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Research paper

The Paediatric AirWay Suction (PAWS) appropriateness guide for endotracheal suction interventions

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ABSTRACT

Background/objective: Endotracheal suction is an invasive and potentially harmful technique used for airway clearance in mechanically ventilated children. Choice of suction intervention remains a complex and variable process. We sought to develop appropriate use criteria for endotracheal suction interventions used in paediatric populations.

Methods: The RAND Corporation and University of California, Los Angeles Appropriateness Method was used to develop the Paediatric AirWay Suction appropriateness guide. This included defining key terms, synthesising current evidence, engaging an expert multidisciplinary panel, case scenario development, and two rounds of appropriateness ratings (weighing harm with benefit). Indications (clinical scenarios) were developed from common applications or anticipated use, current practice guidelines, clinical trial results, and expert consultation.

Results: Overall, 148 (19%) scenarios were rated as appropriate (benefit outweighs harm), 542 (67%) as uncertain, and 94 (11%) as inappropriate (harm outweighs benefit). Disagreement occurred in 24 (3%) clinical scenarios, namely presuction and postsuction bagging across populations and age groups. In general, the use of closed suction was rated as appropriate, particularly in the subspecialty population '*patients with highly infectious respiratory disease*'. Routine application of 0.9% saline for nonrespiratory indications was more likely to be inappropriate/uncertain than appropriate. Panellists preferred clinically indicated suction versus routine suction in most circumstances.

Conclusion: Appropriate use criteria for endotracheal suction in the paediatric intensive care have the potential to impact clinical decision-making, reduce practice variability, and improve patient outcomes.

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Furthermore, recognition of uncertain clinical scenarios facilitates identification of areas that would benefit from future research.

1. Introduction

Endotracheal suction (ETS) is a vital airway intervention to remove respiratory secretions and may assist in maintaining endotracheal tube patency in mechanically ventilated children. Despite its importance, ETS is potentially harmful, with a recent study estimating 22% of suction episodes may result in complications arising from the procedure,[1–3] including oxygen desaturation and hypotension.[3,4] Although often transient, these complications may be important determinants of outcomes following mechanical ventilation including days free of respiratory support.[5–7] While our understanding of the safety and efficacy of many ETS interventions (e.g., lung recruitment, 0.9% saline) is still evolving,[3] variations in care and the inappropriate use (over or under use) of certain interventions may be a strong predictor of ETS complications. Variation in global ETS practices is well known to exist, and while a degree of variability can be attributed to patient heterogeneity (e.g., ventilation for overdose versus asthma exacerbation), the lack of evidence-based recommendations[3,8,9] is a significant contributor.

The diversity of the paediatric intensive care population makes determining the appropriateness of ETS interventions challenging. For mechanically ventilated children, an appropriate ETS intervention is one that is likely to contribute to improved clinical outcomes, whereas inappropriate interventions are potentially harmful, generating unwanted costs to the healthcare system. This study seeks to address the gaps in clinical guidance[10] on how best to utilise ETS interventions in daily clinical care. We therefore sought to develop appropriate use criteria for ETS interventions in children using the RAND Corporation and University of California, Los Angeles (RAND/UCLA) Appropriateness Method. The resulting resource would be referred to as the Paediatric AirWay Suction (PAWS) appropriateness guide for ETS interventions.

2. Methods

Appropriate use criteria were developed using the RAND/UCLA Appropriateness Method.[11] The method involves the following sequential phases: (i) definition of scope and key terms; (ii) information synthesis and evidence review; (iii) expert (technical) panel selection and engagement; (iv) case scenario development; and (v) appropriateness ratings by the expert panel over two rounds. This method combines evidence-based medicine and clinical experience by engaging an expert interdisciplinary panel. To further enhance the rigour of this process, the clinical scenarios were circulated for external review both nationally and internationally before convening the expert panel. A detailed description of the methods used is available (https://doi.org/10.1016/j.aucc.2021.10.006). The study received ethical approval from Griffith University Human Research Ethics Committee (2019/916).

2.1. Definition of scope and key terms

The PAWS appropriateness guide defined the appropriateness of ETS interventions commonly used in mechanically ventilated children in paediatric intensive care units (PICUs), inclusive of patients aged from birth (>37 weeks) to 18 years. The objective of the PAWS was to provide guidance on important clinical questions (i.e., suction intervention, frequency, depth, population-specific interventions) for clinicians primarily caring for mechanically ventilated patients in the PICU.

Definitions of terms used throughout the indications are listed in the development publication (https://doi.org/10.1016/j.aucc.2021.10.006, development paper submitted with results paper [1 of 2]; Supplementary material 1). These include patient population and subgroups, suction interventions (i.e., preoxygenation, mean airway pressure [MAP] manipulation, 0.9% saline instillation, open/closed suction, positive end-expiratory pressure [PEEP] manipulation), and indications for suction (i.e., non-respiratory, or respiratory indications).[12,13] ***Clinical indications for endotracheal suction*** were categorised into two classifications:[13–15] nonrespiratory indications such as routine or proactive/preprocedural indications (e.g., preextubation, before transfer) and respiratory indications, that is a change in the patient's respiratory status (e.g., decreased air entry, visible/audible secretions, change in tidal volume, peak inspiratory pressure, or end tidal CO_2).

2.2. Information synthesis and literature review

A systematic review of ETS literature was undertaken using Cochrane Collaboration methods.[11,16] A detailed literature review[10] and critical appraisal of current ETS guidelines[17] are reported in previous publications. The literature was synthesised and provided to the expert panel before appropriateness rating.[11] Findings from the review were also utilised to inform discussion in the panel discussions during round 2 panel ratings.

2.3. Expert panel selection and engagement

Twelve expert clinicians and researchers representing the specialty requirements of Australian and New Zealand PICUs and typically responsible for decision-making regarding paediatric ventilation and suction management were invited to serve as voting panel members. Full panellist details are available in the development publication (https://doi.org/10.1016/j.aucc.2021.10.006; Supplementary material 2). Five nonvoting panellists including a parent representative and four facilitators (including a methodologist) were included to ensure rigour and a patient-centