising or rating clinical indicators

provided (Table 2.4). A total of 36 criteria were identified within the articles reviewed as the motivation for performing ETT suction. The number of criteria presented within each article ranged from approximately 1 to 19. Articles by Morrow and Argent (2008) and Thomas and Fothergill-Bourbonnais (2005) attempted to identify the criteria currently utilised when assessing the requirement for ETT suctioning. Davies, Monterosso and Leslie (Davies et al., 2011) developed a validated questionnaire to enable Australian and New Zealand paediatric critical care nurses to rate and rank criteria utilised when performing ETT suction. Key findings were then utilised to design an Endotracheal Suction Assessment Tool[®] (ESAT[®]).

Table 2.3 Methodological Characteristics of Selected Articles
(Davies et al., 2015b)

Authors/Dates (Level of evidence)	Purpose	Design	Sample & characteristics	ETT suction criteria identified
American Association of Respiratory Care (AARC), 2010 (I)	Update clinical guideline for ETT suction practices using GRADE	Literature review	Review period 1990-2009 <ul style="list-style-type: none"> • Article review • 114 clinical trials • 62 review articles • 6 meta-analyses 	<ul style="list-style-type: none"> • To maintain patency of the artificial airway • Remove pulmonary secretions • Sawtooth pattern on the flow-volume loop • Increased peak pressure during volume control ventilation or decreased tidal volume during pressure control ventilation • Deterioration of O2 saturation and/or ABG values • Visible airway secretions • Inability of patient to spontaneously cough • Acute respiratory distress • Suspected aspiration • To obtain ETT mucous specimen

Authors/Dates (Level of evidence)	Purpose	Design	Sample & characteristics	ETT suction criteria identified
Morrow and Argent, 2008 (I)	Review evidence for endotracheal suctioning	Comprehensive review	Review period 1962-2007 <ul style="list-style-type: none"> • 118 articles reviewed • 8 clinical trials with paediatric relevance 	<ul style="list-style-type: none"> • Audible or visible secretions in the ETT • Coarse breath sounds • Coughing • Arterial O2 desaturation due to secretions • Bradycardia due to secretions • Decreased tidal volumes • Tracheal aspirate culture • Following chest physio • Changes in flow/loop graphics • HFO ventilated patients changes in oscillation of the chest wall • TCPaO2 and TCPaO2 changes
Davies, Monterosso and Leslie, 2011 (III)	Identify and rank ETT suction criteria Develop ETT suction assessment tool	Descriptive, cohort, exploratory & historical	Review period 1980-2009 <ul style="list-style-type: none"> • 31 articles reviewed • 4-phase study • quantitative & qualitative research • Validation of questionnaire • 104 experienced PICU nurses 	<ul style="list-style-type: none"> • Auscultation • Visible or audible secretions • Changes in O2 saturations • Changes in patient colour • Signs of respiratory distress • Decreased tidal volume • Increased peak pressure • Increased ET CO2 • Diagnosis • Clinical history • Clinical stability • Previous response to ETT suction • Preparation for transport • Suspected ETT obstruction

Authors/Dates (Level of evidence)	Purpose	Design	Sample & characteristics	ETT suction criteria identified
Swartz, Noonan and Edward-Beckett, 1996 (IV)	Survey endotracheal suctioning technique at national level	Descriptive & expert opinion	<ul style="list-style-type: none"> • Questionnaire survey in 92 PICUs • Staff nurses > 3years PICU experience • 90% return rate 	<ul style="list-style-type: none"> • Nursing judgement • Clinical condition • Amount of secretions • Breath sounds • Oxygen saturation • Consistency of secretions • Tolerance to procedure • Response to suctioning • Diagnosis • Arterial or capillary blood gas • End-tidal CO2 values • TCPaO2 and TCPaO2 changes • Child's age • Other unexplained indicators
Carroll, 2010 (IV)	Summarise the physics of suctioning and the impact on patient mucosa and safety	Expert opinion & case study	<ul style="list-style-type: none"> • 1 case study presented on suction pressure • 13 articles reviewed 	<ul style="list-style-type: none"> • Visible or audible secretions within the ETT

Authors/Dates (Level of evidence)	Purpose	Design	Sample & characteristics	ETT suction criteria identified
Thomas and Fothergill- Bourbonnais, 2005 (V)	Examine cues expert critical care nurses used in making clinical judgement about suctioning in intubated and ventilated patients	Observational & descriptive qualitative	<ul style="list-style-type: none"> • 7 expert pediatric nurses with at least 3 years pediatric critical care experience • 3 methods of data collection –participant field observation, concurrent verbalisation & semi-structured interviews 	<ul style="list-style-type: none"> • Changes in O2 saturations • Increased work of breathing • Signs of respiratory distress • Coughing • Agitation • Ventilator alarms (changes in pressure, minute volume & tidal volumes) • Visual or audible secretions • Changes in colour • Asymmetry of the chest wall • Audible secretions • Presence of secretions during hand ventilation • Changes in lung compliance • Decision based on practice environment –unit routine, patient procedures, to suit nurses’ break time

Authors/Dates (Level of evidence)	Purpose	Design	Sample & characteristics	ETT suction criteria identified
Gilbert, 1999 (V)	Identify clinical practice in assessment of the need to suction and patient observations guiding nursing action	Descriptive & expert opinion	<ul style="list-style-type: none"> • Non-participant observation & interviews of 12 nurses in 4 PICUs 	Abnormal/diminished breath sounds Dyspnoea, signs of distress and respiratory distress Auscultation Infant activity Tolerance for the procedure Type and amount of secretions Clinical condition Vital signs Heart rate Alterations in arterial blood gas Decreased O2 saturations Audible secretions Cyanosis Decreased tidal volume Increased carbon dioxide Coughing Feeling of secretions in chest Altered chest movement Visible secretions
Page, Giehl and Luke, 1998 (V)	Identify complications and treatment for the intubated patient	Descriptive & expert opinion	Review period 1980-1997 <ul style="list-style-type: none"> • 23 expert opinion • 2 guideline reviews • 1 case reviews 	Clinical assessment ETT obstruction

Authors/Dates (Level of evidence)	Purpose	Design	Sample & characteristics	ETT suction criteria identified
Curley and Thompson, 1990 (V)	Identify waveform changes indicating obstruction CO2 as an indicator for alveolar ventilation	Descriptive & expert opinion	<ul style="list-style-type: none"> 8 articles listed in reference 	Assessment of ventilation Descriptive of changes in ETCO2 monitoring parameters
Hahn, 2010 (VII)	Identify in the literature 10 important factors to consider during endotracheal suction	Descriptive	<ul style="list-style-type: none"> Summation of 7 articles on key points by author 	Evidence-based practice
Copnell and Ferguson, 1995 (VII)	Determine the criteria nurses use in the decision to perform endotracheal suction	Descriptive & expert opinion	<ul style="list-style-type: none"> 24 registered nurses completed a questionnaire 	Colour Respiratory effort Decreased O2 saturations Maintain patency of ETT Arterial blood gas results Degree of distress Haemodynamic changes Ventilator parameters (no description given) Auscultation Effectiveness of cough reflex

Table 2.4 Criteria Identified for Initiation of Endotracheal Suction (n=36)
(Davies et al., 2015b)

Criteria listed within articles	Number of times listed	Criteria listed within articles	Number of times listed
1. Abnormal/diminished breath sounds	1	19. Increased carbon dioxide	3
2. Altered chest movement	3	20. Increased work of breathing	2
3. Altered haemodynamics	1	21. Ineffective cough	2
4. Assessment of airway patency	3	22. Oscillation changes to chest wall	1
5. Auscultation	2	23. Post chest physio	1
6. Breath sounds – course	2	24. Preparation for transport	1
7. Change of patient colour	3	25. Previous secretion removal (type & amount)	2
8. Child’s degree of distress	3	26. Protocol	1
9. Clinical assessment	1	27. Respiratory distress	2
10. Clinical condition /diagnosis	3	28. Secretion removal	2
11. Coughing	3	29. Specimen collection	2
12. Cyanosis	1	30. Suspected aspiration	1
13. Decreased tidal volume	4	31. TCPaO ₂ and TCPaO ₂ changes	2
14. Decreased oxygen saturations	6	32. Tolerance for the procedure	1
15. Deterioration in arterial blood gas results	6	33. Tube obstruction	4
16. Dyspnoea, & signs of distress	1	34. Ventilator alarms	1
17. Flow loop graphics	3	35. Visible or audible secretions	8
18. Increased airway pressures	3	36. Vital sign changes (heart rate; respiratory rate)	5

Of the 52 articles reviewed, 11 related specifically to the paediatric population and referred to clinical criteria used to assess the requirement for ETT suction. The criteria or clinical indicators listed varied widely between articles and included interrelated physical and behavioural signs relevant to pathophysiology and clinical stability (American Association of Respiratory Care, 2010; Carroll, 2010; Charland & Rouleau, 1999; Copnell & Fergusson, 1995; Curley & Moloney-Harmon, 2001; Davies et al., 2011; Gilbert, 1999; Hahn, 2010; Knox, 1993; Morrow & Argent, 2008; Page et al., 1998; Runton, 1992; Swartz et al., 1996; Thomas & Fothergill-Bourbonnais, 2005). Two articles provided level I evidence; the literature review by the American Association of Respiratory Care (AARC) (American Association of

Respiratory Care, 2010) and the comprehensive review by Morrow and Argent (Morrow & Argent, 2008). Whilst the AARC (American Association of Respiratory Care, 2010) provided the best level of evidence for the criteria utilised for ETT suction, it still presented an incomplete picture as not all criteria listed within other literature was listed within the AARC guidelines (Gilbert, 1999; Morrow & Argent, 2008) were considered and analysed as potential “indications for ETT suction” (e.g. changes in end tidal carbon dioxide (ETCO₂), patient colour changes and haemodynamic alterations). The AARC (American Association of Respiratory Care, 2010) base recommendations utilised the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) criteria evaluating risk to benefit, (Gopalakrishna, Langendam, Scholten, Bossuyt, & Leedflang, 2013) which may explain non-inclusion of these criteria. There is no specific rating or ranking of the criteria listed as indications for ETT suction within the AARC (American Association of Respiratory Care, 2010) guidelines to specifically guide readers. The key focus of indicators presented in the literature reviewed is on maintaining the patency and integrity of the ETT, including removal of accumulated pulmonary secretions. The consensus from the AARC (American Association of Respiratory Care, 2010) was that ETT suction “should only be performed when secretions are present”, a singular specific criteria in contrast to the other articles (Davies et al., 2011; Gilbert, 1999; Hahn, 2010) reviewed which recommended suctioning should occur based on patient assessment. As with the other articles (Davies et al., 2011; Gilbert, 1999; Hahn, 2010) reviewed the AARC included the most commonly listed criterion “the presence of audible or visible secretions” (Table 2.4), but did not include other specific indicators for suctioning within a ranking profile. Under the AARC (American Association of Respiratory Care, 2010) “indications” each individual criterion may indicate the need to suction but the process is complex and “deterioration in oxygen saturations” may not necessarily relate to a respiratory issue relating to secretions, for example impaired cardiac output can cause a deterioration in oxygen saturations (Curley & Thompson, 1990; Hazinski, 2013). Additionally, no specific contraindications to ETT suction are listed within the AARC (American Association of Respiratory Care, 2010) guidelines, which is surely part of the patient assessment when determining benefit to risk.

Morrow and Argent (2008), while providing a comprehensive literature review, did not include certain common clinical indicators that had been described in other articles (e.g. increased ETCO₂ levels)(Curley & Thompson, 1990; Davies et al., 2011; Gilbert, 1999). This may reflect that as technology changes so too can the measurement and assessment of criteria used to identify when ETT suction is required. Technology is an important influence on determining clinical indicators utilised by nurses as part of the respiratory assessment of the patients requirement for ETT suction, several authors discuss assessment of ventilation, changes in ventilation pressures, changes in flow loop graphics and ventilator alarms as part of the process (American Association of Respiratory Care, 2010; Copnell & Fergusson, 1995; Curley & Thompson, 1990; Davies et al., 2011; Thomas & Fothergill-Bourbonnais, 2005).

The lack of consistency in the criteria used for the initiation of ETT suction may be indicative the complexity of this issue and the wide range of diagnoses of intensive care patients affects the selection of suitable ETT suction criteria for individual cases. The challenge will be to identify the clinical indicators that could be used in designing a valid and clinically appropriate tool to use for all patients within the PIC environment.

Thomas and Fothergill-Bourbonnais' (2005) research also identified that clinical judgement is a complex process directly relating back to the nurse's experience and patient cues - adding another facet to an already complex issue.

The article by Davies and colleagues (2011) was the only article that ranked the level of importance of ETT suction criteria used by PIC nurses to make decisions regarding ETT suction. The article authors also defined the importance and ranking of clinical indicators when deciding to perform ETT suction. This evidence was used to develop an Endotracheal Suction Assessment Tool[®] (ESAT[®]) to guide clinical practice for when ETT suction may be required.

Hahn (2010) and Pedersen and colleagues (2009) suggested there was some value in performing ETT suctioning at least eight hourly to prevent the build-up of biofilm (a very thin layer of microscopic organisms that covers the inside surface of the ETT) which could obstruct the ETT, though the level of evidence is low. Copnell and Ferguson (1995) previously researched standard interval times for ETT suction but concluded that potential deterioration in a patient's clinical condition equates to a

complexity of decision making regarding ETT suction that makes standard time frames impractical. There was, however, a consensus of opinion among the articles that a patient's clinical stability requires careful assessment in conjunction with the underlying diagnosis to determine the need to perform ETT suction, rather than performing suction on a prearranged schedule (Carhuapoma & Williams, 1999; Day et al., 2001; Dougherty Wrightson & Askin, 1999; Durand et al., 1989; Dyhr et al., 2003; Gilbert, 1999; Hodge, 1991; Knox, 1993; Moore, 2003; Pedersen, Rosendahl-Nielsen, Hjermind, & Egerod, 2009).

In comparing criteria identified in the reviewed articles, some authors referred to "nursing judgement" or "patient's clinical condition" without clarifying what this actually meant (Swartz et al., 1996; Walsh et al., 1989). Others provided a comprehensive review of the observations assessed prior to ETT suction (Baun, 1984; Copnell & Fergusson, 1995; Hodge, 1991; Moore, 2003). Changes in oxygen saturation, coughing, audible or visible secretions and changes in ventilator parameters were common themes (Baun, 1984; Carhuapoma & Williams, 1999; Copnell & Fergusson, 1995; Curley & Moloney-Harmon, 2001; Durand et al., 1989; Gilbert, 1999; Moore, 2003). This lack of clarity supports the need for further investigation and more precise definition to ensure all assessment criteria is identified.

A precise tally of all criteria could not be performed because terminology was not descriptive enough to define such statements as "acute physiological changes" or "changes in vital signs". No single article included all of the 36 criteria identified within the combined literature review. There may be several reasons for this including differing diagnoses and management within each intensive care unit with differing technology used for patient care. Importantly the authors recommended that ETT suction should only be performed when clinically indicated, emphasising the role of the nurse in assessing accurately the need of the patient and performing appropriate interventions.

Conclusion

In summary, there was a clear dearth of articles directly relating to this subject and the limited article available for review demonstrated limited levels of evidence. There was consensus of opinion that ETT suctioning should only be performed when clinically indicated but the process is complex when assessing the patient's

individual needs. This integrative review of the current literature showed a general lack of evidence regarding which clinical indicators should be measured and used to guide the decision to perform ETT suctioning. As previously stated, the AARC (American Association of Respiratory Care, 2010; Copnell & Fergusson, 1995; Curley & Thompson, 1990; Davies et al., 2011; Thomas & Fothergill-Bourbonnais, 2005) provided the best level of evidence in relation to the criteria utilised for ETT suction but did not adequately analyse or rank other factors common to the other articles reviewed. An expanded approach of analysis and ranking of further factors would provide a more complete picture to guide nursing practice.

Informed, educated, skilled nurses utilising evidence-based practice can improve patient outcomes and reduce health costs. Appropriate nursing responses to initiate procedures will achieve the best possible patient outcomes. The development of a clear evidence-based approach to assist in the key decision making process will be an important step in improving assessment and decision making processes for determining the need for ETT suction. The challenge now is to confirm the validity and reliability of any tool designed which guides clinical practice within the PIC environment for ETT suction.

The published article is now concluded. The following section revisits the literature to provide an updated literature review.

2.6 Updated Literature Search

As previously discussed a review of the literature published from 2012 was considered an important step in this thesis to determine whether any clinical indicators had been identified from more recent work. The previously published integrative review examined literature published between 1980 and 2012 related to clinical indicators used for the initiation of endotracheal suction in children (Davies et al., 2015b).

The current review included articles published between January 1st 2012 and the 31st of December 2017. The following guiding principles for the conduct of integrative reviews described by Whittemore and Knafl (2005) were used: problem identification and formulation, literature search, data evaluation, data analysis and presentation were followed.

Problem Identification and Formulation

The quality of nursing care provided to patients is largely influenced by the knowledge, assessment skill and education of the nurses who deliver care (Blegen, Vaughn, & Vojir, 2008; Bolton et al., 2006). Evidence based protocols and guidelines can enhance clinical practice and improve patient outcomes (Falzer & Garman, 2009). Whilst it is clearly established within the literature that ETT suction should only be performed when clinically indicated, the specific criteria used to guide the procedure are less clear (American Association of Respiratory Care, 2010; Davies et al., 2015b; Davies et al., 2011; Morrow & Argent, 2008). Previous research published by the researcher identified ETT suction criteria perceived as relevant and important by PIC nurses in Australia and New Zealand (Davies et al., 2011). As described these criteria were used as the basis for development of the ESAT[®], a guide the inexperienced PIC nurse caring for the intubated paediatric patients.

Literature Search

To ensure consistency the original search terms were used with the addition of “airway management”. The same primary databases were also revisited (Cinahl, Medline and Pubmed using Ovid) and supplemented with the Summon search engine. A secondary search based on the references identified in the available literature was also performed.

A total of 1,795,788 potential articles were identified using the original articles search parameters. Primary assessment of each article was based again on the title, summary, and conclusion in relation to the contextual significance to the topic. These articles were identified and chosen for inclusion in the review because the key focus was the identification of specific clinical indicators that led to the decision to perform the ETT suction procedure. Articles were excluded if the focus was on how to perform ETT suction or complications associated with the procedure, such as the use of saline for ETT suction, reducing the potential article numbers to 323. Of these, 14 articles met the inclusion criteria identifying criteria used to justify the ETT suction procedure and were deemed eligible for further review. On closer inspection 10 articles were excluded as they related exclusively to either adult research (n = 4), neonatal research (n=4), neonatal nasopharyngeal suction (n=1) or animal based

research (n=1). Therefore, four “new” articles met the inclusion criteria. The search strategy is articulated in the Prisma diagram shown in Figure 2.2.

Data Evaluation and Analysis

Included articles were assessed to determine the level of evidence provided within the text using the “Hierarchy of Evidence for Intervention Studies” (Table 2.5) described by Stillwell, Fineout-Overholt, Melnyk and Williamson (2010).

Of the included four articles, one met the criteria of Level II, two met the criteria of Level IV and one met the evidence for Level VI (Table 2.5) These articles were identified within the primary search results with all secondary articles from the manual search of references excluded as not being specific to paediatrics.

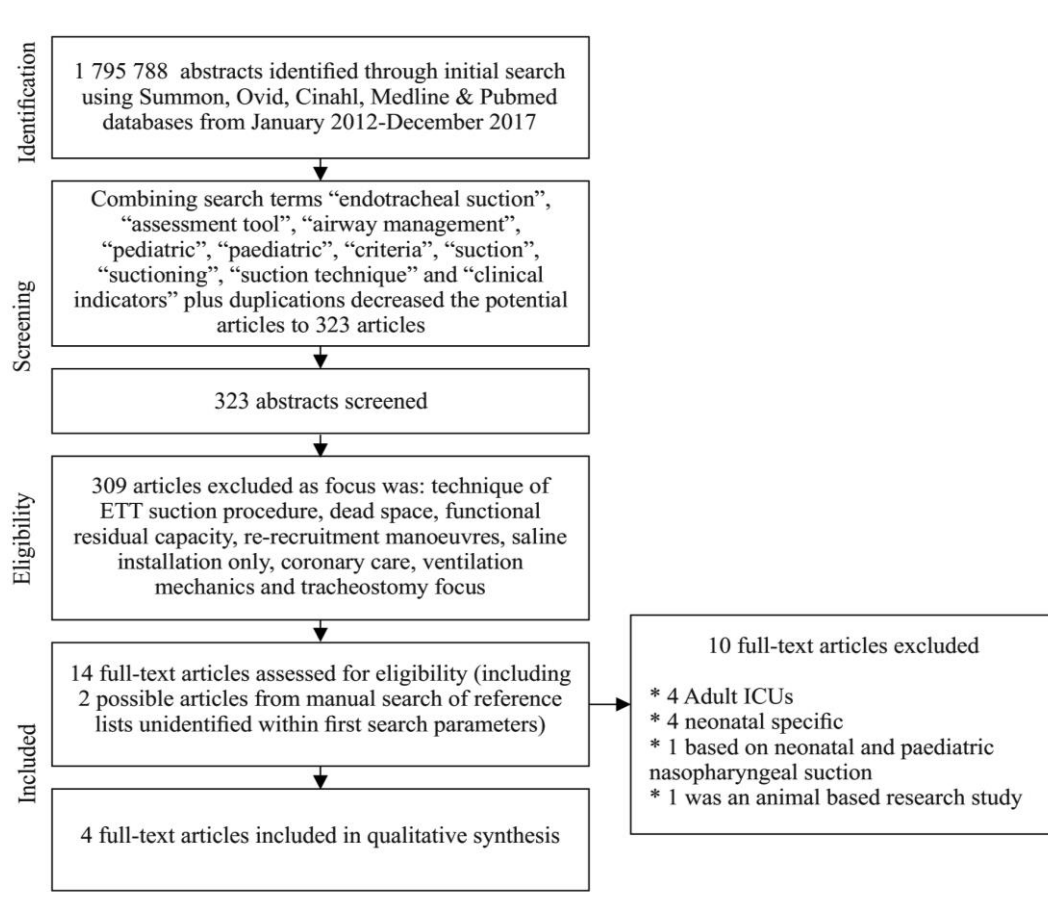


Figure 2.2 Flowchart of the updated literature search results (January 2012-December 2017).

Presentation

The Level II article reported a randomised controlled trial that compared the effect of open ETT suction with closed ETT suction on patient safety, efficacy and nursing time. The study was performed with intubated paediatric patients (n=258) and made reference to use of “pre-existing ETT suction guidelines”, however the guidelines were not described or presented (J. Evans, Syddall, Butt, & Kinney, 2014). The researchers discussed changes in oxygen saturations and blocked or dislodged ETTs as criteria resulting in ETT suction.

The first Level IV article described a prospective study that reviewed over a thousand ETT suction events and identified “coarse crackles over the trachea”, “increased peak pressure” (PP), “decreased tidal volume” (TV), “oxygen desaturation” and “acute respiratory distress” as criteria used to initiate ETT suction (Owen et al., 2016). The second Level IV article presented a descriptive analysis of 143 articles surrounding expert opinion on the care of artificial airways which although not age-specific did include criteria related to paediatric patients within the American Association of Respiratory Care (AARC) guidelines and mentioned “one young person”. The authors identified “changes heard on lung auscultation”, “visual inspection for airway secretions”, “blocked ETT” and “pressure flow curve alterations” on the ventilator graphic display as clinical criteria to justify ETT suction (Branson, Gomaa, & Rodriquez Jr, 2014).

The final article was categorised as Level VI evidence. The study surveyed 18 PIC nurses and identified “lung auscultation”, “the unstable patient”, “visible secretions in the ETT”, “cyanosis”, “audible wheezing”, “decreased oxygen saturations” (SaO₂), “increased end tidal carbon dioxide” (ETCO₂) and changes in “arterial oxygenation” as clinical criteria used to initiate ETT suction (Duzkaya & Kuguoglu, 2015). These criteria were previously identified and included in the ESAT© (Davies et al., 2015b).

The previous literature review demonstrated consensus that ETT suction should only be performed when clinically indicated. This updated literature review confirmed consensus that ETT suction only be performed when clinically indicated. Further, the lack of agreement and clarity relating to which specific criteria that should be utilised when undertaking patient assessment prior to ETT suction was

also demonstrated. Each of the new articles described varying criteria as the rationale for ETT suction. The article by Owen et al. (2016) identified “coarse crackles over the trachea”; which had previously been identified in the original literature search by Morrow and Argent (2008) and classified under “altered chest sounds”. The articles by Evans, Syddall, Butt and Kinney (2014) and Duzkaya and Kuguoglu (2015) lacked clarity, either related to the criteria of existing guidelines or clearly defining the term “unstable”. “Unstable” could have a variety of meanings within the clinical setting as it relates to clinical assessment and observation: respiratory, haemodynamic or neurological instability for instance or a combination of these parameters (Hazinski, 2013).

As with the previous integrative review (Davies et al., 2015b) this updated review confirmed a number of previously identified criteria and failed to identify any newly published criteria related to the initiation of ETT suction in the paediatric intensive care population.

Table 2.5 Characteristics of articles included in the updated review (January 2012-December 2017)

Authors/dates (Level of evidence)	Purpose	Design	Sample & characteristics	ETT suction criteria identified
Evans, Syddall, Butt and Kinney, 2014 (II)	Comparison of open or closed endotracheal tube suction on patient safety, efficacy and nursing time	Randomised controlled trial	<ul style="list-style-type: none"> • 258 Paediatric patients • 6 691 suction events • June 2011-Sept 2011 	<ul style="list-style-type: none"> • Authors stated that pre-existing guidelines were used, however these were not presented • Oxygen saturations • Blocked ETT
Owen, Woods, O'Flynn, Boone, Calhoun and Montgomery, 2016 (IV)	To assess if saline installation increased adverse effects for ETT suctioning in children	Prospective study	<ul style="list-style-type: none"> • 1986 ETT suctioning episodes • 69 paediatric patients • 586 ETT suctioning events with at least one adverse event associated with saline usage. • Transient hypoxemia, bronchospasm and hemodynamic instability – caution with saline especially in unstable patients 	<ul style="list-style-type: none"> • Coarse crackles over trachea • Increased PP • Decreased TV • Oxygen desaturation • Acute respiratory distress

Authors/dates (Level of evidence)	Purpose	Design	Sample & characteristics	ETT suction criteria identified
Branson, Goma and Rodriquez, 2014 (IV)	Management of the artificial airway	Comprehensive descriptive review	<ul style="list-style-type: none"> • 143 articles (1973-2014) • Articles reviewed discussed securing the airway, maintaining airway patency, suctioning, open versus closed suctioning, bronchial suctioning, deep versus shallow suctioning, use of saline, when to suction, novel methods to remove secretions form the artificial airway, Biofilm prevention, monitoring the endotracheal tube and patency, rescuing the endotracheal tube and cuff pressure management. • Not age specific 	<ul style="list-style-type: none"> • Assessment of the patient, however no explanation of details • AARC guidelines 2010 • ETT suction only when required • Lung auscultation • Visual inspection for ETT secretions • Ventilator pressure flow curve alterations • ETT occlusion
Duzkaya and Kuguoglu, 2015 (VI)	Assessment of pain during endotracheal suction	Questionnaire survey	<ul style="list-style-type: none"> • Literature review to determine practice • 18 Paediatric intensive care nurses from Turkey (Jan 1-Jan 2 2008) • 65 suction events from 135 patients analysed 	<ul style="list-style-type: none"> • Lung auscultation • Unstable patient • Secretions in ETT • Cyanosis • Wheezing • Decreased SaO₂ • Increased ETCO₂ • Changes in aerial oxygenation

2.7 Conclusion

In summary, the updated review of literature published from the 1st of January 2012 to the 31st of December 2017 confirms the lack of evidence directly relating to the research topic and a lack of consensus regarding criteria listed in justifying the performance of ETT suction. The four articles reviewed demonstrated low levels of evidence and provided no new insights about the research topic.

Clinical assessment can be a complex process which should be tailored to the patient's individual needs. Informed, educated and skilled nurses who practice evidence-based nursing care contribute to improved patient outcomes and reduced health costs. The development of a clear evidence-based approach to assist in the key decision making process for determining the need for ETT suction is an important step in improving clinical assessment and decision making processes at the bedside. This chapter has established the relevance of original research by identifying clinical criteria used to ascertain if ETT suction is required, as reported in the first article for this PhD entitled "Clinical indicators for the initiation of endotracheal tube suction in children: An integrated review". The subsequent updated integrative review confirmed the relevance of criteria within the ESAT[®]. Having established that criteria within the ESAT[®] remain relevant, the next challenge is to confirm the content, criterion-related construct validity and test-retest reliability of the ESAT[®]. This work is the subject of the following chapters of this PhD thesis.

The following chapter (Chapter Three) provides an overview of the conceptual framework and methodology underpinning this thesis.

Chapter Three

Conceptual Framework

This chapter will describe the conceptual framework underpinning the research methodology conducted for this study.

3.1 Introduction

When used in research, the term methodology refers to the philosophical framework guiding the research process; this can incorporate both quantitative and qualitative methods. Since the 1950s mixed methods research has been described as combining the qualities of both quantitative and qualitative research methods to enable a comprehensive investigation of the topic (Creswell, 2003, 2015; Goering & Streiner, 1996; Neuman, 2011; Schoonenboom & Johnson, 2017; Zohrabi, 2013). Figure 3.1 depicts the conceptual framework for this PhD study, showing the interrelated concepts supporting the research methodology. The rationale and relevance of each concept within the framework is now presented.

Rationale for Use of Mixed Methods (Quantitative and Qualitative)

Historically there has been clear demarcation between quantitative and qualitative research methods. Creswell (2015), who is regarded as a leading expert in mixed methods research, argued this demarcation actually occurs in the research “methods”. The chosen methods usually incorporate specific research techniques for gathering data and information, using either quantitative or qualitative measures (or both) which then determine the most suitable data analysis approach. While qualitative research aims to describe and explain the behaviours, interactions and experiences within the social context, quantitative research uses quantifiable, repeatable measurements that have mathematical outcomes (Kobeissy, 2012; Streiner & Norman, 2005). Each philosophy in itself provides only one dimension of the research problem. Since the purpose of the study presented was to establish and clarify attitudes, processes and outcomes related to the initiation of ETT suction by nurses working in the paediatric intensive care (PIC) setting, mixed methods research was chosen as most suitable for this study.

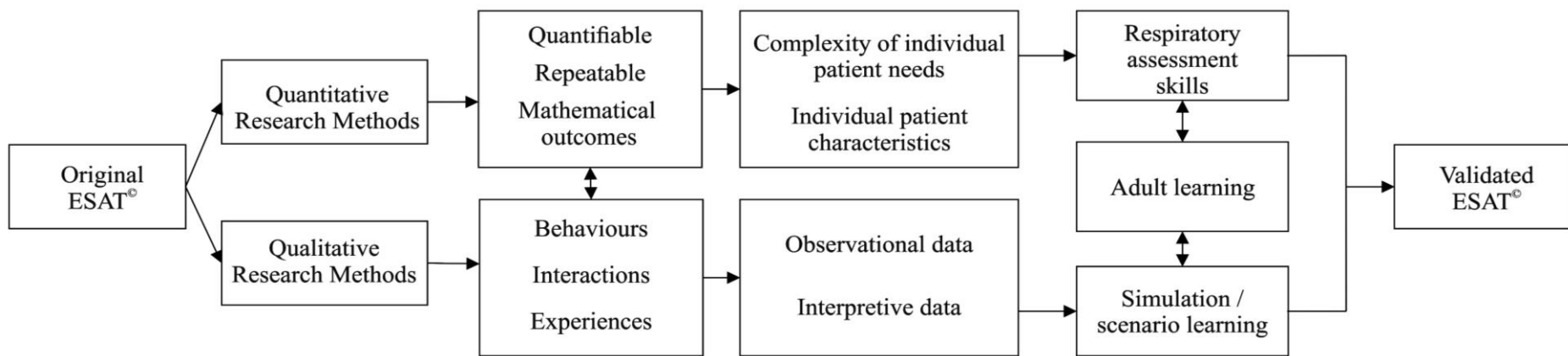


Figure 3.1 Conceptual framework underpinning the research methodology.

3.2 Methodology

Study Design

To overcome the limitations of a single research design, this study incorporates a five-phase mixed methods research design that combines quantitative and qualitative research methods to establish: a) the scale level content validity index by establishing “clarity”, “apparent internal consistency” and “content validity index”; b) criterion-related (construct) validity; and c) test-retest (stability) reliability of the ESAT[®].

Mixed method research has increasingly been gaining popularity since the 1980s with Creswell and Teddlie at the forefront as it allows a more thorough analysis of the issue under research allowing a broader range of tools to work in a complementary manner (Creswell, 2015; Schoonenboom & Johnson, 2017; Teddlie & Tashakkori, 2012). Characterised by the combination of at least one qualitative and one quantitative research process; thus incorporating perspectives of both research philosophies to explore a research problem (Creswell, 2015; Schoonenboom & Johnson, 2017; Zohrabi, 2013). Schoonenboom and Johnson (2017) classified mixed methods design according to typology; a theoretical classification where logical systematic combinations of unidimensional concepts are formed into an interrelated or overlapping subtype (Creswell, 2015; Neuman, 2011; Schoonenboom & Johnson, 2017; Zohrabi, 2013). This classification comprises the following six mixed method designs:

Convergent parallel design: The quantitative and qualitative strands of the research are performed independently, and their results are brought together in the overall interpretation of data collated.

Explanatory sequential design: A first phase of quantitative data collection and analysis is followed by the collection of qualitative data, which are used to explain the initial quantitative results.

Exploratory sequential design: A first phase comprising qualitative data collection and analysis is followed by the collection of quantitative data to test or generalise the initial qualitative results.

Embedded design: In a traditional qualitative or quantitative design, a strand of the other type is added to enhance the overall design.

Transformative design: A transformative theoretical framework shapes the interaction, priority, timing and mixing of the quantitative and qualitative strand.

Multiphase design: More than two phases or both sequential and concurrent strands are combined over a period of time within a program of study addressing an overall program objective.

The following inherent strengths and weaknesses of the mixed methods approach are acknowledged (Creswell, 2015; Neuman, 2011; Schoonenboom & Johnson, 2017; Zohrabi, 2013):

Strengths:

- enables the data to be easily described and reported;
- facilitates the exploration of unexpected results arising from collated data or previous studies associated with the topic;
- enhances the understanding of qualitative data; and
- assists the design and validation of an instrument and provision of a framework to direct the research.

Weaknesses:

- identifying the point of integration of the quantitative and qualitative components can be complex;
- the research process can be excessively time consuming;
- resolving discrepancies between different types of data can be challenging;
- some designs generate unequal evidence; and
- studies using a sequential design may not have clear delineation regarding when best to commence each phase.

In view of the multifaceted nature of the data and research processes, a multiphase exploratory sequential mixed method research design will be employed. Using this process enables the researcher to build on the previous research which identified criteria used to design the Endotracheal Suction Assessment tool[®] (ESAT[®]) and develops an interrelated research design for this study. These sequential steps will include revisiting the literature surrounding the research topic, an audit of patient documentation with reference to criteria used to determine endotracheal suction which will assess both qualitative and quantitative elements specific to the ESAT[®], followed by psychometric testing of the tool to establish

instrument validity using both quantitative and qualitative analysis. As described above, the researcher anticipated the design would confirm the reliability and validity of the ESAT[®] through the application of the applied conceptual framework.

3.3 Instrument Development and Testing: Clinimetrics and Psychometrics

Clinimetrics

As a specialised area of practice, nurses working in a paediatric intensive care unit (PICU) are faced with complex care issues related both to the clinical condition of the patient and the technology required to facilitate and deliver patient care (Curley & Moloney-Harmon, 2001; Hazinski, 2013). As Feinstein (1983) asserted, the complexity of an individual's diagnosis and associated clinical characteristics determine how clinical data should be collected and analysed. Development of clinically relevant instruments designed for use across a variety of patient care settings can therefore be challenging. Feinstein (1983) proposed that "clinimetrics" provided a useful approach for development of instruments designed to collect observational and interpretive data that can be used to improve patient care and outcomes. Establishing the precise purpose of an instrument that can be used reliably enables predictive accuracy and potentially improved clinical care (Feinstein, 1982, 1983a, 1983b, 1983c, 1983d). Likewise, if an instrument is not used in context for which it is designed, data may be considered contaminated or irrelevant (Souza et al., 2017).

Feinstein (1987) recommended clinimetrics as a useful approach to scale (instrument) development, however there has been some debate regarding the use of the term "clinimetrics" over the more traditional "psychometrics". Streiner (2003) argued the clinimetric approach was a subset of psychometrics and was therefore neither unique nor considered a new approach to scale development. In their discussion regarding the challenges of using clinimetrics, De Vet, Terwee and Bouter (2003) acknowledged that clinimetrics is dependent on population and situation and relies on the quality of the measurement instrument and the quality of performance in using the actual instrument. Despite this debate, clinimetrics continues as a methodological discipline suited to clinical research. It was therefore incorporated as a subcategory of the psychometric processes chosen to guide this study (De Vet, Terwee, Mokkink, & Knol, 2011; Streiner, 2003; Streiner & Kottner, 2014).

Feinstein (1982) earlier proposed that new scales (instruments) were required to improve the quality and relevance of clinical observations. The author also emphasised that each item within an instrument should be justified by evidence (evidence-based) and demonstrate consistency in application and measurement to enhance validity. Although somewhat dated, this recommendation remains valid today and supported the premise for this thesis which tested an instrument designed to facilitate the accurate assessment of ventilation parameters and oxygenation in the mechanically ventilated and critically ill patient (Curley & Moloney-Harmon, 2001; Hazinski, 2013).

An instrument that can be used to accurately assess the need for endotracheal tube (ETT) suction is critical to improving the care of PIC patients. Establishing the reliability and validity of such a tool is the key concept underpinning this study.

Psychometric Instrument Testing

The term “psychometrics” is defined as the evaluation of the quality of an instrument based primarily on evidence of its reliability and validity (Pearce, 2017; Polit & Hungler, 2013; Souza et al., 2017; Streiner & Kottner, 2014; Streiner & Norman, 2005). The differentiation between reliability and validity is highlighted here since an instrument may reliably produce the same outcome consistently but may not be measuring the construct of interest, deeming an instrument as invalid for the construct under assessment (Burns, 2000; De Vet et al., 2011; De Von et al., 2007; Mayo, 2015; McKim, 2017; Souza et al., 2017; Tamilselvi & Ramamurthy, 2013; Zohrabi, 2013).

Reliability

The reliability of an instrument relates to the ability of the instrument to consistently reproduce the same results in different situations by either the same or different users (Burns, 2000; McGoey, Cowan, Rumrill, & La Vogue, 2010; Neuman, 2011; Souza et al., 2017). Neuman (2011) explained that reliability encompassed three types: stability, representativeness and equivalence. Similarly, McGoey, Cowan, Rumrill and La Vogue (2010) defined reliability in the context of four standardised assessments: test-retest (stability); alternate form reliability (also known as parallel forms); internal consistency (representative); and inter-rater

reliability (equivalence). As McGoey et al. (2010) and others (Burns, 2000; Neuman, 2011; Souza et al., 2017) have explained, test-retest (stability) reliability requires individuals to complete the same instrument on two separate occasions in order to compare the consistency of the results. Internal consistency (representative reliability) is the extent to which the instrument delivers the same outcome if applied to different clinical situations when measuring the same construct (Burns, 2000; Neuman, 2011). Alternate form reliability is measured by administering two different versions of the same instrument at different times (De Von et al., 2007; Schoonenboom & Johnson, 2017). Equivalence reliability is similar to test-retest reliability in that scores are obtained from the same group of participants. The differentiating factor is that reliability is measured from correlations of scores from instruments designed to measure similar constructs or different version of the same instrument (McGoey et al., 2010; Souza et al., 2017). The interchangeable terminology used to describe measures of reliability as well as the variety of methods used to test an instrument's reliability can at times be confusing unless the researcher has a well-developed understanding of the instrument's underlying purpose, guiding concepts and developmental processes (De Von et al., 2007; Neuman, 2011; Souza et al., 2017). Test-retest (stability) was chosen as the most suitable method to test the reliability and stability of the ESAT[®] instrument.

Construct Validity

Assessment of construct validity is undertaken to determine the degree to which an instrument measures its intended purpose, in this case the need to perform ETT suction (Burns, 2000; Neuman, 2011; Tamilselvi & Ramamurthy, 2013; Zohrabi, 2013). Establishing the construct validity of an instrument can be complex (De Von et al., 2007; Neuman, 2011) because of the abstract nature of the constructs and assumptions that sometimes underpin instruments. Some authors have proposed that construct validity be considered as either translational validity (face and content) or criterion validity (concurrent, predictive, convergent and discriminant) (De Von et al., 2007). Others have proposed that face validity is a separate entity and preferentially focuses on content validity, criterion validity and construct validity as the major subtypes (De Von et al., 2007; Souza et al., 2017). Rosenbaum (1989) recommended use of criterion-related construct validity when assessing unidimensional latent constructs. In this method individual item responses and the

joint distribution of the items scores should be contained within a predictive pattern. However, as with the ESAT[®], this is not always the case as the construct under investigation may have multidimensional outcomes or demonstrate predictive patterns that aren't accounted for when adhering strictly to criterion-related or construct validation principles (Rosenbaum, 1989). McGoey, Cowan, Rumrill and La Vogue (2010) further explained this anomaly. As validity testing continues to evolve it builds on the scientific evidence to support the accuracy of an instrument; it should consider the criterion validity results for the instrument while integrating the construct validity results, rather than judging results from two separate processes.

According to Lynn (1986) whose content validity testing principles were used during the initial design phase of the ESAT[®] (Davies et al., 2011), validity is defined according to content (clarity, apparent internal consistency and content validity index), criterion-related and construct validity. More recently Souza, Alexandre and de Brito Guirardello (2017) also discussed instrument validity testing options. Whilst these authors acknowledged the broader concepts of content, criterion-related and construct validity they also described the following validity sub categories: predictive, concurrent, known-groups techniques, convergent, discriminant, structural or factorial validity and cross-cultural (Souza et al., 2017). These techniques use both quantitative and qualitative research principles according to an instrument's purpose, type and target population (Mayo, 2015; Souza et al., 2017). Similarly Burns (2000) described validity according to five distinct groups: predictive, concurrent, content, construct and face validity. Neuman (2011) later described six distinct forms of validity: face, content, construct, convergent validity and finally criterion validity which comprises two subgroups; concurrent and predictive validity.

As with reliability testing, the terminology used for measures of construct validity are often interchangeable. In addition, a number of techniques are used to measure the construct validity of an instrument. The underlying constructs and assumptions upon which instruments have been developed will ultimately guide the researcher's choice of construct validity testing measures.

Face Validity

Face validity equates to the meaning of the terminology that on the “face of it” or on “face value” an instrument (e.g. the ESAT[®]) measures the construct being assessed (e.g. the requirement for ETT suction) (De Von et al., 2007; Lynn, 1986; Neuman, 2011). Face validity is a subjective measure and by its very nature provides the weakest form of validation (De Von et al., 2007). It may provide insight into how, for example, the inexperienced nurse may interpret and use the criteria listed within an instrument. Face value focuses on the appropriateness, “flow” and “link” between items within the instrument and its perceived purpose (De Von et al., 2007; Lynn, 1986). As face validity is not quantifiable and provides the weakest form of validation some authors view face validity as an inauspicious process with questionable reliability within psychometric testing (Lynn, 1986; Neuman, 2011). Face validity has been briefly described here only to present a complete overview of the various forms of validity; it was not considered an appropriate measure to validate the ESAT[®].

Summary

The varied opinions regarding reliability and construct validity testing demonstrate the potential complexity of the decision making process faced by researchers during instrument development and testing. In this study the following procedures were used for validity testing of the ESAT[®]: content validity (clarity, apparent internal consistency and content validity index) and criterion-related (construct) validity. The third publication of this thesis titled “Content validity testing of the ESAT[®]: A decision aid tool for performing endotracheal suction in children” provides a detailed description of the content validity processes undertaken (Davies et al., 2018a). The fourth publication “Reliability and criterion-related validity testing (construct) of the endotracheal suction assessment tool (ESAT[®])” describes the test-retest reliability and criterion-related validity testing phases (Davies et al., 2018b).

Complexity of Individual Patient Needs and Individual Patient Characteristics

It is well documented that paediatric intensive (critical) care patients have complex and dynamic needs that change over the course of their admission (Denis-Larocque, Williams, St-Sauveur, Ruddy, & Rennick, 2017; Duffield, Roche,

Dimitrelis, Homer, & Buchan, 2014; Hazinski, 2013; Twycross & Powls, 2006). Nursing care should be titrated to the individual patient's needs however clinical experience and knowledge of evidence-based practice determines the nurse's decision-making processes related to the care delivered at the bedside (Denis-Larocque et al., 2017; Gupta et al., 2016; Gupta et al., 2014). Use of a validated instrument such as the ESAT[®] can optimise endotracheal suction care by providing clear evidence-based guidance to the inexperienced practitioner caring for an intubated and ventilated paediatric patient.

Observational Data and Interpretive Data

Observational and interpretative data are common methods of data collection in qualitative research methods (Creswell, 2015; Guest, 2012; McKim, 2017; Paluck, 2010) where this type of qualitative data is drawn from the "real world" (Creswell, 2015; Guest, 2012; McKim, 2017; Paluck, 2010). Observational data has a direct link to nursing care as it is drawn from clinical practice, especially relevant when designing an instrument such as the ESAT[®] for use in the clinical setting (Neuman, 2011). Observational data can reflect the benefits and risks associated with a practice such as ETT suction and ensure the designed instrument has clinical application (Creswell, 2015). Interpretive data facilitates the emergence of data or criteria not previously identified through quantitative research as it relates directly to the individual's actions (Burns, 2000; Creswell, 2015; Neuman, 2011). Further, interpretive data identifies analytically how practice generates an outcome and in the presented research; whether or not ETT suction was performed (Burns, 2000; Creswell, 2015; Neuman, 2011).

Incorporating observational and interpretive data collection for this study will provide a complete picture of the rationale supporting nursing decisions to perform endotracheal suction as it relates to the development of the ESAT[®].

Competency in Respiratory Assessment Skills

A review of the medical and nursing literature regarding competency in respiratory assessment skills identified a number of reported deficits including: poor proficiency of assessment skills; errors in physical diagnosis and poor quality of nursing judgement in making a respiratory assessment (Conkin et al., 2013; Cornock,

2011; Douglas et al., 2014; Melnyk, 2017; Murphy, Llewellyn, & Carlson, 2011; Negroa, Ranzanic, Villa, & Manarab, 2014; Pirret, 2007; Raleigh & Allan, 2017; Reddy, Wakerman, Westhorp, & Herring, 2015). The inadequate knowledge of protocols and practices that directly impact on the quality of patient care was also highlighted (Conkin et al., 2013; Cornock, 2011; Douglas et al., 2014; Melnyk, 2017; Murphy et al., 2011; Negroa et al., 2014; Pirret, 2007; Reddy et al., 2015; Westbrook, Rob, Woods, & Parry, 2011).

Understanding and selecting criteria that should be used to when assessing the need to initiate ETT suction is a complex issue (Davies et al., 2011; Denis-Larocque et al., 2017; Jakimowicz & Perry, 2015). Clinical assessment should be thorough, proficient and based on sound knowledge to identify key clinical indicators for ETT suction because of the potential risks to the patient. Decision making by nurses may vary due to differences in clinical assessment skills, knowledge and experience. Early in this research process, it was identified that a set of validated parameters or criteria which could be used as a point of reference for the inexperienced practitioner when assessing the clinical status of the ventilated patient's requirement for ETT suction was necessary. Further, a reliable and valid instrument comprised of evidence-based indicators such as the ESAT[®] would potentially be a useful instrument to guide the inexperienced nurse in decision making for the initiation of ETT suction.

While patient outcomes are affected by the quality and skill of the bedside nurse there are challenges associated with developing systems to measure the impact of nursing care (interventions) on patient outcomes (Australian Council on Healthcare Standards, 2015; Joynt, Harris, Orav, & Jha, 2011; Lower & Burton, 1989; Twigg, Myers, Duffield, Giles, & Evans, 2015; Twigg et al., 2016). In Australia, indicators such as pressure injuries and hospital-acquired sepsis are currently used to monitor and evaluate the quality of care delivered and its impact on nurse-sensitive indicators on length of stay (Australian Council on Healthcare Standards, 2015). In their review of advanced practice nursing roles, Verger, Trimarchi and Barnsteiner (2002) recommended that morbidity and in-hospital mortality rates should also be used as nurse-sensitive outcomes which can be attributable to the quality of nursing care (Bolick et al., 2013; Martyn, Martin, Gutknecht, & Faleer, 2013; Verger, Trimarchi, & Barnsteiner, 2002). Other authors have suggested that quality of life measures

should also be considered (Aitken & Marshall, 2015; Brett, 2011), while other authors propose use of other outcome measures such as the impact of mortality and morbidities on the family and patient (Aitken & Marshall, 2015; Brett, 2011; Brocklehurst & McGuire, 2005).

Bolton, Donaldson, Rutledge, Bennett and Brown (2006) reported findings from a systematic review and meta-analysis on published research undertaken to demonstrate the relationship between the quality of nursing care and nurse-sensitive outcomes in acute care settings (Berg, Hawkins-Walsh, Gaylord, Lindeke, & Docherty, 2011; Duffield, Roche, et al., 2014; Duffield, Roche, Twigg, Williams, & Clarke, 2016; Duffield, Twigg, et al., 2014; Norridge & While, 2015; Twigg, Duffield, Bremner, Rapley, & Finn, 2011; Twigg et al., 2016). It has been suggested that research related to the development of standardised assessment instruments which are integral to nursing care would add to the understanding of the effects of nursing care and intervention on patient outcomes (Aitken & Marshall, 2015; Bolton et al., 2006; Reddy et al., 2015).

In 2007 Bolton et al. explored nurse staffing ratios and nurse-sensitive outcomes of quality care since the mandating of nurse staffing ratios was implemented in California in 2005. A non-significant trend associating a higher proportion of contracted nurses (agency staff) with the increased incidence of hospital acquired pressure ulcers was shown (Bolton et al., 2007). The authors suggested that patient care may be compromised if staff are unfamiliar with routine unit practice (Bolton et al., 2007). Lake et al.(2012) studied the association between hospital recognition for nursing excellence and outcomes of very low birth weight (VLBW) infants. In neonatal intensive care units, as in paediatric intensive care units, active intervention to prevent life threatening problems is a major aspect of the nursing role (Lake et al., 2012). Nursing care is therefore complex and requires use of multiple assessments that enable nurses to prioritise care and implement intensive therapies. The aim of care is to improve short and longer term outcomes for these patients and requires the maintenance of optimal respiratory, cardiac and feeding regimens. Adjustments and changes to therapeutic interventions and other aspects of care are dependent upon the multifactorial assessment of patient responses (Lake et al., 2012). Lake et al. (2012) analysed mortality, severity of intraventricular haemorrhage and nosocomial infection, hypothesising these outcomes would be influenced by nursing care. Study

findings showed that VLBW infants born in hospitals recognised for nursing excellence, compared with VLBW infants born in hospitals without this recognition, had a significant lower risk-adjusted rate of a 7-day in-hospital mortality, nosocomial infection and severe intraventricular haemorrhage (Lake et al., 2012).

Chlan, Tracey and Grossbach (2011) suggested that development of intensive care nursing skills and competencies required to care for the ventilated patient require targeted education and support. Further, nurses who engage in evidence-based practice and research projects at the PIC unit level can contribute to improved outcomes for mechanically ventilated patients (Chlan et al., 2011; Jacob, McKenna, & D'Amore, 2015; Norridge & While, 2015). To address these issues, strategies such as provision of continuing education and professional development, promotion of evidence-based practice, use of assessment instruments (tools) and maintenance of clinical support in the PIC arena have been shown to improve both patient care and outcome (Bumbarger & Campbell, 2012; De Pedro-Gomez et al., 2011; Mackey & Bassendowski, 2016; McGlynn & Brook, 2003; Moore, 2003; Thompson, Aitken, Doran, & Dowding, 2013).

In the context of the presented study, ensuring procedures such as ETT suction are performed only when necessary could minimise adverse patient outcomes (morbidity) directly attributable to nursing care. The current study will potentially contribute to this body of empirical evidence by producing an evidence-based, reliable and valid instrument that can be used to facilitate the delivery of best ETT suction practice by inexperienced nurses working in a PIC setting. Specifically, the ESAT[®] has been designed to guide nursing assessment and practice in the accurate assessment of the need to perform ETT suction and prevent potential nurse-sensitive complications associated with endotracheal suction. It is proposed the ESAT[®] could potentially be used as a PIC nursing educational tool to guide nursing practice in the future. Adult learning principles should be used to guide the development of any adult-focused educational tool. Hence, the guiding principles of adult learning theory are discussed in the next section.

3.4 Adult Learning

The fast pace of medical and technological advancements combined with finite health budgets all impact on the ability of the health system to provide a knowledgeable, skilled and flexible workforce (Goran, 2012; Jakimowicz & Perry, 2015). The general public, now better informed than ever about expected standards of care, demands quality and accountable health care (Ashton, 2015; Nunes, Rego, & Nunes, 2013; Reeve, Humphreys, & Wakerman, 2015). This presents a challenge to the provision of educational support, within the current finite health budgets, that meets the needs of the health professional.

Malcolm Knowles (1985) first postulated the use of andragogy to differentiate the theory and principles of adult learning from pedagogy, the educational theory of childhood learning. Knowles (1985) claimed that adults differ fundamentally from children in the way they learn. Adult education should be grounded in the participant's prior life experience (Knowles, 1975). Further, adults need to apply what they learn and be active rather than passive throughout the learning process (Burnard, 1989; House & Burns, 1986; Knowles, 1975, 1985). Burnard (1989) proposed andragogy and experiential knowledge could be combined to enhance nursing education. Experiential learning is based on the theory of "knowledge" whereas propositional knowledge is classified as "textbook" based on facts, theories and models. Experiential knowledge is revealed through practice, for example, demonstrating the successful ETT suction of a patient (Day, Iles, & Griffiths, 2009; Gardner & Shirland, 2009; Hahn, 2010). Experiential knowledge is defined as knowledge gained through direct encounters with people, situations and place (Burnard, 1989; Trigg & Cordova, 1987).

Trigg and Cordova (1987) recognised that while andragogy may meet the needs of the self-motivated independent learner it may not meet the needs of the semi-independent learner. When applied to the context of the present research, the acquisition of endotracheal suction knowledge and skills will be "built in" to broader nursing skill development in novice PIC nurses where learning will be situated in the authentic and real-life setting of a tertiary PICU (Trigg & Cordova, 1987).

Consideration must be given to adult learning principles when designing instruments for use in clinical areas by novice nurses in order to facilitate their

appropriate implementation and the accurate collection of patient data and information (Australian College of Critical Care Nurses, 2016; Gill, Kendrick, Davies, & Greenwood, 2017).

Simulation and Scenario Learning

Simulated clinical learning can be used to address the practicalities and potential challenges associated with implementation of practice within the clinical setting. Simulated clinical learning requires use of key learning objectives, flexibility in delivery and the direct association of a practice to the clinical workplace by individuals involved in the learning process (T. Collins, Lambert, Helms, & Minichiello, 2017; Crowe, Ewartb, & Dermanc, 2018; Hudgins, 2017; Okla & Eden, 2015; Reeder & Turner, 2011; Reid et al., 2012; Rutherford-Hemming & Alfes, 2017; Waxman, 2010). As discussed above, the development of clinical scenarios to facilitate simulated clinical learning should incorporate the principles of integrated models of learning, particularly because they incorporate the process of critical thinking in the learning experience (Waxman, 2010).

As previously stated, the researcher's understanding of how adults learn and use of integrated models of learning was critical to the development and future implementation of the ESAT[®] during this research study, the ultimate goal being to potentially improving PIC patient health outcomes. Equally important was understanding how these strategies promote the learning process as a shared responsibility and experience for the adult learner (Crowe et al., 2018; Knowland & Thomas, 2014; Sanchez & Cooknell, 2017). Case (1996) suggested that learning and motivation occurs through creating interest, relevance, developing an expectancy of success, and producing satisfaction through "intrinsic/extrinsic rewards." This supported the researcher's need to develop clinically relevant educational processes to support the implementation of the ESAT[®] into clinical practice by working with PIC nurses to facilitate and construct personal learning. Furthermore, it was considered important to identify the values, aspirations and knowledge of novice PIC nurses (Case, 1996; Crowe et al., 2018; Jones, 2013; Mellard, Krieshok, Fall, & Woods, 2013; Rothes, Lemos, & Gonçalves, 2017; Rutherford-Hemming & Alfes, 2017).

Scenarios were chosen as a known and reliable method for teaching and learning in healthcare that facilitates understanding and key outcomes (Baile & Blatner, 2014;

Cox, 2015). Such scenarios should be clinically relevant and useful for solving identifiable problems which incorporate actual clinically-based patient scenarios that present observational data and clinical information to support a clinical action such as ETT suction (Baile & Blatner, 2014; Cox, 2015). The principles of andragogy and transformative learning combine critically reflective thinking to provide a meaningful perspective that is inclusive, discriminative and integrative (Cox, 2015). Use of scenarios such as those employed in this research can improve teaching practice as a method that can be used to initiate collaboration within a team, critical thinking and stimulate thought, providing the link between the clinical setting and clinimetrics (De Vet et al., 2003; Hudgins, 2017).

3.5 ESAT[®] Validation

The literature review presented in Chapter Two established that apart from the prior work of this researcher, no other research has previously identified or ranked the criteria PIC nursing staff use to initiate ETT suction (Davies et al., 2015b; Davies et al., 2011). This is particularly notable given the frequency of which the procedure is performed and the potential deleterious complications for the patient (Branson et al., 2014; J. Evans et al., 2014; Maggiore et al., 2013). As described previously the items within the ESAT[®] were derived from analysis of the existing literature and data from a national survey of experienced Australian and New Zealand PIC nurses (Davies et al., 2011). The next logical step was the presented validation and testing of the ESAT[®] using established psychometric principles (De Vet et al., 2003; Lynn, 1986; Polit & Hungler, 2013; Souza et al., 2017).

3.6 Summary

This study presents the required number of four publications to link the critical components of the thesis. This five-phase exploratory sequential mixed methods study used both quantitative and qualitative methodological approaches as outlined in the conceptual framework (Figure 3.1). Phase one has presented the integrated literature review that established the rationale for the study (Davies et al., 2015b) and is the precursor for phases two to five. Phase two will present results from a clinical audit undertaken to establish the critical link between the instrument and current clinical practice (Davies et al., 2015a). Data from phase two will be used to

support the methodological approach for phases three to five (Davies et al., 2018a; Davies et al., 2018b). These methodological approaches include content validity testing of the instrument, criterion-related (construct) testing and culminated in test-retest (stability) testing.

In summary, the conceptual framework underpinning the process of the mixed methods research used for this thesis has been presented and clearly defined. The use of psychometric research principles which includes clinimetrics as the clinical sub group of psychometrics has been explained. The methodology presented includes the study design, psychometric testing principles for face validity, content validity, criterion-related validity, construct validity and test-retest reliability. The complexity of the paediatric intensive care patient's individual needs in the context of nursing decision making has been critically discussed and reviewed. As demonstrated in the conceptual framework, the rationale for use of observational and interpretive data is included, as well as nursing competency surrounding respiratory assessment and adult education as linked to the planned mixed methods research. Adult based scenario learning is compared with simulation and discussed to explain and support the inclusion of clinical based scenarios for the test-retest reliability phase. Finally, Table 3.1 presents the ESAT[®] validation and other research phases, a visual representation of the mixed methods research process as related to each study objective, linked publications and chapters.

Table 3.1 Study Phases, Processes, Related Publication and Thesis Chapter

Study Phase	Process	Publication	Chapter
1	Integrative review using a systematic approach to summarise the empirical and theoretical evidence within the literature as it related to clinical practice surrounding clinical indicators nurses use to determine the requirement for ETT suction.	“Clinical Indicators for the initiation of endotracheal suction in children: An integrative review” (Davies et al., 2015b).	2
2	Clinical audit of n=292 patient medical records and nursing observation forms for a 12-month period in a large tertiary PICU to establish the clinical relevance of items (clinical indicators) the ESAT [®] with current clinical practice.	“Audit of Endotracheal Tube Suction in a Paediatric Intensive Care Unit” (Davies et al., 2015a).	4
3	Content validity testing of the ESAT [®] . The tool will be reviewed by PIC nursing experts for: content validity index, clarity, and apparent internal consistency. The ESAT [®] was modified accordingly. Development of clinical ETT suction scenarios and clinical assessment guidelines linked to the ESAT [®] criteria.	“Content validity testing of the ESAT [®] : A decision aid tool for performing endotracheal suction in children” (Davies et al., 2018a).	5
4	Reliability and criterion-related validity testing (construct) of the ESAT [®] will be determined by undertaking scenario simulation in the clinical setting with paediatric nursing staff working in in a large tertiary PICU. Pre-test scenario testing will be performed following education regarding the purpose and use of the ESAT [®] and implementation of the tool. Two distinct groups of nurses (experienced versus inexperienced) will participate in the scenario testing.	“Reliability and criterion-related validity testing (construct) of the endotracheal suction assessment tool (ESAT [®])” (Davies et al., 2018b).	6
5	Post-test scenario testing will be undertaken one month following the introduction of the tool with the same groups of participants from phase four will be undertaken to establish reliability over time.	“Reliability and criterion-related validity testing (construct) of the endotracheal suction assessment tool (ESAT [®])” (Davies et al., 2018b).	6

The following chapter (Chapter Four) presents the second published article for this study “Audit of Endotracheal Tube Suction in a Paediatric Intensive Care Unit”. This manuscript represents phase two of the study and will establish the link between current clinical nursing practice and the ESAT[®] (Davies et al., 2015a)

Chapter Four

Publication Two: Audit of Endotracheal Tube Suction

“Audit of Endotracheal Tube Suction in a Pediatric Intensive Care Unit.”

Davies K, Monterosso L¹, Bulsara M², Ramelet AS³

Publication Two, prepared with advice and editorial support from each member of the supervisory team, describes the findings from a large-scale clinical audit conducted in the sole tertiary paediatric intensive care unit in Western Australia. The purpose of the audit was to identify the indicators used by paediatric intensive care (PIC) nurses to justify the procedure of endotracheal tube suction. The aim of this study phase was to provide further insight by exploring the potential link between the clinical indicators used to develop the Endotracheal Suction Assessment Tool[®] and those used in current PIC nursing practice.

Reference:

Davies K, Monterosso L, Bulsara M, Ramelet AS. (2015). Audit of Endotracheal Tube Suction in a Pediatric Intensive Care Unit. *Clinical Nursing Research*, 26(1), 68-81. doi:10.1177/1054773815598272


¹ Professor L Monterosso is the principal supervisor of this study and provided content direction, review and editorial advice for this article.

² Professor M Bulsara is the co-supervisor of this study and provided biostatistical and editorial advice for this article.

³ Professor A-S Ramelet is the associate supervisor of this study and provided content guidance and editorial advice for this article.

Audit of Endotracheal Tube Suction in a Pediatric Intensive Care Unit

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Abstract

We report outcomes of a clinical audit examining criteria used in clinical practice to rationalize endotracheal tube (ETT) suction, and the extent these matched criteria in the Endotracheal Suction Assessment Tool(ESAT)[®]. A retrospective audit of patient notes ($N = 292$) and analyses of criteria documented by pediatric intensive care nurses to rationalize ETT suction were undertaken. The median number of documented respiratory and ventilation status criteria per ETT suction event that matched the ESAT[®] criteria was 2 [Interquartile Range (IQR) 1-6]. All criteria listed within the ESAT[®] were documented within the reviewed notes. A direct link was established between criteria used for current clinical practice of ETT suction and the ESAT[®]. The ESAT[®], therefore, reflects documented clinical decision making and could be used as both a clinical and educational guide for inexperienced pediatric critical care nurses. Modification to the ESAT[®] requires “preparation for extubation” to be added.

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The complete PDF version of the manuscript was presented in Appendix E for examination purposes only.

4.1 Introduction

Use of an endotracheal tube (ETT) to enable mechanical ventilation forms an integral part of the treatment modality used to provide essential life support to children in the Paediatric Intensive Care Unit (PICU) (Curley & Moloney-Harmon, 2001; Mackway-Jones, Molyneux, Phillips, & Wieteska, 2003). ETT suction used to clear secretions and maintain patency of the tube, is performed by critical care nurses (CCNs) as a key component of routine nursing care. The procedure is not without inherent risks to the patient, ranging from hypoxaemia through to cardiac arrest (Gilbert, 1999; Kline-Tilford, Sorce, Levin, & Anas, 2013; Knox, 1993; Oh & Seo, 2003). There is consensus within current literature on best practice standards that ETT suction should only be performed when clinically indicated (Hahn, 2010; Morrow & Argent, 2008). Of note a recent integrative review of clinical indicators used to initiate ETT suction failed to establish consensus regarding which specific clinical indicators should be measured and used to guide the decision to perform ETT suction (Davies et al., 2015b).

Previous work by Davies, Monterosso and Leslie (2011) comprising a systematic literature review and survey of Australian and New Zealand PICU nurses (n=104) identified clinical indicators used by experienced paediatric critical care nurses to justify the need for ETT suction. The “experienced” nurse was defined as a nurse working within a PICU for five or more years or a nurse who held a graduate Paediatric Intensive Care (PIC) qualification. The systematic review was conducted to identify the most commonly used clinical indicators to justify performance of ETT suction in the PIC setting. In this later study PIC nurses were asked to rank the importance of clinical indicators as identified in the systematic review. Based on the ranked scores of these criteria, the Endotracheal Suction Assessment Tool[®] (ESAT)[®], as shown in Figure 4.1, was then developed to guide the decision making process used by inexperienced PIC nurse regarding when ETT suction should be performed (Davies et al., 2011). The overarching purpose of the ESAT[®] is to provide clinical guidance to improve patient care and potentially avoid adverse events as a result of inappropriate nursing action if not clinically warranted.

Endotracheal Suction Assessment Tool© (ESAT©)

1. Clinical Considerations

- Diagnosis
- Clinical history/ clinical stability
- Previous response to ETT suction
- Current artificial ventilation (eg HFO)
- Preparation for transport

Respiratory Status Criteria

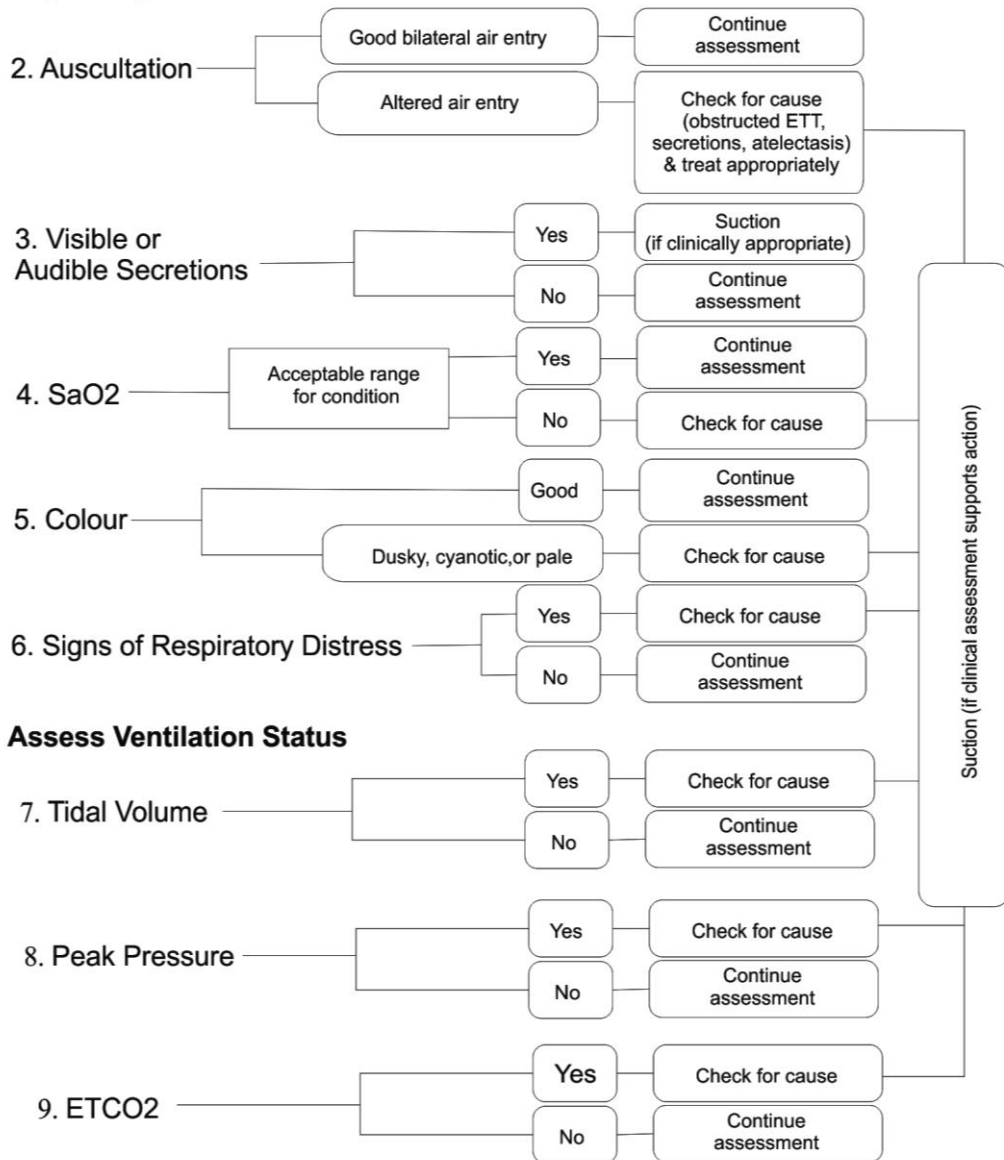


Figure 4.1 Endotracheal Suction Assessment Tool©. Copyright 2014 by K Davies.

To date the ESAT[®] has undergone preliminary content validation. Further work is now required to establish reliability and validity and build on the preliminary work by the researchers (Davies et al., 2011) by ensuring the criteria included in the ESAT[®] are an accurate reflection of current clinical nursing practice. The aim of this clinical audit was to determine whether criteria for ETT suction in the ESAT[®] were representative of criteria used in current clinical practice by CCNs. Therefore the following three questions guided the audit:

Audit Questions

1. Were the criteria included in the ESAT[®] consistent with those documented by CCNs performing ETT suction in the clinical notes and observation sheets of PIC patients who were intubated and ventilated with an ETT in situ?
2. Can a direct link be established between criteria used for current clinical practice of ETT suction and those listed in the ESAT[®]?
3. Is there a correlation between the level of experience of CCNs and the criteria used for ETT suction?

4.2 Method

Setting

The audit was undertaken in the sole level three PICU in Western Australia (WA), which comprises 10 PIC beds and 38.0 full time equivalent nursing staff. This PICU provides critical care for approximately 800 critically ill infants, children and adolescents per year from all areas of the vast state of WA (2.5 million km²). Of these, an average of 37.5% (n=300) patients per year require intubation due to the severity of their clinical condition. The mean number of intubated and ventilated patients admitted per year from 2008-2011 was 286. The Australian and New Zealand Paediatric Intensive Care (ANZPIC) registry data shows an average of 71.55 ventilated hours per intubated patient in 2010, and 127.09 in 2011 (J. Forlonge, personal communication, September 9,2014).

Sample

A sample size of 289 patient records was required for this quality investigation to have a 95% confidence with 5% absolute level of precision when estimating a

proportion of concordance of 75% between ETT suction criteria in hospital nursing records and the ESAT[®] criteria. To allow for incomplete documentation in nursing records, a target value of 300 patient nursing records was set over a 12-month period (September 2010 to August 2011) (Lemeshow, Hosmer, Klar, & Lwanga, 1990). A master list of intubated patients was derived from the Australian and New Zealand Intensive Care (ANZIC) registry in which the details of every patient admitted to the PIC at the study setting is recorded. The medical records and nursing documentation of all patients (n = 292) admitted to the PICU who required ETT intubation and ventilation during this period were reviewed. Patients with a tracheostomy were excluded.

Nursing staff involved in patient care were categorised into one of four groups: Clinical Nurse (CN) with extensive PIC experience whose primary role is that of shift coordinator but also to provide education and clinical support to nursing staff; Senior Registered Nurse (SRN) with more than two years PIC experience; and Junior Registered Nurses (JRN) with less than two years PIC experience but have completed the mandatory introductory program; Relieving or casual pool (R/CP) nurses employed within the PIC setting during periods of high acuity.

Ethical Approval

Ethical approval to undertake this low risk clinical audit was obtained from the Human Research Ethics Committee (HREC) in October 2011(011072F). Approval was also obtained from the Governance Evidence Knowledge Outcomes Committee (GEKO). GEKO is a research governance framework for low risk quality activities, such as this audit. To ensure confidentiality, all data was entered into a password-protected electronic database, patient initials were used as the primary notation with each documented occurrence of ETT suction entry assigned a sequential numerical code.

Methods

As stated, a master list of intubated patients for this study was derived from the ANZIC registry in which the details of every patient admitted to the PICU at the study setting is recorded. Notwithstanding the limitations of documentation (Austin, 2011; Wang, Hailey, & Yu, 2011), for the ESAT[®] to be deemed clinically meaningful, the criteria listed within the tool itself should also be used in clinical practice and documented prior to the conduct of an ETT suction procedure. Within

the audit setting, nurses record criteria used to decide whether to initiate ETT suction in the following patient documentation: the medical records; observation sheets (used to record clinical observations); and a variance sheet (used to record changes in patient condition and treatment). During the audit process each documented ETT suction event was reviewed in each of the above mentioned documentation. The audit compared the type and frequency of each criterion listed in the ESAT[®] with criteria recorded in patient's documentation. Patient medical records and variance sheets were obtained via the Patient Information Management System (PIMS) and reviewed in the PIMS "viewing room". PIMS is a secure locked area which can only be accessed by authorised hospital staff. PICU observation sheets were stored in the PICU ward area and were retrieved for review on site. Patient records were reviewed on site by one researcher (KD) within the medical records department and the PICU.

A total of 5308 ETT suction events were identified for the sample of 292 patients. Demographic variables collected for each patient included: medical record number; admission and discharge date and time; age (years and months); gender; primary diagnosis; weight in kilograms and clinical history.

Clinical observations recorded for each suction event included: auscultation performed (yes/no); auscultation findings such as decreased air entry right upper lobe; skin colour; oxygen saturation (SaO₂) and end tidal carbon dioxide level (ETCO₂).

The following ventilation variables were recorded for each suction event: ventilation type; inspired tidal volume; expired tidal volume; peak pressure; positive end expiratory pressure (PEEP).

ETT suction variables were recorded which included date and time of each ETT suction; how many passes down the ETT of the suction catheter; previous response to ETT suction such as prolonged recovery time for SaO₂ levels; type of sections such as purulent; the nurses level of experience performing the procedure and any comments relating to the ETT suction such as preparation for transport or extubation.

Each ESAT[®] criterion, as shown in Figure 4.1, was allocated a score from one to nine. If any "Clinical Considerations" were documented a score of one was given regardless of number. The total maximum score possible was nine, as there are nine

criteria within the ESAT[®]. For clarity this number will be referred to as the “ESAT[®] score” in the results section.

For each suction event the following ETT suction variables were recorded: Date/time of ETT suction; number of catheter insertions; previous response to ETT suction; type and amount of secretions; level of expertise of the nurse caring for the patient and other relevant comments e.g. preparation for transport or extubation.

To establish the level of expertise of the nurse caring for these patients, nurses’ self-reported designation was transcribed from the patient notes, identified either within the notes or in the PIC clinical nursing pathway (a document each nurse signs at the beginning of their shift which includes their name and designation).

Data Analysis

Data were transcribed into FileMaker Pro (version 11) and the IBM Statistical Package for Social Sciences (SPSS) (version 22) predictive analysis software used to perform statistical analyses (Filemaker, 2010; IBM, 2013). Data entry verification was completed by an independent reviewer who cross checked 5% of all data entries that were randomly generated. No discrepancies were observed.

Demographic and clinical characteristics of the patients were summarised using frequencies and proportions. Cross-correlation and correlational coefficients are standard methods for estimating the degree to which two series of information (i.e. variables) are correlated. Relationships between when ETT suction was performed and individual criteria within the ESAT[®] were investigated using Pearson product-moment correlation coefficient. Preliminary analysis were performed to ensure no violation of the assumptions of normality, linearity and homoscedasticity. Bivariate testing generating Pearson correlation figures were utilised for this audit as a method to examine whether any correlations existed between the level of experience of the CCN and individual ETT suction criteria.

4.3 Results

Demographic Characteristics

Seven hundred and thirty two patients were admitted to the hospital over the 12-month audit review period; of these 292 patients (40%) were intubated and met the inclusion criteria.

Overall, 5308 individual ETT suction events were identified. Fifty three percent (n=2798) of events occurred in patients less than one year of age. Cardiology (n = 120, 41.1%), respiratory (n = 53, 18.2%), neurology (n= 53, 18.2%), sepsis (n=20, 6.8%), trauma (n=16, 5.5%), oncology (n=13, 4.5%), general surgery (n =9, 3.1%), ingestions (n=5, 1.7%), endocrinology (n=2, 0.7%) and poisoning (n=1, 0.3%) comprised the diagnostic groups as shown in Table 4.1. The majority of patients were in PICU for 0-48 hours (n = 152, 52%) as shown in Table 4.1.

Table 4.1 Demographic Characteristics of Patients (n=292)

Variable	n	%
Age		
0 to < 1 year	108	37.0
1 to < 2 years	35	12.0
2 to 3 years	33	11.3
4 to 5 years	38	13.0
6 to 7 years	18	6.2
8 to 10 years	22	7.5
>10 years	38	13.0
Gender		
Male	162	55.5
Female	130	44.5
Diagnosis		
Cardiac	120	41.1
Respiratory	53	18.2
Neurology	53	18.2
Sepsis	20	6.8
Trauma	16	5.5
Oncology	13	4.5
General surgery	9	3.1
Ingestion	5	1.7
Endocrinology	2	0.7
Poisoning	1	0.3
PICU Length of Stay		
Admission (0)-24 hours	73	25.0
>24 and <48 hours	79	27.1
48-72 hours	29	9.9
>72 hours	111	38.0

Level of Clinical Expertise

The majority of nurses caring for patients were either SRNs (n = 2984, 56.2%) with greater than two years PIC experience, or JRN (n = 1160, 21.9%) with less than two years PIC experience. Clinical nurses (n = 923, 17.5%) and R/CP (n = 234.4%) provided the other documented care.

In almost all suction events (n=5255, 99%) at least one criterion from the ESAT[®] was documented. A positive relationship was found between senior CCNs and the criterion “Alterations in peak pressures”. “Peak pressure” was documented more frequently by senior experienced CCNs to justify ETT suction compared with the inexperienced CCN (r = 0.77, p = 0.000).

Criteria Recorded in Patient Documentation for Each ETT Suction Event

The clinical consideration and criteria behind each suction event, as described within the documentation, was matched with those in the ESAT[®], as shown in Table 4.2. The results showed “visible or audible secretions” (n = 5104, 96.1%), “auscultation” (n = 987, 18.6%) and “SaO₂ recordings” (n = 939, 17.7%) were the major rationale of why ETT suction was performed in this cohort of patients, as shown in Table 4.2.

Of note, the clinical consideration “Preparation for extubation” was recorded within the patient documentation on 181 occasions (3.5%) and was not listed in the ESAT[®].

Table 4.2 Criteria Recorded in Patient Documentation for Each ETT Suction Event (N =5308)

Criteria	n	%
ESAT[®] criteria		
Visible or audible secretions	5104	96.1
Auscultation (altered air entry)	987	18.6
SaO ₂ not within acceptable range for patients clinical condition	939	17.7
Increased ETCO ₂	795	14.9
Decreased tidal volume (variation from ideal volumes based on weight)	752	14.2
Increased peak pressure	458	8.6
Signs of respiratory distress	163	3.1
Clinical considerations	43	0.8
Altered patient colour	7	0.1
Clinical considerations		
Preparation for extubation	181	3.4

Proportion of ESAT[®] criteria documented for each ETT suction event was recorded. In 2558 (48.2 %) ETT suction events one ESAT[®] criteria was documented as a rationale to perform the procedure, 1711 (32.2%) of ETT suction events had two ESAT[®] criteria documented as the rationale, 732 (13.8%) ETT suction events had three ESAT[®] criteria listed, 209 (3.9%) had four ESAT[®] criteria listed, 37 (0.7%) had five ESAT[®] criteria listed, 9 (0.2%) had six ESAT[®] criteria listed and 52 (1%) had no criteria listed either relating to the ESAT[®] or identifying the rationale behind performing the procedure.

There was a strong correlation between suction being performed and peak pressure ($r = 0.62$, $n = 5307$, $p < 0.01$), preparation for transport ($r = 0.048$, $n = 5307$, $p < 0.01$) and visible or audible secretions ($r = 0.757$, $n = 5307$, $p < 0.01$).

As previously stated, for statistical analysis, each criterion in the ESAT[®], as shown in Figure 4.1, was allocated a score with a maximum score possible of nine. The median number of criteria documented was 2 (IQR 1-6), with 1-3 criteria recorded for 87% ($n=5001$) of suction events. The additional clinical consideration preparation for extubation was not included in the original ESAT[®] format and therefore not included in the results.

ETT suction events per diagnostic group and ESAT[®] score per ETT event, as shown in Table 4.3. Patients with sepsis (42.5 times) and respiratory (27.9 times) diagnoses had ETT suction performed more often than any other group, as shown in Table 4.3. These two groups also had higher mean ESAT[®] scores per suction event with Respiratory scoring 1.83 and Sepsis 1.64.

Table 4.3 Suction Events per Diagnostic Group and ESAT[®] Scores per ETT Suction Event

Diagnostic Group	<i>M</i> (median)
ETT Suction Events	
Sepsis	42.5
Respiratory	27.9
Neurology	18.9
Trauma	17.0
Cardiac	12.0
Endocrinology	9.5
General surgery	8.8
Oncology	7.6
Ingestion	3.0
Poisoning	2.0
ESAT[®] Score per Suction Event	
Respiratory	1.83
Sepsis	1.64
Cardiac	1.57
Ingestion	1.40
Trauma	1.34
General surgery	1.26
Ingestion	1.07
Oncology	1.00
Neurology	0.87
Endocrinology	0.05

4.4 Discussion

Quality nursing assessment based on empirical evidence is essential when providing optimal care, although clinical assessment can be a complex process (American Association of Respiratory Care, 2010; Davies et al., 2011; Day, Farnell, & Wilson-Barnett, 2002; Epstein & Hundert, 2002; Hazinski, 2013; Manias & Bucknall, 2002). An important component of PIC nursing care is accurate clinical assessment leading to appropriate patient care. Approximately 40% (n=292) of all patients admitted to the PIC during the audit period required advanced airway support with an ETT and ETT suction, exposing them to the potential risks associated with the procedure

justifying the importance of this audit. Previous review of literature pertaining to ETT suction has failed to establish consensus regarding which specific clinical indicators should be measured and used to guide the decision to perform ETT suction (Davies et al., 2015b). All criteria listed within the ESAT[®] was utilised at some point to justify ETT suction within the reviewed documentation. There was a strong correlation between when ETT suction was performed and three criterion within the ESAT[®]: Peak pressure levels displayed on the ventilator, visible or audible secretions and preparation for patient transport. A key finding from this audit was that nurses documented between 1-3 criteria per ETT suction event (median 1-3, IQR 1-6) that were consistent ESAT[®] criteria. When comparing the criteria most commonly documented by nurses, three criteria were identified: “visible or audible secretions” was the most frequently documented criterion (n=5104, 96.1%); “auscultation (altered air entry)” was the second most common documented criterion (n=987, 18.6%); followed by “changes in oxygenation saturation” (n=939, 17.7%). These results correlate with the previous research conducted by Davies and colleagues (2011) to determine the construct of the “Respiratory Status Criteria” component of the ESAT[®]. Further, the same criteria were ranked highly by experienced CCNs as criteria that should be considered when assessing the paediatric patients need for ETT suction. Adding credence that criteria listed within the ESAT[®] are documented as criterion affecting current clinical decision making for nurses to perform ETTT suction.

“Preparation for extubation” was often recorded as a clinical consideration when performing ETT suction in this audit. This criterion was not included in the ESAT[®] when first developed and will now be added to the “Clinical Considerations” component of the tool to better reflect clinical practice.

The level of experience of the PIC nurse can potentially impact on the clinical observations made when determining the need to perform ETT suction as demonstrated in this audit by the positive relationship between senior CCNs and the criterion “alterations in peak pressures”. It is, however, possible this relationship may reflect skewed data as 56% (n=2984) of patients were cared for by senior nurses compared with 22% (n=1160) who were cared for by less experienced CCNs. Further, senior CCNs may be allocated patients of a higher acuity, have a more comprehensive understanding of all factors pertaining to artificial ventilation and may identify criteria other than those included in the ESAT[®]. We suggest that

education for inexperienced CCNs on the clinical indicators for ETT suction should be more comprehensive and include both physiological and ventilation parameters to improve patient assessment.

The underlying clinical diagnosis impacted on the number of times ETT suction was performed with “septic” and “respiratory” diagnostic groups averaging more ETT suction events despite representing 36% (n = 73) of patients reviewed. The mean number of criteria for ETT suction was also higher in these diagnostic groups.

The audit review involved 292 intubated and ventilated patients exceeding the minimum value of 289 patients to establish 95% confidence in the data. The target value of 300 patients (to account for incomplete data) was not achieved, however data was verified as complete and accurate by an independent reviewer. Another factor affecting the accuracy of the audit process is the variability of the reviewed nursing documentation (Wang et al., 2011). Therefore, the audit results need should be considered in this context. The sample under review is limited to the types of patients presented to this PICU reflecting the population this unit services and the experience of the nurses within this area.

This audit confirmed the criteria used in the ESAT[®] design were consistent with those documented by CCNs to justify the need for ETT suction though modification to include “Preparation for extubation” is required.

4.5 Conclusion

Current guidelines for clinical assessment of clinical indicators for ETT suction in children have to date only been established in a broad context. This audit showed a direct link between the clinical indicators for ETT suction in the ESAT[®] with the criteria used by CCNs in the sole tertiary PICU in Western Australia. This confirms the relevance of our previous research findings to the PIC clinical setting. Key findings from the audit showed: 1) the criteria in the ESAT[®] were consistent with those documented by nurses to justify the need for ETT suction, with the exception of “preparation for extubation”; 2) the ESAT[®] reflects current documented clinical decision making and nursing practice by CCNs in a PIC; and 3) the ESAT[®] could be used as both a clinical and educational guide for inexperienced PIC CCNs once validity and reliability have been established. Prior to this process, the ESAT[®] will

be modified to include the newly identified clinical consideration “Preparation for extubation” as a clinical consideration. We consider the ESAT[®] could be a useful clinical and educational guide for the inexperienced CCN working in a PICU to aid the clinical decision process associated with ETT suction in the future.

The following chapter (Chapter Five) presents the third published article for this study which described the process undertaken to establish content validity and scale level content validity index testing of the ESAT[®].

Chapter Five

Publication Three:

Content Validity Testing of the ESAT[®]

“Content validity testing of the ESAT[®]: A decision aid tool for performing endotracheal suction in children”

Davies K, Bulsara M⁷, Ramelet AS⁸, Monterosso L⁹

Publication Three, prepared with advice and editorial support from each member of the supervisory team, describes the methodological framework, procedures and findings associated with the psychometric testing procedures used to establish the content validity and scale level content validity index of the Endotracheal Suction Assessment Tool[®] (ESAT[®]).

Reference:

Davies K, Bulsara M¹, Ramelet AS², Monterosso L³. (2018). Content validity testing of the ESAT[®]: A decision aid tool for performing endotracheal suction in children. *Australian Critical Care*, 31(1), 23-30. doi: 10.1016/j.aucc.2017.01.006

⁷ Professor M Bulsara is the co-supervisor of this study and provided biostatistical and editorial advice for this article.

⁸ Professor A-S Ramelet is the associate supervisor of this study and provided content guidance and editorial advice for this article.

⁹ Professor L Monterosso is the principal supervisor of this study and provided content direction, review and editorial advice for this article.



Research paper

Content validity testing of the ESAT[®]: A decision aid tool for performing endotracheal suction in childrenKylie Davies ^{a,b,*}Max K. Bulsara PhD, MSc, BSc(Hons) ^{c,d,e}Anne-Sylvie Ramelet ^fLeanne Monterosso PhD, BNurs(Hons) ^{g,h}^a Paediatric Intensive Care Unit, Princess Margaret Hospital for Children, Perth, Australia^b University of Notre Dame Australia, Australia^c Institute of Health and Rehabilitation Research, University of Notre Dame Australia, Australia^d University of Western Australia School of Population Health, Australia^e University College London, United Kingdom^f Institute of Higher Education and Research in Healthcare, Faculty of Biology and Medicine, University of Lausanne, Switzerland^g School of Nursing and Midwifery, University of Notre Dame Australia/St John of God Murdoch Hospital, Australia^h School of Nursing and Midwifery, Edith Cowan University, Australia

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ABSTRACT

Background and purpose: Endotracheal tube suction performed in children can affect clinical stability. Previous research has identified clinical indicators used to perform endotracheal suction. These were used to develop the Endotracheal Suction Assessment Tool[®] (ESAT[®]). This study sought to evaluate the degree to which the ESAT[®] items as a whole constitute an operational definition of the construct used to determine whether a paediatric intensive care nurse should perform the endotracheal tube suction procedure.

Methods: Lynn's process for calculation of content validity and scale content validity index using a team of expert reviewers was adopted. Experts were drawn from paediatric intensive care units in Australia (n = 6), United Kingdom (n = 1), Switzerland (n = 1) and Canada (n = 1). These experts established the content validity index of the Endotracheal Suction Assessment Tool[®] using a minimum preset a-priori criterion agreement of 0.78 and a scale content validity index of 0.8. Scale content validity index was used to enhance the interpretability of the content validity data.

Results: All 15 items achieved the preset a-priori agreement for apparent internal consistency. Minor adjustments were required to improve the clarity of four items. The content validity index ranged from 0.8 to 1.0 and scale content validity index ranged from 0.9 to 1.0 for all items.

Conclusion: Item and scale content validity indexes of the tool were established. Further psychometric testing for construct validity and stability over time is required to establish clinical utility of the tool and practice of novice paediatric intensive care nurses and other PIC health professionals.

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1. Introduction

In the paediatric intensive care (PIC) setting an endotracheal tube (ETT) may be inserted to enable airway support and mechanical ventilation in patients unable to maintain adequate oxygenation and ventilation.¹ ETT suction, a procedure to remove mucous secretions from within an ETT, is commonly performed to maintain

a patent artificial airway. The procedure is not without inherent risk to the critically ill ventilated PIC patient, including complications ranging from desaturation to cardiac arrest.^{1–6} Whilst there is consensus within current literature that ETT suction should only be performed when clinically indicated^{7–9} our recent integrative review of clinical indicators used to initiate ETT suction failed to establish agreement regarding specific clinical indicators that should be assessed and used to guide the decision to perform ETT suction by PIC nurses.¹⁰ This is concerning as critically ill paediatric patients require nursing care that is responsive and appropriate to the changing needs of the individual patient, yet justification for the procedure has not been clearly defined within current literature.

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The complete PDF version of the manuscript was presented in Appendix F for examination purposes only.

5.1 Introduction

In the paediatric intensive care (PIC) setting an endotracheal tube (ETT) may be inserted to enable airway support and mechanical ventilation in patients unable to maintain adequate oxygenation and ventilation (Curley & Moloney-Harmon, 2001). ETT suction, a procedure to remove mucous secretions from within an ETT, is commonly performed to maintain a patent artificial airway. The procedure is not without inherent risk to the critically ill ventilated PIC patient, including complications ranging from desaturation to cardiac arrest (Curley & Moloney-Harmon, 2001; Dougherty Wrightson & Askin, 1999; Gilbert, 1999; Godfrey, 2004; Hazinski, 2013; Maggiore et al., 2013). Whilst there is consensus within current literature that ETT suction should only be performed when clinically indicated (Gonçalves, Tsuzuki, Giovanni, & Carvalho, 2015; Hahn, 2010; Morrow & Argent, 2008) our recent integrative review of clinical indicators used to initiate ETT suction failed to establish agreement regarding specific clinical indicators that should be assessed and used to guide the decision to perform ETT suction by PIC nurses (Davies et al., 2015b). This is concerning as critically ill paediatric patients require nursing care that is responsive and appropriate to the changing needs of the individual patient, yet justification for the procedure has not been clearly defined within current literature.

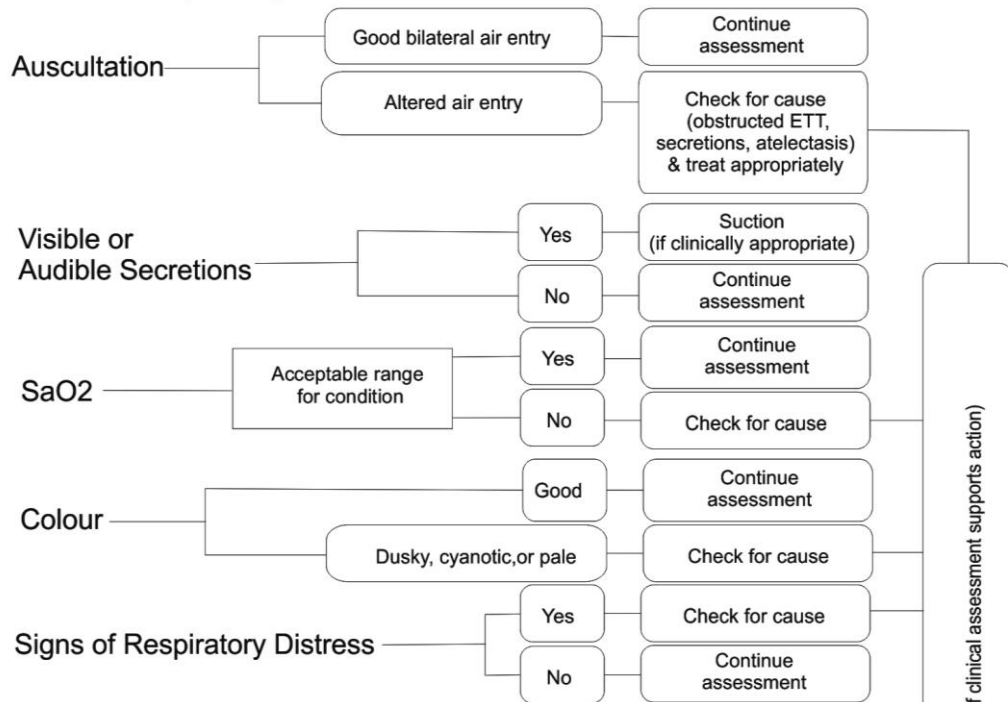
Use of evidence-based practice tools and guidelines is associated with improved patient care and potentially improved outcomes (Bruschettini, Zappettini, Moja, & Calevo, 2015; Clancy, Slutsky, & Patton, 2004). Previous research by the researchers identified clinical indicators deemed most appropriate for use by nurses in the assessment of the PIC patient's need for ETT suction (Davies et al., 2011). Subsequent work led to the development of the Endotracheal Suction Assessment Tool[®] (ESAT)[®] (Figure 5.1) designed to: a) provide guidance and support for clinical decision making related to performance of ETT suction; b) enhance clinical knowledge and practice; and c) reduce the incidence of adverse patient outcomes associated with the procedure (Davies et al., 2015b). To ensure the clinical viability and validation of the tool requires ongoing research past the development stage. This paper describes the process used to establish the item content validity index (CVI) at item-level (I-CVI) and scale content validity index (S-CVI) of the ESAT[®].

Endotracheal Suction Assessment Tool© (ESAT©)

1. Clinical Considerations

- Diagnosis
- Clinical history/ clinical stability
- Previous response to ETT suction
- Current artificial ventilation (eg HFO)
- Preparation for transport
- Preparation for extubation
- Consider clinical observation trends

2. Assess Respiratory Status



3. Assess Ventilation Status



Figure 5.1 Endotracheal Suction Assessment Tool©. Copyright 2014 by K Davies.

Background

Numerous guidelines and published research exist describing ETT suction technique and equipment use, efficacy of saline lavage and maximum pressure gradients for artificial ventilation (American Association of Respiratory Care, 2010; Carroll, 2010; C. Evans, 2005; J. Evans et al., 2014; Pedersen et al., 2009). Likewise tools designed to guide clinical practice within paediatric intensive care units, such as pain or pressure ulcer assessment tools exist, however there are no assessment tools other than the ESAT[®] currently designed to aid nurses' clinical decision making to perform ETT suction (Kottner & Dassen, 2010; Ntoumenopoulos, 2013; Voepel-Lewis, Zanotti, Dammeyer, & Merkel, 2010). A previous mixed methods study undertaken by the researchers underpinned the development of the ESAT[®] rationalising item selection, which is a crucial component in the validation process (Davies et al., 2011; Gelinias, Fillion, & Puntillo, 2009). More recently the researchers reported on a large clinical audit of nursing documentation covering 292 intubated and ventilated PIC patients (Davies et al., 2015a). The purpose of the audit was to determine whether items (criteria) for ETT suction listed in the ESAT[®] reflected those used in current clinical practice by PIC nurses when preparing for ETT suction. Results confirmed a direct association between the clinical indicators for ETT suction as listed in the ESAT[®] with the items documented by PIC nurses in clinical practice to determine if ETT suction was warranted. An important step as it confirmed the currency and relevance of the ESAT[®] items. The audit also revealed that PIC nurses consistently used another previously unreported criterion: "preparation for extubation". The researchers considered this criterion worthy of inclusion in the "Clinical Considerations" category of the ESAT[®] which was duly modified (Davies et al., 2015a). This work confirmed the complexity of the assessment process for ETT suction and demonstrated that a combination of clinical signs and symptoms are used by PIC nurses for the procedure with no single item influencing decision outcomes.

ESAT[®]

The ESAT[®] tested in this study comprised 15 items (criteria) across three categories: "Clinical Considerations", "Assess Respiratory Status" and "Assess

Ventilation Status” to assess the requirement to perform ETT suction (Figure 5.1). The tool was designed to ensure initial consideration of all items within the “Clinical Considerations” section before moving on to the next item listed under the subtitle “Assess Respiratory Status”. Each clinical observation can then be assessed moving left to right across the tool guiding the nurse to the decision to either perform ETT suction or continue on with the clinical assessment of the patient, moving downwards to the next category of items “Assess Ventilation Status” if unsure whether ETT suction is required (Figure 5.1). A table of definitions of each ESAT[®] item was designed to accompany the tool for inexperienced nurses (Table 5.1).

Table 5.1 Definitions of ESAT[®] Criteria

Criterion	Definition
Clinical Considerations	Relating to or directly involving observation of the patient’s respiratory status including diagnosis, clinical observations in an objective, analytical and concise method.
Diagnosis	The process of determining the nature and cause of the disease or injury through critical analysis and evaluation of the patient’s history, direct examination and review of all investigative procedures and laboratory results.
Clinical History or Clinical Stability	Detailed description of the patient’s current physiological condition and acuity. Focused on patient’s ability to tolerate handling or invasive procedures, especially ETT suction.
Previous response to ETT suction	Detailed description of the patient’s physiological response to previous endotracheal tube (ETT) suction and the physiological response during and post ETT suction.
Current Artificial Ventilation	Type of breathing support i.e. high frequency oscillation, mode of ventilation.
Preparation for Transport	Requirement to perform ETT suction in preparation for transport.
Preparation for Extubation	Requirement to perform ETT suction in preparation for extubation.
Assess Respiratory Status	The physical assessment of the patient’s airway, inspiration & expiration respiration effort and ventilation parameters.
Auscultation	Utilising a stethoscope to listen to the sounds produced as air moves into and out of the lungs. Includes assessing for areas of altered air movement within the lungs. Can also include palpation and percussion of the chest.
Visible or Audible Secretions	Any substance within the respiratory system including the ETT, may include mucous, blood or foreign particles.
SpO ₂	Oxygen saturation percentage.
Colour	Patient’s skin colour which may include descriptors such as pale, pink, flushed, dusky, altered capillary return times or cyanotic.

Criterion	Definition
Signs of Respiratory Distress	Any increase in work of breathing for the patient i.e. tachypnoea, tachycardia, chest wall recession, nasal flaring, tracheal tug, paradoxical breathing, agitation, added noises (grunt, wheeze), changes in SpO ₂ , cyanosis, sweating, increased PaCO ₂ and acidosis.
Assess Ventilation Status	Directly related to the parameters displayed on the ventilator screen.
Tidal Volume (Tv)	The volume of air inspired and expired during a single breath.
Peak Pressure (Pp)	Maximum pressure reading displayed on the ventilator during or at the end of the inspiration.
ETCO ₂	The level of expired CO ₂ at the end of expiration.

Purpose

The next step in the validation of the ESAT[®] was to evaluate the degree to which the ESAT[®] items individually and combined were able to be clearly and concisely interpreted and relevant to determining whether a PIC nurse should perform the ETT suction procedure.

5.2 Method

Design

The aim of the study was to establish content validity of the ESAT[®] incorporating Creswell's (Creswell, 2015) mixed methods approach and Feinstein's (1983) "clinimetrics", a method for establishing consistent and reproducible observation and expression of data in the context of the clinical setting. Additionally, Lynn's (1986) framework was integrated to determine the item content validity index (I-CVI) and scale content validity index (S-CVI) as the next logical stage of the validation process for the ESAT[®].

Calculation of the S-CVI requires testing for "content validity", "clarity" and "apparent internal consistency". Establishing content validity involves a "judgement-quantification stage" using a predetermined number of experts to ascertain whether individual items in an instrument are "content valid" and the instrument as a whole is "content valid" (Lynn, 1986). Use of a nominated number of experts to establish agreement is important to avoid chance agreement in the S-CVI process (Lynn, 1986).

Clarity

When designing the ESAT[®] (Figure 5.1) it was essential that each descriptor was clearly defined and unambiguous in its meaning (15 in total). For example, oxygen saturation referring to arterial oxygenation as described as SaO₂ could be confused with pulse oximetry defined as SpO₂ (Hazinski, 2013). It was also important that each item was unambiguous to ensure consistent responses across the expert group. To aid this process, experts were provided with a definition of ESAT[®] items (Table 5.1). “Experts” were asked the following yes/no question: “Is each item (criterion) clearly *defined*”. Experts were also asked to provide comments/suggestions to refine the definition table for improved clarity of items (Table 5.1).

Internal Consistency

When testing reliability, there is a difference between the qualitative approach to determine “apparent internal consistency” and the quantitative approach to determine “internal consistency”. Apparent internal consistency refers to the degree in which each item is measuring the critical attribute of interest (Lynn, 1986; Munro, 2001; Polit & Hungler, 2013). For example, if a research instrument was designed to examine arterial blood gas results then it would be inappropriate to include a question related specifically to venous blood gas results. Qualitative measurements are designed to elicit perceptions and judgements which may change over time while quantitative measurements are based on consistent and reproducible measurement systems. Apparent internal consistency is a preliminary qualitative assessment of homogeneity (or quality) of content (Imle & Atwood, 1988). It was important for the researchers to measure how people (experts) interpret the items specifically “whether they *belong* or not in the ESAT[®].” Their responses are qualitative in nature (i.e. from their personal interpretation) but recorded as a quantifiable measure.

The rationale for reviewing the tool for apparent internal consistency was to critically review each item in the ESAT[®] to ensure it “belongs” in the tool. Experts were asked two yes/no questions: “Does each item *belong* in the ESAT[®]?”, and “Is each item *needed* in the ESAT[®]?”

The extent of the internal consistency is built on the aggregate analysis of the perceptions of the group. The degree to which the items that make up the scale as in the ESAT[®] are all measuring the same underlying attribute consistently as perceived

by the group can then be measured statistically by Cronbach's alpha coefficient (Neuman, 2011; Polit et al., 2007). The coefficient alpha score is a reliability index that estimates the homogeneity (internal consistency) of several items which increases as the intercorrelation among items increases (Polit & Hungler, 1993). In this case the items relate to the appropriateness of inclusion of the items in the tool.

Content Validity

Content validity involves the Judgement-Qualification Stage which utilises a preset number of experts to agree that the items within the instrument are content valid and whether the instrument as a whole is valid using the Content Validity Index (CVI) (Lynn, 1986). Experts were therefore asked "is the item *relevant* when assessing if ETT suction is required" for each item.

The CVI determines if the tool measures what it is purported to measure based on relevance. However, relevance can vary from clinical situation to clinical situation therefore to account for this the Scale-Level Index (S-CVI) has also been calculated and is discussed within this section (Polit & Beck, 2006).

Content Validity Index (CVI)

The CVI is a quantitative scoring system used to establish content validity of items within the tool (Lynn, 1986). Lynn (1986) described the CVI, derived from rating the relevance of each item (I-CVI) using a four point ordinal rating scale, where a score of one denotes irrelevance of the item and a score of four denotes that the descriptor is extremely relevant. For this study experts were asked to rate the relevance of each item in assessing whether ETT suction was required using a four-point rating scale (1 = not relevant; 2 = somewhat relevant; 3 = quite relevant; 4 = highly relevant) where the dependence of the CVI on the number of points in the rating scale avoids a neutral or ambivalent midpoint (Polit & Beck, 2006).

Scale-Level Index (S-CVI)

Polit and Beck (Polit & Beck, 2006) suggested that the S-CVI should also be calculated to enhance the interpretability of the content validity data. The S-CVI statistic represents the average item quality and accounts for any divergent opinion between experts (Table 5.3) (Polit & Beck, 2006; Polit et al., 2007). The S-CVI was an important calculation to include as ETT suction is a complex issue and an item,

depending on the clinical setting, can move from the “somewhat” relevance to “highly” relevant under particular clinical circumstances. For example, diagnosis may be “somewhat” relevant for the patient with a primary neurological condition but becomes “highly” relevant for the patient who subsequently develops a secondary respiratory complication.

Sample

PIC “experts” were purposefully selected to assess the ESAT[®] and were drawn from the PIC context from which the original data was generated (Imle & Atwood, 1988). For the purpose of this study experts were defined as senior clinical nurse educators or clinical development nurses, clinical nurse consultants or clinical nurse researchers with more than five years of experience within PIC and directly involved in the delivery of education of PIC nursing staff.

In keeping with Lynn’s (1986) recommendation for determining the number of expert rating panel members needed to determine content validity, an estimate was determined by calculating the number of experts who might agree out of the total number of experts planned for use, and then setting the standard error of the proportion to identify a cut-off for chance versus real agreement (Lynn, 1986; Mastaglia, Toye, & Kristjanson, 2003). Lynn (1986) argued that using a larger number of experts and a four point likert-type scale ensures the likelihood of chance agreement is removed and addresses the limitations of CVI that were proposed by Waltz and Bausell (Polit & Beck, 2006) which concerned tool items adequately representing the content domain of the instrument. Of the nine experts recruited for this study a minimum of seven was required to establish an a priori criterion (Imle & Atwood, 1988; Lynn, 1986).

Sampling Strategy

PIC nurse experts were recruited from two sources: local and international. The first was the Australian College of Critical Care Nurses (ACCCN) that has a sub-speciality of paediatric critical care nurses and is the key professional body for over 2400 critical care Australian nurses which provides education, clinical support and professional development. Initial email contact was made with the ACCCN Board of Directors outlining the purpose of the research, inclusion criteria and the scope of

tasks required by potential participant attendees at the 2014 ACCCN Institute of Continuing Education (ICE) conference. The ICE organising committee then contacted potential Australian participants via email and with an invitation to participate in a face-to face meeting during the conference. Second, to ensure relevance of the ESAT[®] from an international perspective, experts were also recruited through the PIC colleague network via email from Canada (n=1), United Kingdom (n=1) and Switzerland (n=1). These participants received both the initial explanatory email outlining the research followed by an electronic version of the research study pack once agreement to participate was obtained. The electronic version enabled online completion.

5.3 Procedure

Australian experts were provided with a study pack face-to-face at the ACCCN ICE conference (n=6). International experts were sent the study pack via email (n=3). The pack comprised a study synopsis; participant information sheet (PIS); the Endotracheal Suction Assessment Tool[®] (ESAT[®]) with a definition of terms (Table 5.1); CVI Testing Questionnaire comprising demographic questions (n=9), instructions and a response sheet to rate the clarity, apparent internal consistency and content validity of the ESAT[®]; and a reply paid addressed envelope for return of the completed CVI Testing Questionnaire (ACCCN participants only).

Data Analysis

Data were transcribed into the IBM Statistical Package for Social Sciences (SPSS) (version 22) predictive analysis software for the purposes of statistical analysis (IBM, 2013). Demographic and CVI testing data were summarised using frequencies and proportions.

Lynn's (1986) process for determining validation guided the analysis of clarity, apparent internal consistency and content validity. As this study used nine experts the preset criterion of at least 78% agreement was (Imle & Atwood, 1988; Lynn, 1986). As described by Imle and Atwood (1988) agreement by experts on the panel was expressed as proportion (Table 5.3).

Cronbach alpha coefficient, the most common measure of internal consistency ("reliability"), was used to calculate internal consistency of ESAT[®] items (Pallant,

2013). Cronbach alpha calculates correlation among all items, in every combination with estimates above 0.7 indicating a high reliability estimate that items all reliably measure the same underlying construct (Sullivan, 2011).

Results from the CVI quantitative scoring system required the four ordinal responses to be collapsed to two nominal, dichotomous categories i.e. “content invalid” and “content valid” where ratings of 1 or 2 are converted to content invalid and ratings of 3 or 4 are converted to content valid providing a clear scoring system to delineate between items that are relevant or not (Table 5.3) (Lynn, 1986).

S-CVI was calculated by computing the item-level CVI (I-CVI) for each item on the scale, and then calculating the average I-CVI across items, looking at all possible answers for each item (Polit et al., 2007). The S-CVI statistic was set at the lower limit of 0.80 for S-CVI as this is an acceptable limit for new tools (Table 5.2) (Polit & Beck, 2006; Polit et al., 2007).

Ethics

Low risk ethical approval was obtained from the Human Research Ethics Committee of the University of Notre Dame Australia (UNDA) (011072F). The ACCCN Board of Directors provided permission to conduct the face-to-face meeting at the 2014 ACCCN ICE conference.

The PIS packs detailed the following information: participation was voluntary; consent was implied by completion and return of the questionnaire within two weeks; and the possibility of withdrawing from the study at any time without prejudice.

5.4 Results

Demographic Variables

Experts providing responses were classified as having expertise in the field of paediatric intensive care nursing based on experience level, current role and graduate qualifications. The nine experts originated from the following countries: Australia (n=6), Canada (n=1), Switzerland (n=1) and the United Kingdom (n=1). The nine experts recruited consisted of one male (11%) and eight (89%) females. All experts had worked \geq five or more years in PIC, were aged $>$ 30 years, had been nursing for

over 10 years and held at least one post graduate qualification. Nursing roles varied from clinical development nurse or educator to researcher (Table 5.2).

Table 5.2 Demographic Characteristics of Expert Practitioners (n = 9)

Variable	n (%)
Current nursing role	
Clinical Development Nurse PIC	2 (22.2)
Clinical Educator PIC	4 (44.4)
Clinical Nurse Consultant PIC	1 (11.2)
Nursing Research Fellow PIC	2 (22.2)
Graduate qualifications	
PhD	1 (6.5)
Masters (coursework)	4 (27)
PIC Graduate Diploma	3 (20)
PIC Graduate Certificate	4 (27)
Adult Intensive Care	2 (13)
Coronary Care	1 (6.5)
PIC nurse experience	
7-10 years	2 (22)
>10 years	7 (78)
Country of origin	
Australia <i>(New South Wales = 3; Western Australia = 2; South Australia = 1)</i>	6 (67)
Canada	1 (11)
Switzerland	1 (11)
United Kingdom	1 (11)
Gender	
Female	8 (89)
Male	1 (11)

Clarity

Four items in the “Clinical Considerations” category scored 67% agreement: “Current Artificial Ventilation”, “Visible or audible secretions”, “Oxygen saturations” (SaO₂) and “Colour”. All other items achieved 78% or higher (Table 5.3).

Free text comments from the experts (n=40) focused on the “Definitions of the ESAT[®] Criteria” rather than the tool itself. Comments included suggestions for more specific and simplified descriptions. These comments were extremely useful as the

purpose of the tool is to facilitate a clear understanding for the inexperienced nurse. For example, when discussing clinical history it was suggested the term “ability to tolerate handling” and normal values for the definition of ETCO₂ should be included. Experts also suggested that the wording of Item 4 in the ESAT[®] should be modified from *Current artificial ventilation* to *Current mode of ventilation* to improve clarity.

The definitions for items that failed to meet the preset minimum agreement were modified to improve clarity in accordance with the suggestions made by experts.

Apparent Internal Consistency

Experts were also asked to review each item in the ESAT[®] to determine if the item “*belonged*” in the ESAT[®], was “*relevant*” to the domain under investigation (ETT suction) and “*fitted*” within the format of the ESAT[®] to establish apparent internal consistency. All items achieved scores between 89-100%, meeting the preset minimum agreement of 78% (Table 5.3).

Internal Consistency

The ESAT[®] demonstrated high internal consistency for all items with an overall Cronbach Alpha coefficient of 0.98.

Content Validity Testing

The item content validity index (I-CVI) and scale content validity (S-CVI) were also calculated. All items in the “Clinical Considerations” section of the ESAT[®] achieved the preset minimum agreement with I-CVIs > 0.78 with the exception of “Current Artificial Ventilation” which achieved an I-CVI of 0.7 (6 out of 9 experts in agreement). The S-CVIs for all items were high and ranged from 0.9 to 1.0 (Table 5.3).

Table 5.3 Expert Rating on Relevance Scale for Each ESAT[®] Item

Item (Descriptor)	Clarity clearly defined % agree	Apparent Internal Consistency Item belongs % agree	Apparent Internal Consistency Question needed % agree	Content Validity Assessment by Expert:									Number in agreement	CVI Testing	
				1	2	3	4	5	6	7	8	9		Item CVI*	S-CVI**
1. Diagnosis	100	100	89		X	X	X		X	X	X	X	7	0.80	0.90
2. Clinical history/clinical stability	78	100	89	X	X	X	X	X	X	X	X	X	9	1.00	1.00
3. Previous response to ETT suction	78	100	89	X	X	X	X	X	X	X	X	X	9	1.00	1.00
4. Current artificial ventilation (e.g. HFO)	67	100	100		X		X		X	X	X	X	6	0.70	0.90
5. Preparation for transport	89	100	89	X	X	X	X		X	X	X	X	8	0.90	0.90
6. Preparation for extubation	78	89	89	X	X	X	X	X	X	X	X		8	0.90	0.90
7. Consider clinical observation trends	89	89	89		X	X	X	X	X	X	X	X	8	0.90	0.90
8. Auscultation	89	100	89	X	X	X	X		X	X	X	X	8	0.90	0.90
9. Visible or audible secretions	67	100	89	X	X	X	X	X	X	X	X	X	9	1.00	1.00
10. SaO2	67	100	89		X	X	X	X	X	X	X	X	8	0.90	0.90

Item (Descriptor)	Clarity clearly defined % agree	Apparent Internal Consistency Item belongs % agree	Apparent Internal Consistency Question needed % agree	Content Validity Assessment by Expert:									Number in agreement	CVI Testing	
				1	2	3	4	5	6	7	8	9		Item CVI*	S-CVI**
11. Colour	67	89	89	X	X	X	X	X		X		X	7	0.80	0.90
12. Signs of respiratory distress	78	100	89	X	X	X	X	X	X	X	X	X	9	1.00	0.90
13. Tidal volume	89	100	100	X	X	X	X	X	X	X	X	X	9	1.00	0.90
14. Peak pressure	89	100	100		X	X	X	X	X	X	X	X	8	0.90	0.90
15. ETCO2	89	100	100	X	X	X	X	X	X	X	X	X	9	1.00	0.90
Proportion relevant				0.67	1.00	0.93	1.00	0.73	0.93	1.00	0.93	0.93			

* CVI, Content Validity Index; ** SCVI, Scale Content Validity Index; x = 3-4 point relevance scale achieved

5.5 Discussion

Results from this study complement previous work by describing the empirical testing of the ESAT[®] for content validity (Lynn, 1986). There were a number of strengths in the research methodology including testing for content validity, clarity, apparent internal consistency and relevance. The study used Lynn's (1986) methodology to establish the CVI and S-CVI which are considered empirically sound and widely used for early content validity testing of instruments by health researchers (Hester & Davis, 2013; Streiner & Kottner, 2014; Streiner & Norman, 2005). As recommended by Polit, Beck and Owens (2007) use of a S-CVI focuses on the average item quality rather than average performance of an expert. The scores for items ranged from 0.9 to 1.0 supporting the validity of items included in the ESAT[®].

Our experts were carefully selected using well defined criteria recommended by Grant and Davis (1997) and were drawn from the context within which the original data was generated (Grant & Davis, 1997; Imle & Atwood, 1988). An additional strength was use of nine experts rather than the recommended minimum number of six (Lynn, 1986). The range of qualifications and clinical experience of experts with respect to paediatric intensive care nursing provided a diverse and clinically insightful review of the ESAT[®] (Table 5.2).

When experts were asked if items were clearly *defined* (clarity) the majority of items (11 of 15) achieved the preset a priori agreement (Table 5.3). The four items not achieving the preset a priori agreement were modified as suggested by the expert reviewers, by providing more clarity in the instructions and definitions of ESAT[®] items. This is important when the target nursing group is the inexperienced nurse or health professional.

To both quantify and confirm reliability as part of internal consistency we used Lynn's (1986) validated methodology to interpret the perceptions of the experts and judgement of items (apparent internal consistency) contained within the tool and quantify these results to ensure the tool is measuring the underlying attribute (internal consistency). When experts were asked if items were *needed* and *belonged* (apparent internal consistency) in the ESAT[®], overall agreement was high - ranging from 89-100% - exceeding the required minimum a priori agreement (Table 5.3).

The results establish that these experts agree with the clinical observations being considered in the clinical setting for ETT suction another step forward in the validation process. The ESAT[®] demonstrated high internal consistency for all items, demonstrating good reliability that the tool consistently measures the concept it is designed for.

The overall agreement for the rating of *relevance* was high with all items except “Current Artificial Ventilation” with a I-CVI of 0.7 (Table 5.3). As this item has 100% agreement that it is both needed and belongs within the ESAT[®] the lower value may not preclude it from the ESAT[®]. If the item is important to the core concept being measured it may still be important to include if it relates to current practice and is theoretically or clinically supported (Streiner & Norman, 2005). Certainly previous research supports the relevance of the mode of artificial ventilation in both theoretically and current clinical practice (Davies et al., 2015a, 2015b; Davies et al., 2011).

The ESAT[®] demonstrated high scale and item content validity index scores using Lynn’s (1986) content validity process. Polit, Beck & Owen (2007) would argue that I-CVIs used to demonstrate inter-rater agreement may be influenced by chance. Lynn (1986) however counter argues that chance agreement is avoided by achieving an I-CVI agreement of 1.0 when using five or less expert reviewers, and 0.78 – 0.80 when using six to 10 experts. Our study addressed this issue by using nine experts to review the ESAT[®].

Despite the complexity of determining whether ETT suction is warranted, the ESAT[®] is considered a simple tool that can be used in the clinical PIC setting to guide the inexperienced nurse. To date the tool has undergone a pragmatic approach with regard to development and content validity testing. Incorporating previous empirical evidence from experienced nurses’ regarding the *importance* of each ESAT[®] (Lynn, 1986) item, clinical audit evidence (Davies et al., 2015a; Davies et al., 2011), and extensive nursing documentation records from the clinical PIC setting. The results support use of the tool by nurses within the paediatric clinical setting when contemplating the need to perform ETT suction (Davies et al., 2015a, 2015b; Davies et al., 2011).

Limitations

The researchers acknowledge some limitations; first the study related specifically to the paediatric intensive care (PIC) population and endotracheal tube (ETT) suction and may therefore lack relevance to neonatal or adult intensive care settings. However, given similar research has not been undertaken with these populations it may be considered relevant to test the application of the ESAT[®] in these environments. The researchers did anticipate a gender bias as current Australian nursing demographic data show males represent 10% of the nursing workforce (Australian Health Workforce, 2013). Of the 328,000 nurses currently registered in Australia, less than 5% work within paediatrics and less than 4% are males (Australian Health Workforce, 2013). Whilst the majority of items within the ESAT[®] were judged by experts to be clearly *defined*, feedback from the expert nurses identified that clarification of definitions (Table 5.1) was required for four items.

Implications

The researchers acknowledge the difference between a tool being theoretically useful versus being clinically useful. A more tangible test for the ESAT[®] will be integration into the clinical setting when used at the bedside by the inexperienced PIC nurse. Previous research has demonstrated that the 15 items in the ESAT[®] are relevant to the current clinical practice, (Davies et al., 2015a) however, this represents only part of the picture in determining the validity and clinical application of the ESAT[®]. While the researchers have confirmed the content validity of the ESAT[®], further psychometric evaluation is now required to establish construct validity and stability over time. The research team intends to undertake reliability and criterion-related validity testing (construct) of the ESAT[®] to establish reliability over time to verify the usefulness and relevance of the ESAT[®] for the purpose it serves.

5.6 Conclusion

This article progresses the validation of the ESAT[®] as a tool to guide clinical practice for determining ETT suction, enhances clinical knowledge and reduces the chance of inappropriate actions that may lead to poorer patient outcomes. The research presented reinforces current practices identified from previous research and improves understanding of appropriate clinical assessment for patients with an ETT insitu. The research provides a solid foundation for the next stage in the validation process of the ESAT[®].

The following chapter (Chapter Six) presents the fourth and final published article of this study. The manuscript describes the methodological framework, procedures and findings associated with the psychometric testing procedures undertaken to establish criterion-related (construct) validity and test-retest (stability) reliability of the ESAT[®].

Chapter Six

Publication Four:

Reliability and Criterion-related Validity Testing of the ESAT[©]

“Reliability and criterion-related validity testing (construct) of the Endotracheal Suction Assessment Tool (ESAT[©]).”

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Publication Four, prepared with advice and editorial support from each member of the supervisory team, describes the psychometric procedures used to evaluate criterion-related (construct) validity and test-retest (stability) reliability testing of the Endotracheal Suction Assessment Tool[©] (ESAT[©]) followed by the results.

Reference:

Davies K, Bulsara M¹, Ramelet A-S², Monterosso L³. Reliability and criterion-related validity testing (construct) of the Endotracheal Suction Assessment Tool (ESAT[©]). *J Clin Nurs.* 2018;27:1891–1900. <https://doi.org/10.1111/jocn.14269>

¹ Professor M Bulsara is the co-supervisor of this study and provided biostatistical and editorial advice for this article.

² Professor A-S Ramelet is the associate supervisor of this study and provided content guidance and editorial advice for this article.

³ Professor L Monterosso is the principal supervisor of this study and provided content direction, review and editorial advice for this article.

Reliability and criterion-related validity testing (construct) of the Endotracheal Suction Assessment Tool (ESAT[®])

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Aims and objectives: To establish criterion-related construct validity and test-retest reliability for the Endotracheal Suction Assessment Tool[®] (ESAT[®]).

Background: Endotracheal tube suction performed in children can significantly affect clinical stability. Previously identified clinical indicators for endotracheal tube suction were used as criteria when designing the ESAT[®]. Content validity was reported previously. The final stages of psychometric testing are presented.

Design: Observational testing was used to measure construct validity and determine whether the ESAT[®] could guide "inexperienced" paediatric intensive care nurses' decision-making regarding endotracheal tube suction. Test-retest reliability of the ESAT[®] was performed at two time points.

Methods: The researchers and paediatric intensive care nurse "experts" developed 10 hypothetical clinical scenarios with predetermined endotracheal tube suction outcomes. "Experienced" ($n = 12$) and "inexperienced" ($n = 14$) paediatric intensive care nurses were presented with the scenarios and the ESAT[®] guiding decision-making about whether to perform endotracheal tube suction for each scenario. Outcomes were compared with those predetermined by the "experts" ($n = 9$). Test-retest reliability of the ESAT[®] was measured at two consecutive time points (4 weeks apart) with "experienced" and "inexperienced" paediatric intensive care nurses using the same scenarios and tool to guide decision-making.

Results: No differences were observed between endotracheal tube suction decisions made by "experts" ($n = 9$), "inexperienced" ($n = 14$) and "experienced" ($n = 12$) nurses confirming the tool's construct validity. No differences were observed between groups for endotracheal tube suction decisions at T1 and T2.

Conclusion: Criterion-related construct validity and test-retest reliability of the ESAT[®] were demonstrated. Further testing is recommended to confirm reliability in the clinical setting with the "inexperienced" nurse to guide decision-making related to endotracheal tube suction.

This is the peer reviewed version of the following article: Reliability and Criterion-Related Validity Testing (construct) of the Endotracheal Suction Assessment Tool (ESAT[®]), which has been published in final form at 10.1111/jocn.14269. This article may be used for non-commercial purposes in accordance with Wiley Terms and Conditions for Self-Archiving.

The complete PDF version of the manuscript was presented in Appendix G for examination purposes only.

6.1 Introduction

Airway management in paediatric intensive care (PIC) involves frequent endotracheal tube (ETT) suction for the intubated patient (Hazinski, 2013). This procedure can have major implications on the clinical stability and outcomes for the critically ill patient, including changes in cellular oxygenation and cardiac output (Curley & Moloney-Harmon, 2001). The researchers' previous work identified the clinical indicators utilised by PIC nurses to initiate ETT suction; these indicators were used to design the Endotracheal Suction Assessment Tool[®] (ESAT[®]) (Davies et al., 2011). The purpose of the ESAT[®] is to guide practice and minimise the potential negative procedural impacts of ETT suction on paediatric patients, already in a compromised physical state (Davies et al., 2015b; Davies et al., 2011). The tool is primarily designed to assist the inexperienced nurse (Davies et al., 2011). The purpose of this study was to establish criterion-related construct validity and test-retest reliability over time for the ESAT[®] (Lynn, 1986; Polit, 2014). The latter involved establishing reproducibility for both reliability and agreement (Burns, 2000; Neuman, 2011).

Background

In view of the associated risks of ETT suction, thorough and proficient clinical assessment skills, combined with a sound theoretical knowledge are required by the PIC nurse in order to identify key clinical indicators for ETT suction (American Association of Respiratory Care, 2010; Hazinski, 2013). The decision to perform ETT suction can be complex as the clinical assessment of the intubated and ventilated patient can vary according to the patient's diagnosis (Curley & Moloney-Harmon, 2001). For example, a patient presenting with respiratory failure may have differing needs and require different assessment tools compared with a patient who presents with neurological trauma (Curley & Moloney-Harmon, 2001). Decision making by nurses may also vary due to inherent differences in clinical assessment skills, knowledge and experience (Day, Farnell, Haynes, et al., 2002; Epstein & Hundert, 2002). A review of medical and nursing literature regarding competency in assessment skills identified a number of gaps in clinical practice (Day, Farnell, Haynes, et al., 2002; Epstein & Hundert, 2002; C. Evans, 2005). These included: poor proficiency of

assessment skills; errors in physical diagnosis and poor quality of nursing judgement especially in respiratory assessment (Day et al., 2001; C. Evans, 2005), supporting the need for a tool, such as the ESAT[®] to guide clinical judgement on when to perform ETT suction. Compounding these issues is the complexity of care within the PIC environment and inadequate knowledge of protocols and practices that directly impact the quality of patient care (Blackwood, 1999; Cousins & Power, 1999; Day, Farnell, Haynes, et al., 2002; Day et al., 2001; Jacobe et al., 2004; Lester & Tritter, 2001; Mangione & Nieman, 1997; McGlynn & Brook, 2003; Moore, 2003). Chlan, Tracy and Grossbach (2011) suggested that competence and intensive care skills for the ventilated patient require specific education strategies and support. This underlying premise informed the development and validation of the ESAT[®].

Decision tools have been shown to improve clinical judgement, practice and outcomes (Falzer & Garman, 2009; Thompson et al., 2013). The ESAT[®] is a tool which uses a systematic approach to assist the determination to perform ETT suction. Understanding how adults learn is essential to ensure effective nursing education and consistent usage of any tool. The integrated model of learning postulated by Malcolm Knowles (1975) confirms that adult learners differ in their learning process, as each has unique individual learning needs shaped by their experience and cultural exposure (Knowles, 1975). Use of clinical scenarios that incorporate these differences can improve the learning process by stimulating critical thinking, promoting discussion and expanding knowledge, thereby improving the decision process (Waxman, 2010). Therefore, part of the methodology to test the ESAT[®] involved scenario development to test criterion-related validity and reproducibility for both reliability and agreement.

The ESAT[®] provides a set of validated indicators that can be used by the inexperienced PIC nurse as a point of reference for assessment of the clinical status of the ventilated paediatric patient. To date, the ESAT[®] has undergone several phases of systematic development and psychometric testing: a) an integrative literature review to identify the published clinical indicators used by nurses within the PIC setting to determine when ETT suction is required (Davies et al., 2015b); b) an international exploratory survey of the perceived clinical indicators used by PIC nurses in the clinical setting to guide tool design (Davies et al., 2011); c) development of the ESAT[®]; d) a comprehensive clinical audit to link identified

clinical indicators with real life clinical practice in a PIC setting (Davies et al., 2015a) and d) content validity testing of the ESAT[®] (Davies et al., 2018a).

Content validity of the ESAT[®] was established using Lynn's (1986) process and is reported elsewhere (Davies et al., 2018a). Content validity refers to the degree to which the content of the ESAT, in this case items previously generated from qualitative and quantitative methods (Davies et al., 2011), reflects adequately the construct to be measured. This current article presents the next phases of psychometric testing for the ESAT[®], namely criterion-related construct validity and test-retest reliability. Criterion-related construct validity was deemed necessary to assess whether the ESAT[®] measured or correlated with the specific scientific construct that it purports to measure, in this case, initiation of ETT suction. Criterion-related validity based on a gold standard, if it exists, enables the examination of the extent to which a measurement instrument provides the same result as the gold standard, which in our study was the experts' opinions. Given the complexity of the clinical assessment of the PIC these criterion can be either independent indicators for ETT suction or co indicators (Davies et al., 2015b; Davies et al., 2011). Therefore, due to the unique nature of the tool, responses from IPCNs and EPICNs to the ETT suction scenarios should correlate with those of experts (Burns, 2000; Neuman, 2011). Criterion-related validity also includes the analysis of the internal structure of the test including the relationship between responses to different test items (Burns, 2000; Neuman, 2011). Test-retest reliability was undertaken to establish the stability of the tool's outcomes on repeated administration.

6.2 Methods

Design

Criterion-related construct validity was deemed the most appropriate form of construct validity testing for this type of instrument due to the tool containing multiple criterion (Neuman, 2011) and involved a two-stage process (Burns, 2000). In stage one the researchers collaborated with "experts" (PIC nursing and medical specialists) to develop a series of clinical scenarios representing typical diagnostic groups of ventilated patients where the ESAT[®] could be used to determine the requirement for ETT suction. The dependent variable was the scenario outcome and the independent variable was nurses' decision to either perform or not to perform ETT suction

(Neuman, 2011). In stage two comparisons were made between inexperienced paediatric intensive care nurses (IPICN) decisions regarding whether or not to perform ETT suction for each clinical scenario when using the ESAT[®] with the predetermined outcomes made by experts. For the same scenarios outcomes from experienced paediatric intensive care nurses' (EPICN) decisions regarding whether or not to perform ETT suction using the ESAT[®] were also compared with those of the experts. When using observational study methodology a tool is considered construct valid if there are no differences in scores between groups (Burns, 2000; Lynn, 1986; Sedgwick, 2012). For the purpose of this study IPICNs were classified as having ≤ 3 years PIC experience and EPICNs as those with > 3 years PIC experience. A three year cut-off time point was chosen as a demarcation between the IPICN and EPICN within the participating unit. Three years of professional experience has been demonstrated as an acceptable timeframe to define the transition from novice or advanced beginner (inexperienced) to competent (experienced) (Christensen & Hewitt-Taylor, 2006; Conkin et al., 2013; Reddish & Kaplan, 2007; Valdez, 2008).

Test-retest reliability was determined by comparing ETT suction decisions made for each clinical scenario by IPICNs and EPICNs at two time points, 4 weeks apart. At the first time point nurses were provided with a review of clinical respiratory assessment skills used for the ventilated paediatric patient, followed by instructions for use of the ESAT[®] when determining whether or not to perform the ETT suction. Nurses from both groups were then asked to read five scenarios and use the ESAT[®] to determine whether or not they would perform the procedure. Each participant recorded their decision as "yes" or "no". Four weeks later these nurses were given the same scenarios and asked to record their ETT decision. An effort was made to reduce/prevent nurses' recall of the previous scenarios by mixing the order of scenarios presented. Also five additional scenarios (not used for analysis purposes) were added to the mix (Polit, 2014).

Scenario Design

As there were no pre-existing published scenarios for the purpose of this study, 10 clinical scenarios were for use during criterion-related validity and reproducibility (test-retest) testing of the ESAT[®]. Scenarios were designed exclusively for this study to be used in conjunction with the ESAT[®] to determine

whether ETT suction should or shouldn't be performed. Scenarios were developed in collaboration with expert healthcare professionals working in Australian PICUs comprising: PIC Physician (n=1), PIC Clinical Nurse Educator (n=1) and PIC Clinical Nurse Expert (n=1). The PIC experts were chosen because of their PIC clinical nursing experience and expertise. Use of experts from the PIC area was in keeping with Neuman's (2011) recommendation that experts should be drawn from the area of data generation within the context of the research. As shown in the example presented in Figure 6.1, the scenarios incorporated descriptions of typical PIC patients and included clinical diagnoses, medical and surgical history, age, weight, ventilation parameters and routine clinical observations (C. Evans, 2005; Keller & Keck, 2006; Kneebone et al., 2005).

Scenario X		
Patient History		
6 month old male admitted 3 days ago, positive diagnosis of Respiratory Syncytial Virus Bronchiolitis. Respiratory and oxygenation deterioration on day 2 requiring intubation and ventilation. Patient has an arterial line, central venous line, 50% dextrose infusion, nasogastric feeds at 10ml/hour, indwelling catheter in situ and begins coughing.		
Clinical Observations		
Temperature: 36.8 °C		Colour: pale and mottled limbs to knee
Heart Rate: 175 beats per minute, Sinus Tachycardia (prior to coughing 158)		Capillary refill: < 2 seconds
Respiration Rate: Ventilated at rate of 30 breaths per minute		Chest sounds: Decreased air entry right side with crackles
Respiratory Effort: Tracheal tug noted with decreased chest movement right side		Secretions: Visible in the ETT
Arterial Blood Pressure mmHg: Systolic = 85 Diastolic = 42 Mean = 45		Weight: 6.5kg
SpO2: 85%		Conscious State: Sedated on morphine at 2ml/hr (1ml = 20mcg/kg/hr) and midazolam at 2ml/hr (1ml=50mcg/kg/hr) infusions.
Full Neurological Observation score: 9		PICU MAPS (Pain score): 6
ETT cuffed size 3.5 (good position on Chest X-ray)		Modified Motor Activity Assessment Scale (Sedation score): -2 (deeply sedated)
Last ETT suction performed 2hrs ago		
Current ABG Results:		Ventilation Mode:
Ph: 7.36	Na: 132	Volume control with MMV
PO2: 85	K: 3.5	FiO2: 0.5
PCO2: 42	Cl: 98	ETCO2 reading: 45mmHg
HCO: 25	Ca (Total): 2.0	Peak pressure: 27 mmHg
BE: -ve 3	Lactate: 1.0	PEEP: 5 mmHg
Glucose: 4.5	Hb: 85	Inspired Tidal volume: 65ml
		Expired tidal volume: 60 ml

Figure 6.1 Example of clinical scenario used for construct validity and test-retest reliability testing. Copyright Kylie Davies 2015.

Following development the 10 scenarios were then reviewed by nine “expert” nurses from PICUs in Australia (n=6), Canada (n=1), United Kingdom (n=1) and Switzerland (n=1). Australian PIC “experts” were recruited through the Australian College of Critical Care Nurses (ACCCN) at the 2014 ACCCN Institute of Continuing Education (ICE) conference. International experts were recruited through a PIC nursing network via email. Secondary opinion was obtained to ensure that representation of typical PIC clinical scenarios was achieved and to ensure clarity and accuracy around clinical descriptors contained within the ESAT[®].

Criterion-Related Construct Validity Testing

Scenario Sample Size

Following statistical advice, *a minimum of five* clinical scenarios were required to estimate a reliability of 85% (with an alpha of 5% and power of 80%) between subjects and within subject groups for the test-retest phase. As “expert” opinion can vary and consensus difficult to obtain, 10 scenarios was determined by the researchers as a reasonable number to design to account for these variables (Burgman et al., 2011).

“Expert” Inclusion and Exclusion Criteria

“Experts” were defined as senior clinical nurse educators or clinical development nurses, clinical nurse consultants or clinical nurse researchers with more than five years’ PIC experience and directly involved in the delivery of education to PIC nurses; thereby setting the “gold standard” for clinical practice in the decision process to perform ETT suction. Experts were excluded if they did not meet the above inclusion criteria and were working exclusively in an adult intensive or coronary care unit or a neonatal intensive care unit.

Scenario Review

Six Australian experts completed the review of the scenarios at the ICE conference, where the tool was clearly explained by the primary researcher (KD). The international experts were contacted via email and provided with a written descriptor of the tool. Based on use of the ESAT[®], each expert was asked whether they would perform ETT suction (representing the predictive outcome) for each scenario. The expert reviewers were also given the opportunity to comment on how the scenarios

could be improved for clarity and precision in reflecting actual clinical situations. Each scenario was presented on an individual page with a tick box to answer “yes” or “no” if ETT suction should be performed, followed by a comments section to provide feedback on how the scenario could be improved if considered necessary.

Scenario Data Analysis

Demographic information was transcribed into the IBM Statistical Package for Social Sciences (SPSS) (version 22) summarising frequencies and proportions (IBM, 2013).

SPSS was used to collate and analyse the results from the ‘expert reviewers’ for agreement and cross correlation for the scenarios (IBM, 2013).

A predetermined minimum 85% agreement by the “experts” (7.65 of the 9 agreed) was set by the researchers for the 10 scenarios (Burns, 2000).

Construct Validity Analysis

Demographic information was transcribed into SPSS and summarized as frequencies and proportions (IBM, 2013). Analysis of the ETT suction responses for the scenarios between all groups following the test-retest sessions was performed using chi-square statistical testing using Statistical Data (STATA) (second edition) (Scott Long & Freese, 2006). Cohen’s Kappa Coefficient calculations were used to ensure chance agreement was removed (Munro, 2001; Neuman, 2011). Biostatistical advice recommended to oversample by a minimum of 5-10% ($n = 1-2$) to account for potential dropouts. No statistical difference in responses between all groups would indicate the tool was construct valid. Subgroup analysis of levels of experience appeared to confirm that distinctive differences in experience and knowledge between the groups was not skewed.

6.3 Results

Demographic Variables

Experts who participated in scenario design were all aged over 30 years, had at least seven years PIC experience and had at least one graduate qualification each relevant to PIC. At the time of the criterion-related construct validity testing process there were 55 PIC nurses working a variety of full time equivalent (FTE) shifts from 0.25 to 1.0.

6.4 Scenario Design

Initial results for agreement from experts was mixed; a common issue known to occur between experts (Olson, Lynn, Thoyre, & Graffagnino, 2007). Three scenarios achieved 89% agreement (eight of nine experts agreed), three achieved 78% agreement (seven of the nine agreed), two achieved 67% (six of the nine agreed) and two achieved 56% agreement (five of the nine agreed). Refinement of the seven scenarios that achieved <80% agreement was undertaken based on expert reviewer feedback. These seven scenarios were then resubmitted to the nine experts of which six were available to respond for this review round. For the second round review 83% agreement was achieved for two of these seven scenarios (5 out of 6 agreement) with the other five achieving <70%. Advice was sought on whether the two scenarios achieving 83% could be included in the test-retest process from an international construct validity expert M. R. Lynn (personal communication, May 16, 2015). Lynn explained that agreement above 80% was acceptable and supported use of the two scenarios. The researchers agreed to include these two scenarios since variation in interpretation and individual bias would likely continue to affect agreement (Olson et al., 2007). The minimum requirement of five scenarios with predetermined outcomes was achieved ensuring they could be used in the test-retest sessions.

Criterion-Related Validity Testing (Construct)

There were no statistical differences for any of the five scenarios to perform ETT suction or not between the responses of IPICNs to the Expert panel. Chi Squared analysis determined Fishers Exact (c^2) results ranged from c^2 1.000 to 0.391 and $p=0.290$ - $p=0.640$ (Table 6.3).

Similarly, there were no statistical differences for any of the five scenarios to perform ETT suction or not between the responses of EPICNs to the Expert panel. Chi Squared analysis determined Fishers Exact (c^2) results ranged from c^2 1.000 to 0.340 and $p=0.258$ - $p=0.668$ (Table 6.3).

6.5 Test-retest

Setting

Test-retest of the ESAT[®] was conducted from August to November 2015 at a paediatric intensive care unit (PICU) in Western Australia. The 10-bed PICU is the sole level three PICU in this vast state and provides care for approximately 750 critically ill newborns, children and adolescents per year from all areas of the state. The clinical conditions of patients range from acute respiratory failure to post-operative cardiac surgery. Fifty five PIC nurses were employed in the PICU at the time of the study.

Sample

Advice from the study biostatistician (MB) indicated that to estimate reliability of 85% (with an alpha of 5% and power of 80%) between and within groups a total sample size of 20 PIC nurses using a minimum of five clinical scenarios providing reliability was required. In addition the recommendation was also made to oversample by a minimum of 5-10% (n = 1-2) to account for potential dropouts. A non-probability quota sampling technique was used to ensure a quasi-representative sample of PICU nursing staff who attended the test-retest sessions (Neuman, 2011). Two groups were formed; IPICNs with less than three years PIC experience and EPICNs with three or more years PIC experience. Table 6.1 shows the inclusion criteria and differences between groups based on skill level and clinical exposure within the PIC environment. The EPICN group was included to add trustworthiness to the outcomes for the scenarios as determined by experts and to test for variance between the groups in using the tool.

Table 6.1 Inclusion Criteria for Participation in the Test-Retest Sessions

Inexperienced Paediatric Intensive Care Nurses (IPICN)	Experienced Paediatric Intensive Care Nurses (EPICN)
< 3 years PIC experience	3 years or more PIC experience
Registered nurses	Registered nurses
Currently working within PIC	Currently working within PIC
Able to attend both test-retest sessions	Able to attend both test-retest sessions
Completed or completing PIC introductory program	Worked within PIC >3 years with or without post-graduate PIC course
Care exclusively for high dependency patients or patients with single organ dysfunction in PIC	Care exclusively for the patient with two or more organ dysfunction with complex needs

Exclusion criteria

- Inability to attend both test-retest sessions
- Not working within PIC over the testing period

Data Collection

Data collection was undertaken during test-retest sessions where PIC staff were presented with clinical scenarios and instructed to use the ESAT[®] and hypothetically determine whether or not to perform ETT suction.

6.6 Procedure

Test-retest Sessions

Test-retest was undertaken with PIC nursing staff to establish reliability over time (Burns, 2000; Neuman, 2011). All PIC nurses were invited to voluntarily participate through use of a poster display within the PIC unit to outline the study aim, participation requirements and a request for participation. Previous use of this process for research conducted in the PIC unit (Davies et al., 2011) found it effective in recruiting adequate numbers of nurses to participate in research. Both test-retest sessions was conducted by the primary researcher (KD) who is an experienced clinical nurse educator with extensive knowledge of PIC and led the development of the tool. Test-retest was conducted by the same researcher to prevent variability in the information provided and to standardise PIC nursing staff education on assessment and usage of the ESAT[®], enabling consistent interpretation of the criterion involved and agreement on the use of the tool (Burns, 2000).

Test sessions were conducted over a 12-week period during dedicated hourly education periods ensuring ease of participation, avoiding any negative impact on patient care and focused participation time. Retest sessions commenced 4 weeks after the last test sessions concluded. A 4-week retest period was chosen to mitigate potential changes in clinical experience with various patients' acuity, which may in turn have altered participants' responses and decisions by IPICNs (Burns, 2000; Polit, 2014).

Test-retest sessions were standardised with the initial test session including education to revise paediatric respiratory physiology and clinical assessment, use of the

ESAT[®] (Appendix B), a definition sheet (Appendix H) and instructions on how to complete the scenario sheets. Time was allocated for clarification of terminology and ESAT[®] use. Participants were instructed not to discuss their responses or scenarios until after the final retest session. Participants were isolated from each other when completing the packages and the primary researcher attended to ensure compliance.

To distinguish between groups, IPICNs (n=14) received a different coloured package than the EPICNs (n=12) for the first test session. These packages contained an overview of the aims of the research and the participant's rights and requirements, demographic questions (n= 5), the ESAT[®] (Appendix B) with definition sheet (Appendix H) and the five scenarios. Following the education session, the participants were then asked, based on the ESAT[®], to review the scenarios and to indicate if they would or wouldn't perform ETT suction. Participants could give feedback on the ESAT[®] design and content.

Participants were required to return all documentation at the end of the session to the primary researcher, with the exception of the participation information sheet which was to be kept for their personal record. At this point they were thanked and reminded of their commitment to be available in a month's time for the retest and to not discuss the scenarios or their responses.

The retest process was standardised and included no education. Study packages were identical to the first test packages, and contained an overview of the study aims, the participants rights and requirements, the ESAT[®] (Appendix B) with definition sheet (Appendix H). The exception was that the five previously used scenarios were randomly mixed with an additional five scenarios that had not met the gold standard of agreement from the experts. IPICNs again received different coloured packages to the EPICNs to differentiate between groups. These were to ensure consistency in the clinical scenarios provided and minimise the influence on the participant's responses from having completed the initial test sessions. Participants were again isolated from each other, reminded not to discuss the tool, scenarios or responses until the packages were completed and were then asked to return the packages to the primary researcher when completed. The primary researcher attended sessions to ensure compliance. Retest sessions were conducted between October and November 2015 with the same test group participants and included IPICNs (n=14) and EPICNs (n=12).

Ethics

Ethical approval to undertake the study was obtained from the Human Research Ethics Committee (HREC) of the University of Notre Dame Australia (UNDA) in October 2011(011072F). Approval was also obtained from the Governance Evidence Knowledge Outcomes Committee through the study setting's HREC. To ensure confidentiality, all data was entered into a password-protected electronic database, staff were assigned a sequential numerical code with their initials and level of expertise as the primary notation at the initial test and the same numerical coding used for the retest. Voluntary attendance at the test-retest venue implied consent.

Data Analysis

Demographic information was transcribed into SPSS and summarized as frequencies and proportions (IBM, 2013). The analysis of the scenario results from the test-retest sessions involved chi-square statistical testing using Statistical Data (STATA) (second edition) (Scott Long & Freese, 2006). Cohen's Kappa Coefficient calculations was used to ensure chance agreement was removed (Munro, 2001; Neuman, 2011). Oversampling by a minimum of 5-10% (n = 1-2) would account for potential dropouts. Test-retest results from both groups and sessions were compared with the expert nurses' responses. If the ESAT[®] was reliable there would be no statistical differences between the responses from the two groups and the expert nurses over the two time points. This would confirm reliability of the ESAT[®] to precisely measure the same requirement to perform ETT suction or not under varying conditions over time (Devitt et al., 1998).

6.7 Test-Retest Reliability Results

Demographic Variables

As previously stated, 55 PIC nurses were working within the PIC at the time of testing. Of these 31 were designated IPICNs and 24 were designated EPICNs. Twenty six PIC nurses agreed to participate; 14/31 (45%) were IPICNs and 12/24 (50%) were EPICNs. Of the 14 IPICN nurses, defined as caring for high dependency patients or patients with single organ dysfunction in PIC, all were aged below 30 years and had less than 3 years' experience in PIC, with one having a paediatric graduate diploma (Table 6.2). Of these IPICNs, 12 had completed a Bachelor of

Nursing qualification in Australia while two qualified in Ireland. EPICNs, defined as those caring for patients with two or more organ dysfunction with complex needs, all but two of these participants had greater than five years' experience in PIC, eight had a PIC graduate qualifications and only three were less than 30 years of age (Table 6.2). Of these EPICNs all but one nurse completed their initial training in Australia with the exception completing training in New Zealand.

Table 6.2 Demographic Characteristics of all Participants (N=26) according to Level of Experience

Inexperienced Paediatric Intensive Care Nurse N=14		Experienced Paediatric Intensive Care Nurse N=12	
	n (%)		n (%)
Age		Age	
IPICN <30	14 (100)	EPICN <30	2 (17)
		EPICN >30	10 (83)
Gender		Gender	
Female Level 1-2	14 (100)	Female Level 3-4	10 (83)
		Male Level 3-4	2 (17)
Graduate Qualifications Test-Retest Participants		Graduate Qualifications Test-Retest Participants	
Bachelor of Nursing	14 (100)	Bachelor of Nursing	12 (100)
Paediatric Graduate Diploma	3 (21)	PIC Graduate Certificate	7 (58)
		PIC Graduate Diploma	1 (8)
Paediatric Intensive Care Years		Paediatric Intensive Care Years	
1-2	14 (100)	3-5	2 (17)
		>5	10 (83)

Reliability

For the test-retest phase with IPICNs, the Chi Squared test with Fisher's Exact *p*-value was used. The χ^2 results ranged from 1.0 to 0.34 and *p*-values ranged from 0.208 to 0.668 (Table 6.3). There were no statistical differences in decisions to perform ETT suction or not between IPICNs and the expert panel for any of the five scenarios.

For the test-retest session with EPICNs, Chi Squared test with Fisher's Exact *p*-value was used. The χ^2 results ranged from 1.0 to 0.338 and *p*-values ranged from 0.258 to 0.686 (Table 6.3).

Similarly, there were no statistical differences in decisions to perform ETT suction or not between EPICNs and the Expert panel for any of the five scenarios.

Table 6.3 IPICNs and EPICNs versus Expert Opinion to Perform or Not ETT Suction with Chi Square Testing

Scenario	IPICN <i>n</i> = 14		EPICN <i>n</i> = 12		Experts % Agreement <i>n</i> = 9	χ^2 IPICN/Expert		χ^2 EPICN/Expert	
	Test	Retest	Test	Retest	Test	Test	Retest	Test	Retest
1	13*	14*	12*	12*	8* (89%)	1.000 <i>p</i> =0.640	0.391 <i>p</i> =0.391	0.429 <i>p</i> =0.429	0.429 <i>p</i> =0.429
2	10*	9*	8*	8*	7* (78%) 83% (5 of 6 experts)	0.611 <i>p</i> =0.327	0.340 <i>p</i> =0.208	0.338 <i>p</i> =0.258	0.338 <i>p</i> =0.258
3	8*	10*	10*	10*	7* (78%) 83% (5 of 6 experts)	0.400 <i>p</i> =0.290	1.000 <i>p</i> =0.565	1.000 <i>p</i> =0.586	1.000 <i>p</i> =0.586
4	13#	12#	10#	10#	8# (89%)	1.000 <i>p</i> =0.640	1.000 <i>p</i> =0.668	1.000 <i>p</i> =0.612	1.000 <i>p</i> =0.612
5	14#	14#	12#	11#	8# (89%)	0.391 <i>p</i> =0.391	0.391 <i>p</i> =0.391	0.429 <i>p</i> =0.429	1.000 <i>p</i> =0.686

* = Yes to ETT suction; # = No to ETT Suction

6.8 Discussion

Results from this study represent the final stage of the ESAT[®] validation process; criterion-related validity testing (construct) and test-retest reliability over time, building on previous reliability and validity work by the researchers (Davies et al., 2018a; Davies et al., 2015a, 2015b; Davies et al., 2011). To the best of the researchers' knowledge, this is the first study that tested a newly developed decision tool, the ESAT[®] to enable PIC nurses' independent critical thinking and to support decisions making for changes in therapy related to the changing clinical condition of the patient. The ESAT[®] also provides a tool to apply evidence based care decisions to improve outcomes for critical care patients (Bannigan & Moores, 2009; C. Evans, 2005).

The methodology which used observational testing with predetermined scenarios to determine cause and effect is considered sound and enabled direct comparison with expert opinion (Burns, 2000; Neuman, 2011). The ESAT[®]'s success as a clinically appropriate tool was confirmed by our study findings. These results showed no statistical difference between inexperienced, experienced and expert groups responses in determining if ETT suction was required for both test-retest session scenarios (Table 6.3). Study results demonstrated sound test-retest reliability and criterion-related validity of the ESAT[®] tool when used by experts, by inexperienced and experienced PIC nurses.

There were a number of strengths in the research methodology presented. These included: the ESAT[®] having established content validity prior to use in the test-retest reliability sessions (Davies et al., 2018a), appropriate qualification of the experts confirming the predictive outcomes of the scenarios used, and following test-retest principles to establish agreement and reliability over time (Burns, 2000).

Using the same researcher to conduct both test-retest sessions provided a consistent process in explaining the use of the ESAT[®] mitigating potential bias or confusion over how to use the tool (Neuman, 2011). Separation of participants prevented contamination and ensured answers were unique to each participant.

There were no drop outs for either of the test-retest sessions with a total of 26 nurses participating in both test-retest sessions. This exceeded the required total sample size of 20 PIC nurses providing reliability between subjects and within subject groups

of 85% (with an alpha of 5% and power of 80%) for the Cohen's Kappa Coefficient calculations thus ensuring chance agreement was removed as a consideration.

The researchers acknowledge some limitations. In round one three of the five scenarios used as gold standard scenarios had clear agreement ($\geq 85\%$) for the predetermined answer on whether to perform ETT suction or not. Two scenarios were modified in accordance with recommendations from experts and reviewed in a subsequent review round, achieving 83% agreement. Whilst these two scenarios did not meet the predetermined $\geq 85\%$ advice from MR Lynn (International expert on instrument development and testing) $\geq 80\%$ agreement is considered sufficient. These results may reflect that some experts received face-to-face education and instruction regarding the scenario review phase while others received this information via email instruction.

There may also have been some influence of the experienced nurse on the inexperienced nurses' clinical education in the work place resulting in an inherent bias towards the outcome of the scenarios irrespective of the tool. Though nurses were requested not to discuss the scenarios until after the test-retest phases, the researchers cannot guarantee this did not occur, thus responses for the retest sessions may have been affected. Further research is recommended over multiple sites to assess the reproducibility of the results.

6.9 Conclusion

This article represents the final stage in the psychometric testing of the ESAT[®] tool to guide clinical practice for determining whether ETT suction is warranted in the sick ventilated PICU patient. The tool can be used to enhance clinical practice and reduce the chance of inappropriate nursing actions that may lead to poorer patient outcomes. The research presented reinforces current practices identified from previous research and improves understanding of appropriate clinical assessment for patients with an ETT in situ. The research provides a tool to support decision making for the inexperienced nurse in to guide the clinical practice of endotracheal suction within the PICU environment.

The researchers propose the clinical application and further testing of the ESAT[®] across a range of PIC settings. Consideration could also be given to application and testing the tool in the adult intensive care setting.

Relevance to Clinical Practice

The final validity and reliability testing of the ESAT[®] provides the first validated clinical tool to guide nursing practice within the PIC on ETT suction. The tool provides a systematic approach to assess intubated patients and guide inexperienced nurses in determining whether ETT suction is required. Evidence-based decision tools can enhance practice and improve patients' outcomes. Clear definition of the tools criteria and the tools format will guide education to improve nursing knowledge and practice.

The article presented the details of the criterion-related (construct) validity and test-retest (stability) reliability testing of the Endotracheal Suction Assessment Tool[®] (ESAT[®]) used for phases four and five of this study. The article included the methodology behind the process, scenario design, the research results, relevance to clinical practice and what future research could be applicable to extend the application of the instrument across a variety of clinical settings and patient cohorts.

The following chapter (Chapter Seven) summarises the psychometric testing processes and findings of the study, compares the conceptual framework with the empirical evidence, followed by presentation of the limitations and strengths of the study, application of the ESAT[®] to clinical practice and a summary of the chapter.

Chapter Seven

Discussion

Endotracheal tube (ETT) suction is an integral part of airway management for the intubated and ventilated patient within the paediatric intensive care (PIC) unit. This unavoidable procedure is largely performed by nurses (Hazinski, 2013) to maintain airway patency of ventilated children. Unfortunately, there are many associated inherent risks to the procedure such as microatelectasis and hypoxaemia (Curley & Moloney-Harmon, 2001; Hazinski, 2013; Tume et al., 2017). It is therefore crucial that where possible, risks are minimised by making appropriate decisions about whether the ETT suction procedure is warranted. Prior to commencement of this research there was no instrument available to guide clinical nursing decisions and practice in determining the need for appropriate ETT suction.

This study is, to the best of the researcher's knowledge, the first to address this clinical issue through use of a validated Endotracheal Suction Assessment Tool[®] (ESAT[®]). Validation is an important step in ensuring an instrument is measuring what it purports to in a consistent and effective manner, to optimise patient care and outcomes through appropriate evaluation (Feder, Eccles, Grol, Griffiths, & Grimshaw, 1999; Reddy et al., 2015). Though instrument validation is an ongoing process, garnering and updating evidence as it evolves is an essential process to ensure current evidence-based practice is accurate and fit for purpose (Souza et al., 2017). This study has used sound psychometric research principles to ensure content validity and the scale level content validity index, criterion-related (construct) validity and test-retest (stability) reliability of the ESAT[®] as part of the ongoing validation process of the instrument.

The conceptual framework used to guide this mixed methods multi-phase research used both quantitative and qualitative methodologies (Creswell, 2015; Schoonenboom & Johnson, 2017; Souza et al., 2017; Teddlie & Tashakkori, 2012). The four psychometric principles, as stated above, are well established and represented a credible process (Aamodt, 1983; Imle & Atwood, 1988; Lynn, 1986). Choosing the appropriate validation testing processes for the ESAT[®] initially presented a challenge since the ESAT[®] is an instrument to guide the decision process

of the inexperienced nurse and is more aligned to a decision making algorithm than a numerical scoring tool (R. Collins, 2017; Duzkaya & Kuguoglu, 2015; Rathbun & Ruth-Sahd, 2009). The complexity of the paediatric intensive care (PIC) environment in which the ESAT[®] is used, and the clinical indicators used by nurses to determine nursing actions, have been previously discussed in two of the presented articles for this thesis: “Clinical indicators for the initiation of endotracheal tube suction in children: An integrated review” (Davies et al., 2015b) and “Audit of endotracheal tube suction in a paediatric intensive care unit” (Davies et al., 2015a).

The design of the ESAT[®] was based on a structured four-phase study undertaken as the researcher’s Master of Nursing (research) thesis (Davies, 2009). The study used both quantitative and qualitative methodological approaches for instrument development and initial testing (Aamodt, 1983; Imle & Atwood, 1988; Lynn, 1986) the findings of which were presented in the publication: “Determining standard criteria for endotracheal suctioning in the paediatric intensive care patient: An exploratory study” (Davies et al., 2011). The results of this early research established the clinical indicators used to determine the requirement for ETT suction and a sound rationale for the design of the ESAT[®].

In this study, the first article entitled “Clinical indicators for the initiation of endotracheal tube suction in children: An integrated review” (Davies et al., 2015b) reviewed the literature surrounding the decision processes and clinical indicators (criteria) used by paediatric nurses to perform ETT suction. This review revealed a paucity of high quality evidence describing the clinical indicators (criteria) which should be used when assessing the need for ETT suction. The review also confirmed a general consensus that ETT suction should only be performed when clinically warranted. This was followed by an updated review of literature published between the years 2012-2018. This additional review also failed to identify any additional clinical indicators currently used when assessing the need for ETT suction. These two reviews of the published literature confirmed the appropriateness of the current content of the ESAT[®]. However, it is acknowledged that future research in this area may emerge and potentially lead to future modification of the ESAT[®].

The second article presented in this PhD entitled “Audit of endotracheal tube suction in a paediatric intensive care unit” (Davies et al., 2015a) was considered the

“key” to establishing the direct link between clinical indicators used in current clinical nursing practice and the criteria listed within the ESAT[®]. Of note, all criteria (clinical indicators) listed within the ESAT[®] were also identified within the audited patient medical records (n=292) and confirmed as justification by nurses to perform the ETT suction procedure in the sole tertiary paediatric intensive care unit in Western Australia. There was a median number of 2 (interquartile range 1-6) documented respiratory and ventilator status criteria per ETT suction event which matched criteria within the ESAT[®]. Another key finding was the identification of a previously unidentified clinical indicator “preparation for extubation”. After due consideration, this clinical indicator was added to the “Clinical Considerations” section of the ESAT[®] in recognition that inexperienced paediatric intensive care nurses (IPICNs) do provide care for patients who are being prepared for extubation. This further established the clinical utility of the ESAT[®] in assisting the IPICN care for patients they will typically be required to provide care (Aitken & Marshall, 2015).

Findings from the audit also suggested that IPICNs required further training and guidance in the care of the more complex patient and that skill acquisition should be targeted to this area of care (Birks, Cant, James, Chung, & Davis, 2012). This phase of the study demonstrated that instrument design and validation is an ongoing process. Further, the ESAT[®] can be considered an integral contribution to nursing knowledge surrounding ETT suction with regard to decision making processes and the delivery of appropriate patient care by the IPCN.

Article three was titled “Content validity testing of the ESAT[®]: A decision aid tool for performing endotracheal suction in children” (Davies et al., 2018a). Lynn’s (1986) process for calculating content validity and scale content validity index was the guiding research methodology. Nine paediatric nursing experts were used representing a mix of PIC nursing experience and expertise ranging from Clinical Nurse Consultants and Clinical Educators to PIC Research Fellows. The experts were drawn from PIC units in Australia (n=6), the United Kingdom (n=1), Switzerland (n=1) and Canada (n=1). This phase of the study established the content validity index of the ESAT[®] using a minimum preset a-priori criterion agreement of 0.78 and a scale content validity index of 0.8. Measurement of the scale content validity index was undertaken to enhance the interpretability of the content validity data (Lynn, 1986; Polit & Beck, 2006). All 15 items within the ESAT[®] achieved the preset a-priori

agreement for apparent internal consistency (Davies et al., 2018a). Minor adjustments were required to improve the clarity of descriptive terminology for four items with one item requiring contextual modification from “Current artificial ventilation” to “Current mode of ventilation”. The content validity index ranged from 0.8-1.0 and scale content validity index ranged from 0.9-1.0 for all items justifying the inclusion within the instrument of these criteria and establishing the content validity and scale level content validity index of the ESAT[®] (Davies et al., 2018a). Therefore, the only adjustment required for the ESAT[®] at this time was to improve the clarity of the “Definition of the ESAT[®] criteria”. Use of Lynn’s (1986) process for content validity testing added credibility to the research presented in article three. Choosing experts from the environment for which the instrument was designed provided further credibility to the process (De Von et al., 2007; Schoonenboom & Johnson, 2017; Souza et al., 2017). Finally, in this phase nine experts rather than the recommended minimum number of six experts was used to establish content validity beyond the >0.05 level of significance (Lynn, 1986).

The final article presented was entitled “Reliability and criterion-related validity testing (construct) of the endotracheal suction assessment tool (ESAT[®])” (Davies et al., 2018b). Observational testing was used to measure criterion-related (construct) validity and to determine whether the ESAT[®] could guide IPICNs decision making regarding ETT suction (Lynn, 1986; Sedgwick, 2012). If the ESAT[®] was indeed a valid instrument there should be no difference between the predictive ETT suction outcomes for scenarios designed by the experts and the IPICNs. Test-retest (stability) reliability of the ESAT[®] was performed at two time points; T1 and T2 (4 weeks apart) (Polit, 2014). The researchers, together with PIC nurse experts, developed and tested 10 hypothetical clinical scenarios with predetermined ETT suction outcomes. Experienced PIC nurses (EPICNs) (n=12) and IPICNs (n=14) were then presented with the scenarios and used the ESAT[®] to guide their decision-making about whether to perform ETT suction or not for each scenario. EPICNs were included to enable subgroup analysis by level of experience to confirm that any potential and distinctive differences in experience and knowledge between the groups was not skewed. Outcomes were then compared with those predetermined by the experts (n=9). As no statistical differences were observed between ETT suction decisions for these

scenarios between experts, IPICNs or EPICNs the criterion-related (construct) validity of the ESAT[®] was confirmed (Davies et al., 2018b).

The methodology chosen to guide criterion-related (construct) validity and test-retest reliability testing of the ESAT[®] as detailed in the fourth article was carefully constructed and followed principles recommended by Lynn (1986), with further exploration and execution of the validation process as identified by Souza et al. (2017), Creswell (2015) and McGoey et al. (2010). Use of sound psychometric principles supports not only the process but the outcomes identified from the five-phased mixed methods research presented.

The researcher was cognisant of the potential pitfalls associated with undertaking a multi-phase mixed methods study (Bazeley, 2009; Creswell, 2015; Eisenlohr, 2013; Pallant, 2013). Such problems can include ensuring sufficient participants, avoiding bias, skewed data, sampling and data collection errors, choosing appropriate scales and measures and choosing the correct statistical analysis (Padilla & Benitez, 2014; Pallant, 2013; Polit & Hungler, 2013). To avoid these pitfalls statistical advice and support was provided by an experienced and highly regarded biostatistician (M. Bulsara, personal communication, August 16, 2011). Sample sizes and data analysis plans were established during the proposal development phase, where appropriate, and assessed by independent readers before candidacy was confirmed. A sample size of 20 PIC nurses was required for the test-retest reliability phase to ensure a reliability between subjects and within subject groups of 85% (with an alpha of 5% and power of 80%) for the Cohen's Kappa Coefficient calculations. This ensured that chance agreement was an unlikely consideration. Clearly defining the required sampling numbers prior to study commencement ensured adequate sampling was achieved.

Australian National, Safety and Quality Health Service Standards (NSQHS) (2015) suggested that clinical care standards which are systematic and promote excellence in care should be established to improve patient care (Australian Council on Healthcare Standards, 2015). Use of clinical standards that reflect contemporary critical care nursing should appropriately identify the scope of a clinical guideline, including key elements for inclusion and identification of the target group (Gill et al., 2017). The format of this research provided a clear rationale for why the ESAT[®], a

peer reviewed and validated instrument, should be incorporated into clinical guidelines or protocols related to ETT suction within the PIC. Therefore, it is proposed by the researcher that NSQHS requirements have been met in development of the ESAT[®] which reflects current clinical indicators used to determine ETT suction requirement.

Some would argue that having quality evidence-based validated instruments, protocols or guidelines does not necessarily translate into quality care at the bedside (Craske, Carter, Jarman, & Tume, 2017; Douglas et al., 2014; Flodgren et al., 2016). Simply because an instrument or guideline exists does not necessarily mean it is read or implemented appropriately (Jakimowicz & Perry, 2015; Negroa et al., 2014; Shanbhag et al., 2018). Monitoring the effectiveness and application of a validated instrument should form part of the ongoing quality assessment as set out in the NQHS (2015) standards. Having a quality improvement program around the care of the intubated and ventilated patient meets NQHS (2015) national standards and complies with the Australian national accreditation process (Australian Council on Healthcare Standards, 2015). Mitigating the adverse events associated with ETT suction by having quality validated instruments with skilled nurses will help maintain patient safety while potentially improving patient care and outcomes.

7.1 Limitations

The researcher acknowledges four limitations of this study. First, during the clinical audit phase, when investigating a large volume of patient notes over an extended period, only 1-2 criteria (80%) were documented per ETT suction event. It is well established that nursing documentation can be haphazard and is often incomplete (Akhu-Zaheya, Al-Maaitah, & Bany Hani, 2018; Austin, 2011). There is a strong likelihood this could well have affected the completeness of records reviewed during the audit process and therefore the number of criteria identified per ETT suction event (Akhu-Zaheya et al., 2018; Wang et al., 2011). Another potential explanation for this finding may have been the level of experience and knowledge of individual PIC nurses, where less experienced PIC nurses may have been responsible for documentation. While the previously unidentified clinical consideration “preparation for extubation” was revealed during the audit process, there may be other potential criteria yet to be recognised due to poor or incomplete nursing documentation.

The second limitation relates to round one of the test-retest process, where three of the five scenarios demonstrated a high level of agreement ($\geq 85\%$) for the predetermined responses to whether or not to perform ETT suction. It was necessary to modify two scenarios in accordance with recommendations from experts and when reviewed in a subsequent review round these scenarios achieved an acceptable level of 83% agreement. The researcher was advised by her supervisors to contact MR Lynn for expert advice regarding the level of agreement. Whilst the two scenarios did not initially meet the predetermined agreement of $\geq 85\%$, advice from MR Lynn (personal communication, May 21, 2015) indicated that agreement of $\geq 80\%$ agreement is acceptable since obtaining agreement from a group of nursing experts can sometimes be a difficult proposition. This advice was in concurrence with other relevant research studies (Hutchinson, 2003; Kosov et al., 2016; Olson et al., 2007; van der Salm, de Haan, Cath, van Rootselaar, & Tijssen, 2013). It is also possible the results may reflect the fact that some experts received face-to-face education and instruction regarding the scenario review phase, while for practical reasons others received the information via email.

The third issue concerned testing for criterion-related (construct) validity and test retest (stability) reliability of the ESAT[®]. It is possible there may have been some influence of the EPICNs on the IPICN's clinical assessment techniques through education provided in the study setting. This may have led to an inherent bias towards the outcome of the scenarios between these two groups of participants irrespective of the study-related participant information and education provided by the researcher regarding clinical assessment and/or use of the instrument. The researcher did attempt to mitigate this possibility by requesting that study participants refrain from discussing the scenarios until after the test-retest phase was completed. Participants may have also been influenced by the recollection of their previous responses to scenarios during the testing for criterion-related (construct) validity and test retest (stability) reliability of the ESAT[®]. As previously discussed, the researcher was aware of this possibility and purposefully added five "dummy" scenarios (not included in the analysis) that were randomly mixed with the original five scenarios. The intent of this action was to reduce nurses' recall of their previous scenario responses during the initial testing phase to mitigate sampling errors (Burns, 2000; Polit, 2014).

7.2 Strengths

The study limitations were balanced by several strengths. The ESAT[®] has undergone a systematic approach with regard to development and content validity testing. The study incorporated previous empirical evidence from a large panel of Australian and New Zealand experienced PIC nurses' regarding the *importance* of each ESAT[®] item (Davies et al., 2011) as well as an extensive and comprehensive clinical audit of nursing documentation from the clinical PIC setting for which the instrument was designed that established the clinical relevance of each ESAT[®] item (Davies et al., 2015a). Inclusion of an independent checking process of the audit data moderated potential inherent errors such as data entry errors during the auditing process conducted by the researcher. The independent review showed the checked data was accurate with no missing data. Use of the PIC nurse-centred approach to data collection supports the clinical relevance of this research work.

A number of methodological strengths are noted for content validity index (CVI) and scale content validity index (S-CVI) testing of the ESAT[®]. The study used Lynn's (1986) well established and highly regarded methodology to establish these content validity indexes which are considered empirically sound and widely used for early content validity testing of instruments by health researchers (Hester & Davis, 2013; Streiner & Kottner, 2014; Streiner & Norman, 2005). The ESAT[®] demonstrated high CVI and S-CVI scores using Lynn's content validity process (Lynn, 1986). Polit, Beck & Owen (2007) would argue that I-CVIs used to demonstrate inter-rater agreement may be influenced by chance. Lynn (1986) however counter argues that chance agreement is avoided by achieving an I-CVI agreement of 1.0 when using five or less expert reviewers, and 0.78 – 0.80 when using six to 10 experts. This issue was addressed in this research by using nine, rather than a minimum number of six experts to review the ESAT[®]. Moreover, these experts were carefully selected using well defined criteria recommended by Grant and Davis (1997) and were drawn from the context within which the original data was generated (Imle & Atwood, 1988). The range of qualifications and clinical experience of experts with respect to PIC nursing provided a diverse and clinically insightful review of the ESAT[®].

There were also a number of strengths in the research methodology to test criterion-related (construct) validity and test retest (stability) reliability of the ESAT[®]. First, establishing content validity of the ESAT[®] prior to use of the instrument in the test-retest reliability sessions (Davies et al., 2018a). Second, using appropriately qualified PIC experts to both design and confirm the predictive outcomes of the scenarios used enabled direct comparison with IPICNs and EPICNs outcomes. Third, test-retest principles were followed to establish agreement and reliability over time (Burns, 2000; Souza et al., 2017). These included using the same researcher to conduct both test-retest sessions, providing a consistent process in explaining the use of the ESAT[®] and mitigating potential bias or confusion over how to use the instrument (Neuman, 2011). Participants were isolated from each other by separate desk allocation to ensure contact between participants did not occur. This prevented contamination during T1 and T2 phases and ensured answers were unique to each participant during the testing process. Finally, there were no drop outs for either of the test-retest sessions with the same 26 nurses participating in both test-retest sessions. This exceeded the required total sample size of 20 PIC nurses providing reliability between subjects and within subject groups of 85% (with an alpha of 5% and power of 80%) for the Cohen's Kappa Coefficient calculations thus ensuring chance agreement was removed as a consideration (Davies et al., 2018b).

7.3 Implications for Nursing Practice

Four areas of nursing care are potentially affected through the enhancement of nursing assessment skills and knowledge through use of a validated instrument to guide ETT airway management such as the ESAT[®] (Australian Council on Healthcare Standards, 2015; Gill et al., 2017; Ramelet, 2006). These are explained in detail below.

Improving Nursing Respiratory Assessment and Care of the Artificial Airway

Respiratory assessment is key to ensuring use of appropriate nursing care that is tailored to the needs of the individual patient (Chlan et al., 2011; Cornock, 2011; Hazinski, 2013). The Australian College of Critical Care Nurses' standards recommend that bedside nurses in critical care must maintain their "knowledge and skillsat an appropriate level to ensure high quality care for a complex mix of

critically ill patients” (Australian College of Critical Care Nurses, 2016). Unfortunately, research has identified bedside nursing skill deficits in the areas of airway assessment, quality judgement and appropriate physical diagnosis (Cornock, 2011; Day, Farnell, Haynes, et al., 2002; Douglas et al., 2014; Thompson et al., 2013; Zambas, 2010). These deficits may be compounded by time constraints within the clinical setting that may negatively impact on completion of detailed respiratory assessments and compliance with practice standards within the clinical setting (Zambas, 2010). The simplicity and brevity of the ESAT[®] should promote comprehensive and accurate assessment by the IPICN regarding the need for ETT suction. Use of a standardised evidence-based instrument to guide the ETT suction procedure will potentially assist the clinical judgement of the IPCN when providing tailored respiratory care for the ventilated PIC patient. Further, it is anticipated that use of the ESAT[®] will assist in ensuring appropriate action is provided in a timely fashion with the aim to continue to improve patient care and outcomes.

Standardising Endotracheal Tube Suction Practice

As stated previously the evidence-based ESAT[®] will potentially assist PIC nurses to meet the 2015 NSQHS standards (Australian Council on Healthcare Standards, 2015) that stipulate clinical care should be timely, appropriate, evidence-based and be provided with reduced unwarranted variations. Once the ESAT[®] has been validated in the clinical setting it is anticipated the instrument will be used to standardise care and minimise care variations, yet still allow flexibility in meeting individual needs of the patient. Section 8.4 of the NSQHS (2015) highlights that recognition and responding to clinical deterioration is key to provision of timely, appropriate and quality care. The ESAT[®] provides clinical guidance in this respect by identifying the key criteria for assessment for ETT suction.

Professional Education

Education of IPICNs in the usage of the validated ESAT[®] is essential to improve clinical decision making and judgement (Thompson et al., 2013). Feinstein’s (1983) exploration of the principles of clinimetrics attests to the requirement of an instrument that is both clinically relevant and simplistic in design. Flexibility in the delivery of education for the adult learner is required to ensure distribution, assimilation and usage of the ESAT[®] (Knowles, 1975, 1985). The validated ESAT[®]

will potentially provide nurse educators with a clinically relevant tool to guide education and skill development in the IPCN.

Audit

Accountability and transparency in paediatric healthcare is paramount to promoting confidence of quality care for both patients and parents alike (Kurtzman, 2010). The revised Australian Practice Standards for Specialist Critical Care Nurses (2017) provide the benchmark to evaluate both the effectiveness and competency of implementation of the ESAT[®] (Gill et al., 2017). These 15 practice standards were developed by an expert panel of critical care nurses in Australia and have relevance to current clinical practice. Linking the 15 practice standards within the four domains of professional practice, provision and coordination of care, critical thinking and analysis individual, and collaboration and leadership will enable assessment of an individual's clinical performance. Targeted education and constructive review based on these standards will improve the individuals practice and patient care incorporating the principles of adult learning as espoused by both Feinstein (1983) and Knowles (1985). The practice standards applicable to the delivery of appropriate care surrounding ETT suction by the PIC nurse are:

- Functions within professional and legal parameters of critical care nursing practice
- Demonstrates accountability for nursing practice
- Demonstrates and contributes to ethical decision making
- Provides patient and family centred care
- Promotes optimal comfort, well-being and safety in a highly technological environment that is often unfamiliar to patients and families
- Manages and coordinates the care of a variety of patients
- Manages therapeutic interventions
- Applies integrated patient assessment and interpretive skills to achieve optimal patient outcomes
- Develops and manages a plan of care to achieve desired outcomes
- Evaluates and responds effectively to changing situations
- Engages in and contributes to evidence-based critical care nursing practice
- Acts to enhance the professional development of self and others

The ongoing knowledge and attitude of nurses to the ESAT[®] could potentially be assessed using the Endotracheal Suction Questionnaire (ESQ) that was validated during the original design phase of the ESAT[®] (Davies, 2009).

7.4 Future Directions

Quality Improvement in Endotracheal Tube Care Practice

There is a need for structured and systematic strategies to ascertain the effectiveness of the implementation of the ESAT[®] into the clinical setting (Allen, 2016). Such processes could include clinical audits of bedside nursing care, workshops focused on care of the intubated and ventilated patient, interviewing clinical facilitators regarding the implication, compliance and effectiveness of the ESAT[®], auditing of patients notes and feedback from both patients (when applicable) and parents (Allen, 2016; Bannigan & Moores, 2009; De Pedro-Gomez et al., 2011).

Development and Implementation of Evidence-Based Guidelines for Endotracheal Tube Care

Implementation of any instrument without using standardised protocols and guidelines to ensure care is directive and encapsulates the needs of the individual patient could lead to ineffective or inaccurate usage (Australian College of Critical Care Nurses, 2016; Feder et al., 1999). Improved documentation and justifiable nursing actions improve accountability and provision for an open dialogue between the nurse and the patient or primary carer (Austin, 2011). Introducing supporting guidelines and protocols for the validated ESAT[®] would potentially facilitate critical thinking and reflective practice (Bannigan & Moores, 2009).

Implications for Future Research

This research has been conducted in the context of the PIC population. Whilst not directly transferable to neonatal or adult intensive care settings, further research of this instrument within these environments is recommended. The researchers acknowledge the difference between an instrument being theoretically useful, versus being clinically useful, and in diverse PIC populations. Further, how well the instrument translates into other languages and clinical environments is not known and also requires further research. A more tangible test for the ESAT[®] will be its

integration into the clinical setting when used at the bedside by the inexperienced practitioner caring for the intubated and ventilated patient in PIC.

As technology evolves and improves the need may arise for additional criterion to be added to the ESAT[®]. For example, respiratory functional capacity dynamic measurements may evolve over time, flow-pressure graphics or nano technology that give real time feedback at a cellular level to direct care may also potentially impact on the criteria being utilised to assess the need for ETT suction. Further research may also unearth criterion relevant to differing diagnostic groups not previously identified from the research presented.

7.5 Conclusion

This study has progressed the validation of the ESAT[®] as an instrument that can potentially be used to guide PIC clinical practice for determining whether or not to perform ETT suction. It has also enhanced clinical knowledge related to ETT suction in the PIC environment and potentially reduced the chance of inappropriate nursing actions that may lead to poorer patient outcomes. The research presented reinforces results from the researcher's previous foundational research and improves understanding of appropriate clinical assessment for patients with an ETT in situ. The research also contributes to the standardisation and provision of evidence-based clinical practice for patients with an ETT in situ with the aim to improve nursing care, nursing assessment, patient care and patient outcomes.

The research provides a validated instrument (using clinical scenarios) to support the decision making process for the inexperienced nurse in guiding the clinical practice of ETT suction within the PIC environment. Use of validated instruments such as the ESAT[®] should also enable evidence-based clinical education surrounding ETT suction and clinical auditing around a complex issue.

To date, the ESAT[®] has been tested solely using clinical ETT suction scenarios. Future validation of the ESAT[®] must be undertaken in real-life PIC clinical settings which may or may not result in modifications. It is anticipated that following validation of the instrument in the clinical setting, the ESAT[®] could potentially be translated into multiple languages to facilitate its use in a variety of international PIC settings.

References

- Aamodt, A. (1983). Problems in doing nursing research: Developing a criteria for qualitative research. *Western Journal of Nursing Research*, 5(4), 398-402.
doi:10.1177/019394598300500422
- Adewale, L. (2009). Anatomy and assessment of the pediatric airway. *Pediatric Anesthesia*, 19, 1-8.
- Ahrens, T., & Sona, C. (2003). Capnography application in acute & critical care. *Advanced Practice in Acute Critical Care*, 14(2), 123-132.
doi:10.1097/00044067-200305000-00002
- Aitken, L., & Marshall, A. (2015). Monitoring and optimising outcomes of survivors of critical illness. *Intensive and Critical Care Nursing*, 31, 1-9.
doi:org/10.1016/j.iccn.2014.10.006
- Akhu-Zaheya, L., Al-Maaitah, R., & Bany Hani, S. (2018). Quality of nursing documentation: Paper-based health records versus electronic-based health records. *Journal of Clinical Nursing*, 27(3-4), e578-e589.
doi:10.1111/jocn.14097
- Allen, B. (2016). Effective design, implementation and management of change in healthcare. *Nursing Standard*, 31(3). doi:10.7748/ns.2016.e10375
- American Association of Respiratory Care. (2010). AARC clinical practice guidelines: Endotracheal suctioning of mechanically ventilated patients with artificial airways 2010. *Respiratory Care*, 55(6), 758-764.
- Ashton, T. (2015). Measuring health system performance: A new approach to accountability and quality improvement in New Zealand. *Health Policy*, 119, 999–1004. doi:org/10.1016/j.healthpol.2015.04.012
- Austin, S. (2011). Stay out of court with proper documentation. *Nursing2011*, 41(4), 25-29. doi:10.1097/01.NURSE.0000395202.86451.d4
- Australian College of Critical Care Nurses. (2016). Workforce standards for intensive care nursing (pp. 1-42). Melbourne: Australian College of Critical Care Nurses.
- Australian Council on Healthcare Standards. (2015). *National safety and quality health service standards program: An introduction to the ACHS NSQHS standards program*. Australia: The Australian Council on Healthcare Standards. Retrieved from [https://www.achs.org.au/programs-services/the-national-safety-and-quality-health-service-standards-\(nsqhss\)/](https://www.achs.org.au/programs-services/the-national-safety-and-quality-health-service-standards-(nsqhss)/).

- Australian Health Workforce. (2013). *Australian Health Workforce Series - Nurses in Focus*. Adelaide: Australian Government. Retrieved from <https://www.hwa.gov.au/sites/default/files/Nurses-in-Focus-FINAL.pdf>.
- Australian Nursing & Midwifery Council. (2006). *National Competency Standards for the Registered Nurse*. Australia. Retrieved from <http://www.nursingmidwiferyboard.gov.au/Codes-Guidelines-Statements.aspx>.
- Baggot, D., Hensinger, B., Parry, J., Valdes, M., & Zaim, S. (2005). The new hire/preceptor experience: Cost-benefit analysis of one retention strategy. *The Journal of Nursing Administration*, 35(3), 138-145. doi:10.1097/00005110-200503000-00007
- Baile, W., & Blatner, A. (2014). Teaching communication skills using action methods to enhance role-play in problem-based learning. *Simulation in Healthcare*, 9(4), 220-227. doi:10.1097/SIH.0000000000000019
- Bannigan, K., & Moores, A. (2009). A model of professional thinking: Integrating reflective practice and evidence based practice. *Canadian Journal of Occupational Therapy*, 76(5), 342-350. doi:10.1177/000841740907600505
- Baun, M. (1984). Physiological determinants of a clinically successful method of endotracheal suction. *Western Journal of Nursing Research*, 6(2), 214-228. doi:10.1177/019394598400600206
- Bazeley, P. (2009). Editorial: Integrating data analyses in mixed methods research. *Journal of Mixed Methods Research*, 3(3), 203-207. doi:10.1177/1558689809334443
- Berg, M., Hawkins-Walsh, E., Gaylord, N., Lindeke, L., & Docherty, S. (2011). Emerging issues regarding pediatric nurse practitioner education in acute and primary care. *Journal of Pediatric Health Care*, 25(1), 62-66. doi:10.1016/j.pedhc.2010.07.002
- Birks, M., Cant, R., James, A., Chung, C., & Davis, J. (2012). The use of physical assessment skills by registered nurses in Australia: Issues for nursing education. *Collegian*, 20, 27-33. doi:10.1016/j.colegn.2012.02.004
- Blackwood, B. (1999). Normal saline instillation with endotracheal suctioning: Primum non-nocere (first do no harm). *Journal of Advanced Nursing*, 29(4), 928-934. doi:10.1046/j.1365-2648.1999.00977.x
- Blegen, M., Vaughn, T., & Vojir, C. (2008). Nursing staffing levels: Impact of organisational characteristics and registered nurse supply. *Health Services Research*, 43, 154-173.

- Bolick, B., Bevacqua, J., Kline-Tilford, A., Reuter-Rice, K., Haut, C., McComiskey, C., . . . Verger, J. (2013). Recommendations for matching pediatric nurse practitioner education and certification to pediatric acute care populations. *Journal of Pediatric Health Care, 27*(1), 71-77. doi:org/10.1016/j.pedhc.2012.09.009
- Bolton, L., Aydin, C., Donaldson, N., Brown, D., Sandhu, M., Fridman, M., & Aronow, H. (2007). Mandated nurse staffing ratios in California: A comparison of staffing and nurse-sensitive outcomes pre and postregulation. *Policy, Politics and Nursing Practice, 8*(4), 238-250. doi:10.1177/1527154407312737
- Bolton, L., Donaldson, N., Rutledge, D., Bennett, C., & Brown, D. (2006). The impact of nursing interventions: Overview of effective interventions, outcomes, measures, and priorities for future research. *Medical Care Research and Review, 64*(2), 123S-143S. doi:10.1177/1077558707299248
- Branson, R., Gomaa, D., & Rodriguez Jr, D. (2014). Management of the artificial airway. *Respiratory Care, 59*(6), 974-990. doi:10.4187/respcare.03246
- Brett, S. (2011). Critical care outcomes: Current and future issues. *Current Opinion in Critical Care, 17*(5), 493-494.
- Brocklehurst, P., & McGuire, W. (2005). ABC of preterm birth evidence based care. *British Medical Journal, 330*(7481), 36-38. doi:10.1136/bmj.330.7481.36
- Bruschettini, M., Zappettini, S., Moja, L., & Calevo, M. (2015). Frequency of endotracheal suctioning for the prevention of respiratory morbidity in ventilated newborns (Protocol). *Cochrane Database of Systematic Review, 1*(CD011493.), 1-8. doi:10.1002/14651858.CD011493.
- Bumbarger, B., & Campbell, E. (2012). A state agency-university partnership for translational research and the dissemination of evidence-based prevention and intervention. *Administration and Policy in Mental Health and Mental Health Services Research, 39*(4), 268-277. doi:10.1007/s10488-011-0372-x
- Burgman, M., McBride, M., Ashton, R., Speirs-Bridge, A., Flander, L., Wintle, B., . . . Twardy, C. (2011). Expert status and performance. *Plos One, 6*(11). doi:10.1371/journal.pone.0022998
- Burnard, P. (1989). Experimental learning and andragogy-negotiated learning in nurse education: a critical appraisal. *Nurse Education Today, 9*, 300-306.
- Burns, R. (2000). *Introduction to research methods* (Fourth ed.). Australia: Pearson Education.
- Carhuapoma, J., & Williams, M. (1999). Endotracheal suctioning and cerebral ischemia in traumatic brain injury: "The phantom menace?" *Critical Care Medicine, 27*(12), 2843-2844.
- Carroll, P. (2003). Improve your suctioning technique. *RN, 66*(5), 30ac32-30ac36.

- Carroll, P. (2010). Enhancing the safety of medical suction through innovative technology. *Canadian Journal of Respiratory Therapy*, 46(2), 47-49.
- Case, B. (1996). Breathing air into adult learning. Active involvement, individual differences and relevance and motivation. *The Journal of Continuing Education in Nursing*, 27(4), 148-158.
- Chang, V. (1995). Protocol for prevention of complications of endotracheal intubation. *Critical Care Nurse*, 15(5), 19-27.
- Charland, S., & Rouleau, J. (1999). *L'Aspiration des secretions endotracheales*. Centre Hospitalier Universitaire Mere-Enfant, Sainte-Justine. Centre Hospitalier Universitaire Mere-Enfant, Sainte-Justine.
- Chlan, L., Tracy, M., & Grossbach, I. (2011). Achieving quality patient-ventilator management: Advanced evidence-based nursing care. *Pulmonary Care*, 31(6), 46-50. doi:10.4037/ccn2011852
- Christensen, M., & Hewitt-Taylor, J. (2006). Defining the expert ICU nurse. *Intensive and Critical Care Nursing*, 22, 301-307. doi:org/10.1016/j.iccn.2005.07.003
- Clancy, C., Slutsky, J., & Patton, L. (2004). Evidence-based healthcare 2004: AHRQ moves research to translation and implementation. *Health Service Research*, 39(5), xiv-xxii. doi:10.1111/j.1475-6773.2004.00286.x
- Collins, R. (2017). *Algorithmic diagnosis of symptoms and signs* (4th ed.). Philadelphia: Wolters Kluwer.
- Collins, T., Lambert, L., Helms, C., & Minichiello, V. (2017). Use of mindful observer to extend simulation learning experience. *Innovation Center Perspectives*, 38(2), 98-99. doi:10.1097/01.NEP.0000000000000087
- Commonwealth Department of Education Science and Training. (2001). *Aspects of nursing education: The types of skills and knowledge required to meet the changing needs of the labour force involved in nursing-Literature review*. In *science and training*. Australia. Retrieved from http://www.dest.gov.au/archive/highered/nursing/pubs/aspects_nursing/7.htm.
- Conkin, D., Drews, B., Dimmitt, P., Hildebrandt, E., Hittle, K., & Tielsch-Goddard, A. (2013). Novice to expert: The evolution of an advanced practice evaluation tool. *Journal of Pediatric Health Care*, 27(3), 195-201. doi:org/10.1016/j.pedhc.2011.12.004
- Cook, D., Ricard, J., Reeve, B., Randall, J., Wigg, M., Brochard, L., & Dreyfuss, D. (2000). Ventilator circuit and secretion management strategies: A Franco-Canadian survey. *Critical Care Medicine*, 28(10), 3547-3554.
- Copnell, B., & Fergusson, D. (1995). Endotracheal Suctioning: Time-worn ritual or timely intervention. *American Journal of Critical Care*, 4(2), 100-105.

- Cornock, M. (2011). Clinical competency in children's nursing: A legal commentary. *Nursing Children and Young People*, 23(10), 18-19. doi:org/10.7748/ncyp2011.12.23.10.18.c8833
- Cousins, M., & Power, I. (1999). *Acute and postoperative pain*. Hong Kong: Churchill Livingstone.
- Cox, E. (2015). Coaching and adult learning: Theory and practice. *New Directions for Adult and Continuing Education*, 2015(148), 27-38. doi:10.1002/ace.20149
- Craske, J., Carter, B., Jarman, I., & Tume, L. (2017). Nursing judgement and decision-making using the sedation withdrawal score (SWS) in children. *Journal of Advanced Nursing*, 73, 2327-2338. doi:10.1111/jan.13305
- Creswell, J. (2003). *Research design: Qualitative, quantitative, and mixed methods approaches* (Second ed.). California: Sage Publications.
- Creswell, J. (2015). *A concise introduction to mixed methods research*. United States of America: SAGE Publications Inc.
- Crowe, S., Ewartb, L., & Dermanc, S. (2018). The impact of simulation based education on nursing confidence, knowledge and patient outcomes on general medicine units. *Nurse Education in Practice*, 29, 70-75. doi:org/10.1016/j.nepr.2017.11.017
- Curley, M., & Moloney-Harmon, P. (2001). *Critical care nursing of infants and children* (2nd ed.). Philadelphia: W.B.Saunders Company.
- Curley, M., & Thompson, J. (1990). End-tidal CO₂ monitoring in critically ill infants and children. *Pediatric Nursing*, 16(4), 397-403.
- Davies, K. (2009). *Determining standard criteria for endotracheal suctioning in the paediatric intensive care patient: An exploratory study*. (Masters by Nursing Research Thesis), Edith Cowan Univeristy, Western Australia.
- Davies, K., Bulsara, M., Ramelet, A., & Monterosso, L. (2018a). Content validity testing of the ESAT[®]: A decision aid tool for performing endotracheal suction in children. *Australian Critical Care*, 31(1), 23-30. doi:10.1016/j.aucc.2017.01.006
- Davies, K., Bulsara, M., Ramelet, A., & Monterosso, L. (2018b). Reliability and Criterion-Related Validity Testing (construct) of the Endotracheal Suction Assessment Tool (ESAT[®]). *Journal of Clinical Nursing*, 27(9-10), 1891-1900. doi:org/10.1111/jocn.14269
- Davies, K., Monterosso, L., Bulsara, M., & Ramelet, A. (2015a). Audit of endotracheal tube suction in a paediatric intensive care unit. *Clinical Nursing Research*, 26 (1), 68-81. doi:10.1177/1054773815598272

- Davies, K., Monterosso, L., Bulsara, M., & Ramelet, A. (2015b). Clinical indicators for the initiation of endotracheal tube suction in children: An integrated review. *Australian Critical Care*, 28(1), 11-18. doi:10.1016/j.aucc.2014.03.001
- Davies, K., Monterosso, L., & Leslie, G. (2011). Determining standard criteria for endotracheal suctioning in the paediatric intensive care patient: An exploratory study. *Intensive and Critical Care Nursing*, 27(2), 85-93. doi:10.1016/j.iccn.2011.01.002
- Day, T., Farnell, S., Haynes, S., Wainwright, S., & Wilson-Barnett, J. (2002). Tracheal suctioning: An exploration of nurses' knowledge and competence in acute and high dependency ward areas. *Journal of Advanced Nursing*, 39(1), 35-45. doi:10.1046/j.1365-2648.2002.02240.x
- Day, T., Farnell, S., & Wilson-Barnett, J. (2002). Suctioning: A review of current research recommendations. *Intensive and Critical Care Nursing*, 18, 79-89. doi:10.1016/S0964-3397(02)00004-6
- Day, T., Iles, N., & Griffiths, P. (2009). Effect of performance feedback on tracheal suctioning knowledge and skills: Randomised controlled trial. *Journal of Advanced Nursing*, 65(7), 1423-1431. doi:10.1111/j.1365-2648.2009.04997.x
- Day, T., Wainwright, S., & Wilson-Barnett, J. (2001). An evaluation of a teaching intervention to improve the practice of endotracheal suctioning in intensive care units. *Journal of Clinical Nursing*, 10(5), 682-696. doi:10.1046/j.1365-2702.2001.00519.x
- De Pedro-Gomez, J., Morales-Asencio, J., Bennasar-Veny, M., Artigues -Vives, G., Perello-Campaner, C., & Gomez -Picard, P. (2011). Determining factors in evidence-based clinical practice among hospital and primary care nursing staff. *Journal of Advanced Nursing*, April, 452-459. doi:10.1111/j.1365-2648.2011.05733.x
- De Vet, H., Terwee, C., & Bouter, L. (2003). Current challenges in clinimetrics. *Journal of Clinical Epidemiology*, 56, 1137-1141. doi:10.1016/j.jclinepi.2003.08.012
- De Vet, H., Terwee, C., Mokkink, L., & Knol, D. (2011). *Measurement in medicine: A practical guide (Practical guides to biostatistics and epidemiology)*. Cambridge: Cambridge University Press.
- De Von, H., Block, E., Moyle-Wright, P., Ernst, D., Hayden, S., Lazzara, D., . . . Kostas-Polston, E. (2007). A psychometric toolbox for testing validity and reliability. *Journal of Nursing Scholarship*, 39(2), 155-164. doi:10.1111/j.1547-5069.2007.00161.x

- Denis-Larocque, G., Williams, K., St-Sauveur, I., Ruddy, M., & Rennick, J. (2017). Nurses' perceptions of caring for parents of children with chronic medical complexity in the pediatric intensive care unit. *Intensive and Critical Care Nursing, 43*, 149-155. doi:org/10.1016/j.iccn.2017.01.010
- Devitt, J., Kurrek, M., Cohen, M., Fish, K., Fish, P., Noel, A., & Szalai, J. (1998). Testing internal consistency and construct validity during evaluation of performance in a patient simulator. *Anesthesia and Analgesia, 6*(86), 1160-1164. doi:10.1097/00000539-199806000-00004
- Dougherty Wrightson, D., & Askin, D. (1999). Suctioning smarter: Answers to eight common questions about endotracheal suctioning in neonates. *Neonatal Network, 18*(1), 51-55. doi:10.1891/0730-0832.18.1.51
- Douglas, C., Osborne, S., Reid, C., Batch, M., Hollingdrake, O., Gardner, G., & Members of the RBWH Council. (2014). What factors influence nurses' assessment practices? Development of the barriers to nurses' use of physical assessment scale. *Journal of Advanced Nursing, 70*(11), 2683-2694. doi:10.1111/jan.12408
- Duffield, C., Roche, M., Dimitrelis, S., Homer, C., & Buchan, J. (2014). Instability in patient and nurse characteristics, unit complexity and patient and system outcomes. *Journal of Advanced Nursing, 71*(6), 1288-1298. doi:10.1111/jan.12597
- Duffield, C., Roche, M., Twigg, D., Williams, A., & Clarke, S. (2016). A protocol to assess the impact of adding nursing support workers to ward staffing. *Journal of Advanced Nursing, 72*(9), 2218-2225. doi:10.1111/jan.12965
- Duffield, C., Twigg, D., Pugh, J., Evans, G., Dimitrelis, S., & Roche, M. (2014). The use of unregulated staff: Time for regulation? *Policy, Politics & Nursing Practice, 15*(1-2), 42-48. doi:10.1177/1527154414529337
- Durand, M., Sangha, B., Cabal, L., Hoppenbrouwers, T., & Hodgman, J. (1989). Cardiopulmonary & intracranial pressure changes related to endotracheal suctioning in preterm infants. *Critical Care Medicine, 17*(6), 506-510.
- Duzkaya, D., & Kuguoglu, S. (2015). Assessment of pain during endotracheal suction in the pediatric intensive care unit. *Pain Management Nursing, 16*(1), 11-19. doi:org/10.1016/j.pmn.2014.02.003
- Dyhr, T., Bonde, J., & Larsson, A. (2003). Lung recruitment manoeuvres are effective in regaining lung volume and oxygenation after open endotracheal suction in acute respiratory distress syndrome. *Critical Care Medicine, 7*(1), 55-62. doi:10.1186/cc1844

- Eisenlohr, P. (2013). Challenges in data analysis: Pitfalls and suggestions for a statistical routine in vegetation ecology. *Brazilian Journal of Botany*, 36(1), 83-87. doi:10.1007/s40415-013-0002-9
- Epstein, R., & Hundert, E. (2002). Defining and accessing professional competence. *Journal of the American Medical Association*, 287(2), 243-244. doi:10.1001/jama.287.2.226
- Evans, C. (2005). Clinical decision making theories: Patient assessment in A&E. *Emergency Nursing*, 13(5), 16-19. doi:10.7748/en2005.09.13.5.16.c1192
- Evans, J., Syddall, S., Butt, W., & Kinney, S. (2014). Comparison of open and closed suction on safety, efficacy and nursing time in a paediatric intensive care unit. *Australian Critical Care*, 27, 70-74. doi:org/10.1016/j.aucc.2014.01.003
- Falzer, P., & Garman, M. (2009). A conditional model of evidence-based decision making. *The Journal of Evaluation in Clinical Practice*, 15 (6), 1142-1151. doi:10.1111/j.1365-2753.2009.01315.x
- Feder, G., Eccles, M., Grol, R., Griffiths, C., & Grimshaw, J. (1999). Using clinical guidelines. *British Medical Journal*, 318, 728-730. doi:10.1136/bmj.318.7185.728
- Feinstein, A. (1982). The Jones criteria and the challenges of clinimetrics. *Circulation*, 66(1), 1-5. doi:10.1161/01.CIR.66.1.1
- Feinstein, A. (1983a). An additional basic science for clinical medicine: 1.The constraining fundamental paradigm. *Annals of Internal medicine*, 99(3), 393-397.
- Feinstein, A. (1983b). An additional basic science for clinical medicine: IV.The development of clinimetrics. *Annals of Internal medicine*, 99(6), 843-848.
- Feinstein, A. (1983c). An additional basic science for clinical medicine: II.The limitations of randomized trials. *Annals of Internal medicine*, 99(4), 544-550.
- Feinstein, A. (1983d). An additional basic science for clinical medicine: III.The challenges of comparison and measurement. *Annals of Internal medicine*, 99(5), 705-712.
- Filemaker. (2010). FileMaker Pro (Version 11) [Computer software]. Santa Clara, USA: Filemaker Inc.
- Flodgren, G., Hall, A., Goulding, L., Eccles, M., Grimshaw, J., Leng, G., & Shepperd, S. (2016). Tools developed and disseminated by guideline producers to promote the uptake of their guidelines. *Cochrane Database Systematic Review* (Vol. 4).
- Gardner, D., & Shirland, L. (2009). Evidence-based guideline for suctioning the intubated neonate and infant. *Neonatal Network*, 28(5), 281-302.

- Gelinas, C., Fillion, L., & Puntillo, K. (2009). Item selection and content validity of the critical-care pain observation tool for non-verbal adults. *Journal of Advanced Nursing*, *65*(1), 203-216. doi:10.1111/j.1365-2648.2008.04847.x
- Gilbert, M. (1999). Assessing the need for endotracheal suction. *Pediatric Nursing*, *11*(1), 14-17. doi:10358635
- Gill, F., Kendrick, T., Davies, H., & Greenwood, M. (2017). A two phase study to revise the Australian practice standards for specialist critical care nurses. *Australian Critical Care*, *30*, 173-181. doi:org/10.1016/j.aucc.2016.06.001
- Godfrey, S. (2004). Pulmonary hemorrhage/hemoptysis in children. *Pediatric Pulmonology*, *37*, 476-484. doi:10.1002/ppul.20020
- Goering, P., & Streiner, D. (1996). Research methods in psychiatry reconcilable differences: The marriage of qualitative and quantitative methods. *Canada Journal of Psychiatry*, *41*(8), 491-497.
- Gonçalves, R., Tsuzuki, L., Giovanni, G., & Carvalho, S. (2015). Endotracheal suctioning in intubated newborns: An integrative literature review. *The Revista Brasileira de Terapia Intensiva*, *27*(3), 284-292. doi:10.5935/0103-507X.20150048
- Gopalakrishna, G., Langendam, M., Scholten, R., Bossuyt, P., & Leedflang, M. (2013). Guidelines for guideline developers: A systematic review of grading systems for medical tests. *British Medical Journal*, *78*(8). doi:10.1188/1748-5908-8-78
- Goran, S. (2012). Measuring tele-ICU impact: Does it optimize quality outcomes for the critically ill patient? *Journal of Nursing Management*, *20*(3), 414-428. doi:10.1111/j.1365-2834.2012.01414.x.
- Grant, J., & Davis, L. (1997). Selection and use of content experts for instrument development. *Research in Nursing and Health*, *20*, 269-274. doi:10.1002/(SICI)1098-240X(199706)20:3<269::AID-NUR9>3.0.CO;2-G
- Guest, G. (2012). Describing mixed methods research: An alternative to typologies. *Journal of Mixed Methods Research*, *7*(2), 141-151. doi:10.1177/1558689812461179
- Gupta, P., Rettiganti, M., Jeffries, H., Scanlon, M., Ghanayem, N., Daufeldt, J., . . . Wetzell, R. (2016). Risk factors and outcomes of in-hospital cardiac arrest following pediatric heart operations of varying complexity. *Resuscitation*, *105*, 1-7. doi:org/10.1016/j.resuscitation.2016.04.022
- Gupta, P., Tang, X., Gall, C., Lauer, C., Rice, T., & Wetzell, R. (2014). Epidemiology and outcomes of in-hospital cardiac arrest in critically ill children across hospitals of varied center volume: A multi-center analysis. *Resuscitation*, *85*, 1473-1479. doi:org/10.1016/j.resuscitation.2014.07.016

- Hahn, M. (2010). 10 considerations for endotracheal suctioning. *Journal for Respiratory Care Practitioners*, 23(7), 32-33. doi:52013005
- Hazinski, M. (Ed.) (2013). *Nursing care of the critically ill child* (3rd ed.). St. Louis: Mosby, Elsevier Inc.
- Hester, A., & Davis, D. (2013). Validation of the Hester Davis scale for fall risk assessment in a neurosciences population. *Journal of Neuroscience Nursing*, 45(5), 298-305.
doi:org.pklibresources.health.wa.gov.au/10.1097/JNN.0b013e31829d8b44
- Hodge, D. (1991). Endotracheal suctioning and the infant: A nursing care protocol to decrease complications. *Neonatal Network*, 9(5), 7-15.
- House, J., & Burns, E. (1986). A study of the use of adult learning theory in medical instruction. *Family Practice Research Journal*, 5(4), 241-246.
- Hudgins, K. (2017). Clinical simulation learning in critical care. *Critical Care Nursing Quarterly*, 40(2), 108-110. doi:10.1097/CNQ.000000000000147
- Hummel, P. (2017). Demystifying Research 1: Psychometrics. *Pediatric Nursing*, 43(4), 175-184.
- Hutchinson, T. (2003). Agreement between experts: An answer, but is it the answer for you? *Journal of Clinical Neuroscience*, 10(2), 213-215. doi:10.1016/S0967-5868(02)00340-5
- IBM. (2013). Statistical package for social sciences (Version 22) [Computer software]. St Leonards, NSW: IBM.
- Imle, M., & Atwood, J. (1988). Retaining qualitative validity while gaining quantitative reliability and validity: Development of the transition to parenthood concerns scale. *Advances in Nursing Science*, 11(1), 61-75.
- Inselman, L. (2001). *Pediatric pulmonary pearls*. Philadelphia: Hanley & Belfus INC.
- Jacob, E., McKenna, L., & D'Amore, A. (2015). The changing skill mix in nursing: Considerations for and against different levels of nurse. *The Journal of Nursing Management*, 23, 421-426. doi:10.1111/jonm.12162
- Jacobe, J., Denessen, E., & Postma, C. (2004). The structure of medical competence and results of an OSCE. *Netherlands Journal of Medicine*, 62(10), 397-403.
- Jakimowicz, S., & Perry, L. (2015). A concept analysis of patient-centred nursing in the intensive care unit. *Journal of Advanced Nursing*, 71(7), 1499-1517.
doi:10.1111/jan.12644
- Jones, A. (2013). Increasing adult learner motivation for completing self-directed e-learning. *Performance Improvement*, 52(7), 32-42. doi:10.1002/pfi.21361

- Joynt, K., Harris, Y., Orav, E., & Jha, A. (2011). Quality of care and patient outcomes in critical access rural hospitals. *Journal of the American Medical Association*, 306(1), 45-52. doi:10.1001/jama.2011.902
- Keller, V., & Keck, J. (2006). An instrument for observational assessment of nausea in young children. *Pediatric Nursing*, 32(5), 420-426. doi:a0fab99d42bb011e7c0d4a57d185b132.pdf
- Khilnani, P. (2011). *Pediatric & neonatal mechanical ventilation* (2nd ed.). New Delhi: Jaypee Brothers Medical Publishers LTD.
- Kline-Tilford, A., Sorce, L., Levin, D., & Anas, N. (2013). Pulmonary disorders. In M. Hazinski (Ed.), *Nursing care of the critically ill child* (3rd ed., pp. 483-561). St. Louis, Mo: Mosby, Elsevier inc.
- Kneebone, R., Kidd, J., Nestel, D., Barnet, A., Lo, B., King, R., . . . Brown, R. (2005). Blurring the boundaries: Scenario-based simulation in a clinical setting. *Medical Education*, 39, 580-587. doi:10.1111/j.1365-2929.2005.02110.x
- Knowland, V., & Thomas, M. (2014). Educating the adult brain: How the neuroscience of learning can inform educational policy. *International Review of Education*, 60(1), 99-122. doi:10.1007/s11159-014-9412-6
- Knowles, M. (1975). *Self-directed learning. A guide for learners and teachers*. Cambridge: Englewood Cliffs: Prentice Hall.
- Knowles, M. (1985). *Andrology in action*. California: University of California.
- Knox, A. (1993). Performing endotracheal suction on children: A literature review and implications for nursing practice. *Intensive and Critical Care Nursing*, 9(1), 55-61.
- Kobeissy, F. (2012). Psychiatric disorders: Methods and protocols. *Methods in Molecular Biology*, 829, 49-62. doi:10.1007/978-1-61779-458-2_3
- Kondo, Y., & Horiuchi, S. (1999). Reaction of preterm infants to soothing care after endotracheal suction: Case study. *Journal of St Luke's Society for Nursing Research*, 3(1), 1-10.
- Kosov, M., Maximovich, A., Riefler, J., Batson, E., Dignani, M., & Belotserkovskiy, M. (2016). Interexpert agreement on adverse events' evaluation: Study measures the differing judgements between clinical investigators and drug safety experts. *Applied Clinical Trials*, 25(8-9).
- Kottner, J., & Dassen, T. (2010). Pressure ulcer risk assessment in critical care: interrater reliability and validity studies of the Braden and Waterlow scales and subjective ratings in two intensive care units. *International Journal of Nursing Studies*, 47(6), 671-677. doi:10.1016/j.ijnurstu.2009.11.005

- Kurtzman, E. (2010). A transparency and accountability framework for high-value inpatient nursing care. *Nursing Economics*, 28(5).
- Lake, E., Staiger, D., Horbar, J., Cheung, R., Kenny, M., Patrick, T., & Rogowski, J. (2012). Association between hospital recognition for nursing excellence and outcomes of very low-birth-weight infants. *Journal of American Medical Association*, 307(16), 1709-1716. doi:10.1001/jama.2012.504
- Landsman, I. (2004). Cricoid pressure: Indications and complications. *Pediatric Anesthesia*, 14(1), 43-50. doi:10.1046/j.1460-9592.2003.01202.x
- Lemeshow, S., Hosmer, D., Klar, J., & Lwanga, S. (1990). *Adequacy of sample size in health studies*. Chichester, UK: Wiley.
- Lester, H., & Tritter, J. (2001). Medical error: A discussion of the medical construction of error and suggestions for reforms of medical education to decrease error. *Medical Education*, 35(9), 855-861. doi:10.1046/j.1365-2923.2001.01003.x
- Lower, M., & Burton, S. (1989). Measuring the impact of nursing interventions on patient outcomes - The challenge of the 1990s. *Journal of Nursing Quality Assurance*, 4(1), 27-34.
- Lynn, M. (1986). Determination and quantification of content validity. *Nursing Research*, 35(6), 382-385. doi:10.1097/00006199-198611000-00017
- Mackey, A., & Bassendowski, S. (2016). The history of evidence-based practice in nursing education and practice. *Journal of Professional Nursing*, 33(1), 51-55. doi:org/10.1016/j.profnurs.2016.05.009
- Mackway-Jones, K., Molyneux, E., Phillips, B., & Wieteska, S. (2003). *Advanced paediatric life support*. London, UK: BMJ.
- Maggiore, S., Lellouche, F., Pignataro, C., Girou, E., Maitre, B., Richard, J., . . . Brochard, L. (2013). Decreasing the adverse effects of endotracheal suctioning during mechanical ventilation by changing practice. *Respiratory Care*, 58(10), 1588-1597. doi:org/10.4187/respcare.02265
- Mangione, S., & Nieman, L. (1997). Cardiac auscultatory skills of internal medicine and family practice trainees: A comparison of diagnostic proficiency. *Journal of the American Medical Association*, 278(9), 717-722. doi:10.1001/jama.1997.03550090041030
- Manias, E., & Bucknall, T. (2002). Observation of pain assessment and management – The complexities of clinical practice. *Journal of Clinical Nursing*, 11(6), 724-733. doi:10.1046/j.1365-2702.2002.00691.x
- Mantzoukas, S. (2008). A review of evidence-based practice, nursing research and reflection: levelling the hierarchy. *Journal of Clinical Nursing*, 17(2), 214-223. doi:10.1111/j.1365-2702.2006.01912.x

- Martyn, K., Martin, J., Gutknecht, S., & Faleer, H. (2013). The pediatric nurse practitioner workforce: Meeting the health care needs of children. *Journal of Pediatric Health Care, 27*(5). doi:org/10.1016/j.pedhc.2013.03.005
- Mastaglia, B., Toye, C., & Kristjanson, L. (2003). Ensuring content validity in instrument development: Challenges and innovative approaches. *Contemporary Nurse, 14*(3), 281-291. doi:10.5172/conu.14.3.281
- Mayo, A. (2015). Psychometric instrumentation reliability and validity used for clinical practice, evidence-based practice projects and research studies. *Clinical Nurse Specialist, 29*(3), 134-138. doi:10.1097/NUR.000000000000131
- McGlynn, E., & Brook, R. (Producer). (2003). Full disclosure: Time for the naked truth about health. *Rand review*. Retrieved from <http://www.rand.org/publications/randreview/issues/rr.0801/disclosure.html>
- McGoey, K., Cowan, R., Rumrill, P., & La Vogue, C. (2010). Understanding the psychometric properties of reliability and validity in assessment. *Work, 36*(1), 105–111. doi:10.3233/WOR-2010-1012
- McGrath, J. (2010). Using evidence-based practice to guide caregiving in the neonatal intensive care unit. *The Journal of Perinatal & Neonatal Nursing, 24*(4), 293-294. doi:10.1097/JPN.0b013e3181f8a7b5
- McGrath, J. (2012). Systematic and integrative reviews of the literature. How are they changing our thoughts about practice? *The Journal of Perinatal & Neonatal Nursing, 26*(3), 193-195. doi:10.1097/JPN.0b013e3182629c7d
- McKim, C. (2017). The value of mixed methods research: A mixed methods study. *Journal of Mixed Methods Research, 11*(2), 202-222. doi:10.1177/1558689815607096
- Mellard, D., Krieshok, T., Fall, E., & Woods, K. (2013). Dispositional factors affecting motivation during learning in adult basic and secondary education programs. *Reading and Writing, 26*(4), 515-538. doi:10.1007/s11145-012-9413-4
- Melnyk, B. (2017). Breaking down silos and making use of the evidence-based practice competencies in healthcare and academic programs: An urgent call to action. *Worldviews on Evidence-Based Nursing, 15*(1), 3-4. doi:10.1111/wvn.12271
- Moore, T. (2003). Suctioning techniques for the removal of respiratory secretions. *Nursing Standard, 18*(9), 47-55. doi:org/10.7748/ns2003.11.18.9.47.c3504
- Morrow, B., & Argent, A. (2008). A comprehensive review of pediatric endotracheal suctioning: Effects, indications, and clinical practice. *Pediatric Critical Care Medicine, 9*(5), 465-477. doi:10.1097/PCC.0b013e31818499cc

- Morrow, B., Futter, M., & Argent, A. (2004). Endotracheal suctioning: from principles to practice. *Intensive Care Medicine*, 30(6), 1167-1174. doi:10.1007/s00134-004-2238-0
- Morrow, B., Futter, M., & Argent, A. (2008). Commentary: Morrow B, Futter M, Argent A. (2006). Effect of endotracheal suction on lung dynamics in mechanically-ventilated paediatric patients. *Nursing in Critical Care*, 13(1), 54-55. doi:10.1111/j.1478-5153.2007.00256.x
- Munro, B. (2001). *Statistical methods for healthcare research* (4th ed.). Philadelphia: Lippincott.
- Murphy, M., Llewellyn, J., & Carlson, E. (2011). Promoting professional nursing practice: Linking a professional practice model to performance expectations. *Nursing Clinics of North America*, 46(1), 67-79. doi:10.1016/j.cnur.2010.10.009
- Namachivayam, P., Shann, F., Shekerdemian, L., Taylor, A., von Sloten, I., Delzoppo, C., . . . Butt, W. (2010). Three decades of pediatric intensive care: Who was admitted, what happened in intensive care, and what happened afterward. *Pediatric Critical Care Medicine*, 11(5), 549-555.
- Negroa, A., Ranzanic, R., Villa, M., & Manarab, D. (2014). Survey of Italian intensive care unit nurses' knowledge about endotracheal suctioning guidelines. *Intensive and Critical Care Nursing*, 30, 339-345. doi:org/10.1016/j.iccn.2014.06.003
- Neuman, W. (2011). *Social research methods qualitative and quantitative approaches* (7th ed.). Boston: Pearson.
- Norridge, M., & While, A. (2015). The impact PICU nursing expertise has on a child's unplanned extubation. *British Association of Critical Care Nurses*, 21(5), 295-303. doi:10.1111/nicc.12160
- Ntoumenopoulos, G. (2013). Endotracheal suctioning may or may not have an impact, but it does depend on what you measure! *Respiratory Care*, 58 (10), 1707-1710. doi:10.4187/respcare.02745
- Nunes, S., Rego, G., & Nunes, R. (2013). Awareness of costs and individual accountability in health care. *Nursing Ethics*, 20(6), 645-659. doi:10.1177/0969733012468464
- Oh, H., & Seo, W. (2003). A meta-analysis of the effects of various interventions in preventing endotracheal suction-induced hypoxemia. *Journal of Clinical Nursing*, 12(6), 912-924. doi:10.1046/j.1365-2702.2003.00796.x
- Okla, G., & Eden, D. (2015). Learning by simulation. *Middle East Journal of Anaesthesiology*, 23(2).

- Olson, D., Lynn, M., Thoyre, S., & Graffagnino, C. (2007). The limited reliability of the Ramsay scale. *Neurocrit Care*, 7(3), 227-231. doi:10.1007/s12028-007-0069-x
- Owen, E., Woods, C., O'Flynn, J., Boone, M., Calhoun, A., & Montgomery, V. (2016). A bedside decision tree for use of saline with endotracheal tube suctioning in children. *American Association of Critical-Care Nurses*, 36(1), E1-10. doi:10.4037/ccn2016358
- Oxford. (2015). *Oxford concise colour medical dictionary* (6th ed.). United States of America, New York: Oxford University Press.
- Padilla, J., & Benitez, I. (2014). Validity evidence based on response processes. *Psicothema*, 26(1), 136-144. doi:10.7334/psicothema2013.259
- Page, N., Giehl, M., & Luke, S. (1998). Intubation complications in the critically ill child. *AACN Clinical Issues Advanced Practice in Acute Critical Care*, 9(1), 25-35. doi:10.1097/00044067-199802000-00003
- Pallant, J. (2013). *SPSS survival manual: A step by step guide to data analysis using IBM SPSS* (5th ed.). Crows Nest, N.S.W: Allen & Unwin.
- Paluck, E. (2010). The Promising Integration of Qualitative Methods and Field Experiments. *The Annals of the American Academy of Political and Social Science*, 628(1), 59-71. doi:10.1177/0002716209351510
- Pearce, J. (2017). Psychometrics in action, science as practice. *Advances in Health Science Education*. doi:10.1007/s10459-017-9789-7
- Pedersen, C., Rosendahl-Nielsen, M., Hjermand, J., & Egerod, I. (2009). Endotracheal suctioning of the adult intubated patient-what is the evidence? *Intensive and Critical Care Nursing*, 25(1), 21-30. doi:10.1016/j.iccn.2008.05.004
- Pirret, A. (2007). The level of knowledge of respiratory physiology articulated by intensive care nurses to provide rationale for their clinical decision-making. *Intensive and Critical Care Nursing*, 23(3), 145-155. doi:10.1016/j.iccn.2006.11.004
- Place, B., & Fell, H. (1998). Clearing tracheobronchial secretions using suction. *Nursing Times*, 94(47), 54-56.
- Polit, D. (2014). Getting serious about test-retest reliability: A critique of retest research and some recommendations. *Quality of Life Research*, 23(6), 1713-1720. doi:10.1007/s11136-014-0632-9
- Polit, D., & Beck, C. (2006). The content validity index: Are you sure you know what's being reported? Critique and recommendations. *Research in Nursing and Health*, 29(5), 489-497. doi:10.1002/nur.20147

- Polit, D., Beck, C., & Owen, S. (2007). Is the CVI an acceptable indicator of content validity? Appraisal and recommendations. *Research in Nursing and Health, 30*, 459-467. doi:10.1002/nur.20199
- Polit, D., & Hungler, B. (1993). *Essentials of nursing research: methods, Appraisals and utilization*. Philadelphia: J.B. Lippencott Company.
- Polit, D., & Hungler, B. (2013). *Essentials of nursing research: Methods, appraisal, and utilization* (8th ed.). Philadelphia: Wolters Kluwer/Lippincott Williams and Wilkins
- Pritchard, M., Flenady, V., & Woodgate, P. (2003). Systematic review of the role of pre-oxygenation for tracheal suctioning in ventilated newborn infants. *Australian College of Paediatrics, 39*(3), 163-165. doi:10.1046/j.1440-1754.2003.00123.x
- Raleigh, M., & Allan, H. (2017). A qualitative study of advanced nurse practitioners' use of physical assessment skills in the community: Shifting skills across professional boundaries. *Journal of Clinical Nursing, 26*(13-14), 2025-2035. doi:10.1111/jocn.13613
- Ramelet, A. (2006). *The Development of a Multidimensional Pain Assessment Scale for Critically ill Preverbal Children*. (Doctor of Philosophy by Publication), Curtin University of Technology, Western Australia.
- Rathbun, M., & Ruth-Sahd, A. (2009). Algorithmic tools for interpreting vital signs. *Journal of Nursing Education, 48*(7), 395-400. doi:10.3928/01484834-20090615-07
- Reddish, M., & Kaplan, L. (2007). When are new graduate nurses competent in the intensive care unit? *Journal of Critical Care Nursing Quarterly, 30*(3), 199-205. doi:org/10.1097/01.CNQ.0000278919.29444.b3
- Reddy, S., Wakerman, J., Westhorp, G., & Herring, S. (2015). Evaluating impact of clinical guidelines using a realist evaluation framework. *Journal of Evaluation in Clinical Practice, 21*(6), 1114-1120. doi:10.1111/jep.12482
- Reeder, B., & Turner, A. (2011). Scenario-based design: A method for connecting information system design with public health operations and emergency management. *Journal of Biomedical Informatics, 44*(6), 978-988. doi:10.1016/j.jbi.2011.07.004
- Reeve, C., Humphreys, J., & Wakerman, J. (2015). A comprehensive health service evaluation and monitoring framework. *Evaluation and Program Planning, 53*, 91-98. doi:org/10.1016/j.evalprogplan.2015.08.006
- Reid, J., Stone, K., Brown, J., Caglar, D., Kobayashi, A., Lewis-Newby, M., . . . Quan, L. (2012). The simulation team assessment tool (STAT): Development, reliability and validation. *Resuscitation, 83*(7), 879-886. doi:10.1016/j.resuscitation.2011.12.012

- Rischbieth, A. (2006). Matching nurse skill with patient acuity in the intensive care units: A risk management mandate. *Journal of Nursing Management*, 14(5), 397-404. doi:10.1111/j.1365-2934.2006.00622.x
- Rosenbaum, P. (1989). Criterion-related construct validity. *Psychometrika*, 54(4), 625-633. doi:org/10.1007/BF02296400
- Roths, A., Lemos, M., & Gonçalves, T. (2017). Motivational profiles of adult learners. *Adult Education Quarterly*, 67(1), 3-29. doi:10.1177/0741713616669588
- Runton, N. (1992). Suctioning artificial airways in children: Appropriate technique. *Pediatric Nursing*, 18(2), 115-118.
- Rutherford-Hemming, T., & Alfes, C. (2017). The use of hospital-based simulation in nursing education - A systematic review. *Clinical Simulation in Nursing*, 13(2), 78-89. doi:org/10.1016/j.ecns.2016.12.007
- Ryan, T., Hills, B., & Webb, L. (2004). Nursing staffing levels and budgeted expenditure in acute mental health wards: A benchmarking study. *Journal of Psychiatric and Mental Health Nursing*, 11(1), 73-81. doi:10.1111/j.1365-2850.2004.00691.x
- Sanchez, L., & Cooknell, L. (2017). The Power of 3: Using adult learning principles to facilitate patient education. *Nursing2017*, 47(2), 17-19. doi:10.1097/01.NURSE.0000511819.18774.85
- Schoonenboom, J., & Johnson, R. (2017). How to construct a mixed methods research design. *KZfSS Kölner Zeitschrift für Soziologie und Sozialpsychologie*, S2 (69), 107-131. doi:10.1007/s11577-017-0454-1
- Scott Long, J., & Freese, J. (2006). Regression models for categorical dependent variables using stata. College Station, Texas: Stata Press.
- Sedgwick, P. (2012). Observational study design. *British Medical Journal*, 345, e5856. doi:10.1136/bmj.e5856
- Shanbhag, D., Graham, I., Harlos, K., Haynes, R., Gabizon, I., Connolly, S., . . . Van Spall, C. (2018). Effectiveness of implementation interventions in improving physician adherence to guideline recommendations in heart failure: A systematic review. *British Medical Journal*, 8(3). doi:10.1136/bmjopen-2017-017765
- Sims, C., & Johnson, C. (2011). *Your guide to paediatric anaesthesia*. Australia McGraw-Hill Australia PTY Limited.
- Sims, C., & von Ungern-Sternberg, B. (2012). The normal and challenging pediatric airway. *Pediatric Anesthesia*, 22(6), 521-526. doi:10.1111/j.1460-9592.2012.03858.x

- Souza, A., Alexandre, N., & Brito Guirardello, E. (2017). Psychometric properties in instruments evaluation of reliability and validity. *Epidemiologia e Serviços de Saúde*, 26 (3), 649-659. doi:10.5123/S1679-49742017000300022
- Stillwell, S., Fineout-Overholt, E., Mazurek Melnyk, B., & Williamson, K. (2010). Searching for the Evidence. *American Journal of Nursing*, 110(5), 41-47.
- Streiner, D. (2003). Clinimetrics vs. psychometrics: An unnecessary distinction. *Journal of Clinical Epidemiology*, 56(12), 1142-1145. doi:10.1016/j.jclinepi.2003.08.011
- Streiner, D., & Kottner, J. (2014). Recommendations for reporting the results of studies of instrument and scale development and testing. *Journal of Advanced Nursing*, 70 (9), 1970-1979. doi:10.1111/jan.12402
- Streiner, D., & Norman, G. (2005). *Health measurement scales. A practical guide to their development and use*. Oxford: Oxford University Press.
- Sullivan, G. (2011). A primer on the validity of assessment instruments. *Journal of Graduate Medical Education*., 3 (2), 119-120. doi:10.4300/JGME-D-11-00075.1
- Sunder, R., Haile, D., Farrell, P., & Sharma, A. (2012). Pediatric airway management: current practices and future directions. *Pediatric Anesthesia*, 22, 1008-1015.
- Swartz, K., Noonan, D., & Edwards-Beckett, J. (1996). A national survey of endotracheal suctioning techniques in the pediatric population. *Heart & Lung*, 25(1), 52-60. doi:10.1016/S0147-9563(96)80013-6
- Tamilselvi, P., & Ramamurthy, G. (2013). Reliability and validity in nursing research. *Asian Journal of Nursing Education and Research*, 3(4), 270-272.
- Teddlie, C., & Tashakkori, A. (2012). Common “core” characteristics of mixed methods research: A review of critical issues and call for greater convergence. *American Behavioral Scientist*, 56(6), 774-788. doi:org.ipacez.nd.edu.au/10.1177%2F0002764211433795
- Thomas, M., & Fothergill-Bourbonnais, F. (2005). Clinical judgments about endotracheal suctioning: What cues do expert pediatric critical care nurses consider? *Critical Care Nursing Clinics of North America*, 17(4), 329-340 doi:org/10.1016/j.ccell.2005.08.002
- Thompson, C., Aitken, L., Doran, D., & Dowding, D. (2013). An agenda for clinical decision making and judgement in nursing research and education. *International Journal of Nursing Studies*, 50(12). doi:org/10.1016/j.ijnurstu.2013.05.003
- Tolles, C., & Stone, K. (1990). National survey of neonatal endotracheal suctioning practices. *Neonatal Network*, 9(2), 7-14.

- Trigg, A., & Cordova, F. (1987). An integrated model of learning. *Radiologic Technology*, 58(5), 431-436.
- Tume, L., Baines, P., Guerrero, R., Johnson, R., Ritson, P., Scott, E., . . . Walsh, L. (2017). Patterns of instability associated with endotracheal suctioning in infants with single-ventricle physiology. *American Journal of Critical Care*, 26(5). doi:10.4037/ajcc2017844
- Turner, D., & Cheifetz, I. (2011). Pediatric acute respiratory failure: Areas of debate in the pediatric critical care setting. *Expert Review of Respiratory Medicine*, 5(1), 65-73. doi:10.1586/ers.10.93
- Twigg, D., Duffield, C., Bremner, A., Rapley, P., & Finn, J. (2011). The impact of the nursing hours per patient day (NHPPD) staffing method on patient outcomes: A retrospective analysis of patient and staffing data. *International Journal of Nursing Studies*, 48(5), 540-548. doi:10.1016/j.ijnurstu.2010.07.013
- Twigg, D., Myers, H., Duffield, C., Giles, M., & Evans, G. (2015). Is there an economic case for investing in nursing care - what does the literature tell us? *Journal of Advanced Nursing*, 71(5), 975-990. doi:doi: 10.1111/jan.12577
- Twigg, D., Myers, H., Duffield, C., Pugh, J., Geldera, L., & Roche, M. (2016). The impact of adding assistants in nursing to acute care hospital ward nurse staffing on adverse patient outcomes: An analysis of administrative health data. *International Journal of Nursing Studies*, 63, 189-200. doi:org/10.1016/j.ijnurstu.2016.09.008
- Twycross, A., & Powls, L. (2006). How do children's nurses make clinical decisions? Two preliminary studies. *Journal of Clinical Nursing*, 15(10), 1324-1335. doi:10.1111/j.1365-2702.2006.01453.x
- Valdez, A. (2008). Transitioning from novice to competent: What can we learn from the literature about graduate nurses in the emergency setting? *Journal of Emergency Nursing*, 34(5), 435-440. doi:10.1016/j.jen.2007.07.008
- van der Salm, S., de Haan, R., Cath, D., van Rootselaar, A., & Tijssen, M. (2013). The eye of the beholder: Inter-rater agreement among experts on psychogenic jerky movement disorders. *Journal of Neurology, Neurosurgery, and Psychiatry*, 84(7), 742-747. doi:10.1136/jnnp-2012-304113
- Verger, J., Trimarchi, T., & Barnsteiner, J. (2002). Challenges of advanced practice nursing in pediatric acute and critical care: Education to practice. *Critical Care Nursing Clinics of North America*, 14(3), 315-326. doi:10.1016/S0899-5885(02)00014-X

- Voepel-Lewis, T., Zanotti, J., Dammeyer, J., & Merkel, S. (2010). Reliability and validity of the face, legs, activity, cry, consolability behavioral tool in assessing acute pain in critically ill patients. *American Journal of Critical Care, 19*(1), 55-61. doi:10.4037/ajcc2010624
- Wainwright, S., & Gould, D. (1996). Endotracheal suctioning an example of the problems of relevance and rigour in clinical research. *Journal of Clinical Nursing, 5*(6), 389-398.
- Walsh, J., Vanderwarf, C., Hoscheit, D., & Fahey, P. (1989). Unsuspected hemodynamic alterations during endotracheal suctioning. *Chest, 95*(1), 162-165. doi:10.1378/chest.95.1.162
- Wang, N., Hailey, D., & Yu, P. (2011). Quality of nursing documentation and approaches to its evaluation: A mixed-methods systematic review. *Journal of Advanced Nursing, 67*(9), 1857-2078. doi:10.1111/j.1365-2648.2011.05634.x
- Waxman, K. (2010). The development of evidence-based clinical simulation scenarios: Guidelines for nurse educators. *Journal of Nursing Education, 49*(1), 29-35. doi:org.ipacez.nd.edu.au/10.3928/01484834-20090916-07
- Westbrook, J., Rob, M., Woods, A., & Parry, D. (2011). Errors in the administration of intravenous medications in hospital and the role of correct procedures and nurse experience. *BMJ Quality and Safety, 20*(12), 1027-1034. doi:10.1136/bmjqs-2011-000089
- Whittemore, R., & Knaf, K. (2005). The integrated review: Updated methodology. *Journal of Advanced Nursing, 52*(5), 546-553. doi:10.1111/j.1365-2648.2005.03621.x
- Wood, C. (1998). Endotracheal suctioning: A literature review. *Intensive and Critical Care Nursing, 14*(3), 124-136. doi:10.1016/S0964-3397(98)80375-3
- Zambas, S. (2010). Purpose of the systematic physical assessment in everyday practice: Critique of a “sacred cow”. *Journal of Nursing Education, 49*(6), 305-310. doi:10.3928/01484834-20100224-03
- Zohrabi, M. (2013). Mixed method research: Instruments, validity, reliability and reporting findings. *Theory and Practice in Language Studies, 3*(2), 254-262. doi:10.4304/tpls.3.2.254-262

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APPENDICES

Appendix A

Content Validity Testing of the ESAT[®]: A Decision Aid Tool for Performing Endotracheal Suction in Children

Authors

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Background and Aim

Performing endotracheal tube suction in children can adversely affect clinical stability. Our previous research identified clinical indicators that should be used to inform decision making for this procedure resulting in development of the Endotracheal Suction Assessment Tool[®] (ESAT[®]). Our research aimed to validate the tool for clinical practice.

Methods

Estimation of item content validity index (IVI-I) and scale content validity index (SCI-I) involved testing for ‘clarity’, ‘apparent internal consistency’ and ‘content validity’ using nine expert reviewers from paediatric intensive care units in Australia (n=6), United Kingdom (n=1), Switzerland (n=1) and Canada (n=1). The ICV-I and SCI-I of the ESAT[®] were determined using minimum preset a-priori criterion agreements of 0.78 and 0.8 respectively.

Results

The majority of items achieved preset a-priori agreements for clarity, apparent internal consistency and content validity with ICV-I scores ranging from 0.8-1.0 and

SCV-I scores from 0.9-1.0. Minor adjustments were required to improve clarity of four ESAT[®] items.

Discussion

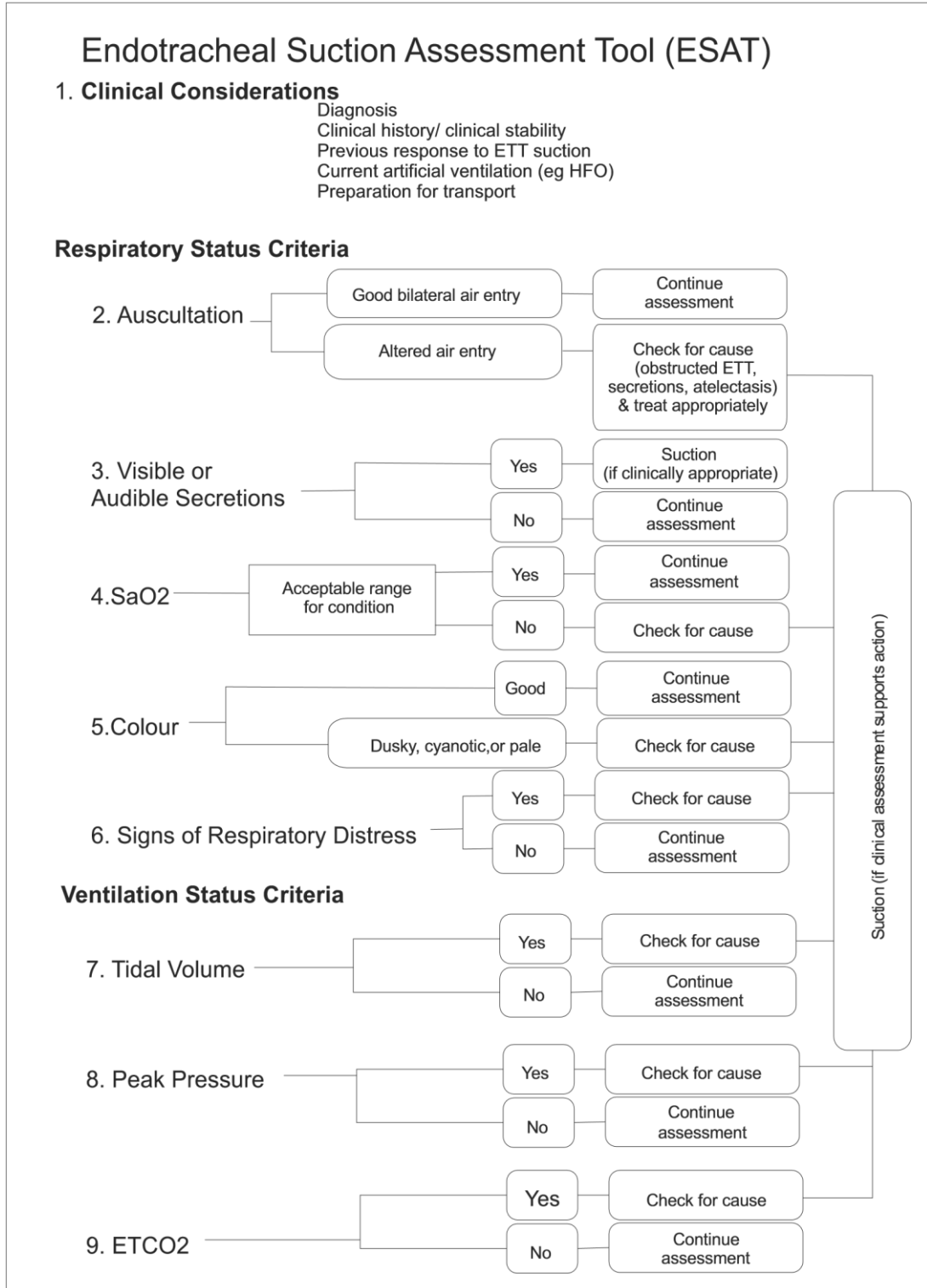
The ICV-I and SCV-I of the ESAT[®] were established. Further psychometric testing for construct validity and stability over time is required to establish clinical utility of the tool and improve patient outcomes and practice of novice paediatric intensive care nurses and other health professionals.

Key Nursing/Midwifery Message

The ESAT[®] is the first tool developed to assist in the decision making process to perform endotracheal suction. Tool validation is a complex and lengthy process, required in the development of validated tools that can be used to improve nursing practice and patient health outcomes.

Appendix B

Original ESAT[©] Design



Appendix C

Endotracheal Suction Questionnaire (ESQ)

ENDOTRACHEAL SUCTIONING QUESTIONNAIRE

Section 1 Demographic Information

Code Number:

1. Designation:

RN CN CNS Other (please state)

2. Age: _____ years.

3. Gender: Male Female

4 Number of years of experience working in Paediatric Intensive/Critical Care:

5 Experience in other Critical Care areas (please tick which is appropriate & write the number of years experience in these areas)

1. Neonatal Intensive Care Number of Years _____
2. Adult Intensive Care Number of Years _____
3. Coronary Care Number of Years _____

6. Have you completed post-graduate qualifications in any of the following specialities? (please tick all that apply):

Neonatal Intensive Care	Yes	<input type="checkbox"/>	No	<input type="checkbox"/>
Paediatric Intensive Care	Yes	<input type="checkbox"/>	No	<input type="checkbox"/>
Adult/Coronary Care Intensive Care	Yes	<input type="checkbox"/>	No	<input type="checkbox"/>

7. Please state the name of the hospital in which you are currently employed.

Section 2 Criteria on ETT Suctioning

8) Respiratory Assessment Criteria

For each of the following criteria please **mark an 'x' on the line** at the point that best shows how often you use the criteria when determining if endotracheal suction is required.

For example: How often do you use *the criteria of the patient's weight* before determining whether to give pressure area care? (The x indicates that this criteria is seldom used).

Not at all	_____ X _____	Always
------------	---------------	--------

a. Dyspnoea or signs of respiratory distress.

Not at all _____ Always

b. Auscultation: (altered, diminished, abnormal air entry).

Not at all _____ Always

c. Decreased oxygen saturation/cyanosis.

Not at all _____ Always

d. Visible or audible secretions.

Not at all _____ Always

e. Coughing.

Not at all _____ Always

f. Altered chest movement.

Not at all _____ Always

g. Suspected aspiration.

Not at all _____ Always

h. Haemodynamics (unexplained changes in heart rate/BP & ICP if applicable).

Not at all _____ Always

i. Alteration in arterial blood gas results.

Not at all _____ Always

j. Decreased tidal volume delivery.

Not at all _____ Always

k. Increasing end tidal CO₂.

Not at all _____ Always

l. Increased peak pressure.

Not at all _____ Always

m. Unexplained patient restlessness.

Not at all _____ Always

n. Suspected obstruction of the endotracheal tube by secretions.

Not at all _____ Always

o. Frequency of endotracheal tube suction is set by unit protocol/guidelines.

Not at all _____ Always

9) To rate the importance of each respiratory assessment criteria **please mark an 'x' on the line** at the point that best shows how important you believe that criteria is when determining whether to perform suction.

For example: How important do you consider *the criteria of a patient's weight* before determining whether to give pressure area care? (The x indicates that this criteria is not very important).

<i>Not at all important</i> _____ <i>Very Important</i>

a. Dyspnoea or signs of respiratory distress.

Not at all important _____ *Very Important*

b. Auscultation: (altered, diminished, abnormal air entry).

Not at all important _____ *Very Important*

c. Decreased oxygen saturation/cyanosis.

Not at all important _____ *Very Important*

d. Visible or audible secretions.

Not at all important _____ *Very Important*

e. Coughing.

Not at all important _____ *Very Important*

f. Altered chest movement.

Not at all important _____ *Very Important*

g. Suspected aspiration.

Not at all important _____ *Very Important*

h. Haemodynamics (unexplained changes in heart rate/BP & ICP if applicable).

Not at all important _____ *Very Important*

i. Alteration in arterial blood gas results.

Not at all important _____ *Very Important*

j. Decreased tidal volume delivery.

Not at all important _____ *Very Important*

k. Increasing end tidal CO₂.

Not at all important _____ *Very Important*

l. Increased peak pressure.

Not at all important _____ *Very Important*

m. Unexplained patient restlessness.

Not at all important _____ *Very Important*

n. Suspected obstruction of the endotracheal tube by secretions.

Not at all _____ Always

o. Frequency of endotracheal tube suction is set by unit protocol/guidelines.

Not at all _____ Always

10. For the following questions, if more space is required to write your answers please use a separate sheet and attach it to the back of this questionnaire – Thank you.

a Describe as fully as possible a recent ETT suction experience you performed. Include in your description the specific factors that influenced your decision to perform endotracheal suction for this patient.

b What criteria (other than you have described above) do you personally consider when determining if a child requires endotracheal suction? (e.g. alteration in the pressure curve on the graphic display of the ventilator).

Thank you for taking the time to complete this form – please enclose within the attached envelope for return.

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Appendix D

Article 1 (PDF)

Clinical indicators for the initiation of endotracheal suction in children: An integrative review

To view the published article please refer to:

Davies K, Monterosso L, Bulsara M, Ramelet AS. (2015). Clinical indicators for the initiation of endotracheal tube suction in children: An integrated review. *Australian Critical Care*, 28(1), 11-8. doi:10.1016/j.aucc.2014.03.001

Appendix E

Article 2 (PDF)

Audit of endotracheal tube suction in a pediatric intensive care unit

To view the published article please refer to:

Davies K, Monterosso L, Bulsara M, Ramelet AS. (2015). Audit of Endotracheal Tube Suction in a Pediatric Intensive Care Unit. *Clinical Nursing Research*, 26(1), 68-81. doi:10.1177/1054773815598272

Appendix F
Article 3 (PDF)
Content validity testing of the ESAT©

To view the published article please refer to:

Davies K, Bulsara M¹, Ramelet AS², Monterosso L³. (2018). Content validity testing of the ESAT©: A decision aid tool for performing endotracheal suction in children. *Australian Critical Care*, 31(1), 23-30. doi: 10.1016/j.aucc.2017.01.006

Appendix G

Article 4 (PDF)

Reliability and criterion-related validity testing (construct) of the Endotracheal Assessment Tool (ESAT®)

To view the published article please refer to:

Davies K, Bulsara M¹, Ramelet A-S², Monterosso L³. Reliability and criterion-related validity testing (construct) of the Endotracheal Suction Assessment Tool (ESAT®). J Clin Nurs. 2018;27:1891–1900. <https://doi.org/10.1111/jocn.14269>

Appendix H

Definitions of ESAT[®] Criteria

Table H.1 Definitions of ESAT[®] Criteria

Criterion	Definition
Clinical Considerations	<p>Relating to or directly involving observation of the patient's respiratory status including diagnosis, clinical observations in an objective, analytical and concise method.</p> <p><i>Q: Does the patient need ETT suction & will this improve or compromise the stability of the patient?</i></p>
Diagnosis	<p>The process of determining the nature and cause of the disease or injury through critical analysis and evaluation of the patient's history, direct examination and review of all investigative procedures and laboratory results.</p> <p><i>Q: How does the patient's diagnosis impact on the need to perform ETT suction or their ability to tolerate the procedure?</i></p>
Clinical History or Clinical Stability	<p>Detailed description of the patient's current physiological condition and acuity. Focused on patient's ability to tolerate handling or invasive procedures, especially ETT suction.</p> <p><i>Q: Did performing ETT suction or repositioning the patient improve or compromise patient's clinical stability?</i></p>
Previous response to ETT suction	<p>Detailed description of the patient's physiological response to previous endotracheal tube (ETT) suction and the physiological response during and post ETT suction.</p> <p><i>Q: Did this improve or compromise patient's clinical stability?</i></p>
Current Artificial Ventilation	<p>Type of breathing support i.e. high frequency oscillation, mode of ventilation.</p> <p><i>Q: What compromise to the patient's ventilation and haemodynamics will occur with disconnection from the ventilator for ETT suction?</i></p>
Preparation for Transport	<p>Requirement to perform ETT suction in preparation for transport.</p> <p><i>Q: Does the patient require ETT suction to assess or stabilise the patient's airway prior to moving?</i></p>
Preparation for Extubation	<p>Requirement to perform ETT suction in preparation for extubation.</p> <p><i>Q: Will this improve and clear the patient's airway to maximise successful extubation?</i></p>
Assess Respiratory Status	<p>The physical assessment of the patient's airway, inspiration & expiration respiration effort and ventilation parameters.</p> <p><i>Q: Have you assessed the patient by auscultation of the chest, assessing for secretions, looked at the SaO₂ readings, assessed the patient colour, work of breathing, looked for signs of respiratory distress, noted and interpreted ventilator tidal volumes, peak pressure & ETCO₂ readings?</i></p>
Auscultation	<p>Utilising a stethoscope to listen to the sounds produced as air moves into and out of the lungs. Includes assessing for areas of altered air movement within the lungs. Can also include palpation and percussion of the chest.</p> <p><i>Q: What sounds are you hearing, are they directly related to the patient's airway so are they transmitted sounds?</i></p>

Criterion	Definition
Visible or Audible Secretions	Any substance within the respiratory system including the ETT, may include mucous, blood or foreign particles. <i>Q: Are these secretions interfering with the oxygenation and ventilation of the patient?</i>
SpO ₂	Oxygen saturation percentage. <i>Q: Is this normal or abnormal for this patient and would ETT suction improve the reading?</i>
Colour	Patient's skin colour which may include descriptors such as pale, pink, flushed, dusky, altered capillary return times or cyanotic. <i>Q: Is this normal or abnormal for this patient and would ETT suction improve the situation?</i>
Signs of Respiratory Distress	Any increase in work of breathing for the patient i.e. tachypnoea, tachycardia, chest wall recession, nasal flaring, tracheal tug, paradoxical breathing, agitation, added noises (grunt, wheeze), changes in SpO ₂ , cyanosis, sweating, increased PaCO ₂ and acidosis. <i>Q: Are these signs of respiratory distress due to oxygenation and ventilation issues that would improve on ETT suction or related to inadequate sedation?</i>
Assess Ventilation Status	Directly related to the parameters displayed on the ventilator screen. <i>Q: Have you assessed the tidal volume, peak pressure & ETCO₂ of the patient?</i>
Tidal Volume (Tv)	The volume of air inspired and expired during a single breath. <i>Q: Is the Tv (inspired & expired readings) within acceptable parameters for this patient and would ETT suction improve the situation?</i>
Peak Pressure (Pp)	Maximum pressure reading displayed on the ventilator during or at the end of the inspiration. <i>Q: Is the Pp within acceptable parameters for this patient and would ETT suction improve the situation?</i>
ETCO ₂	The level of expired CO ₂ at the end of expiration. <i>Q: Is the ETCO₂ within acceptable parameters for this patient and would ETT suction improve the situation?</i>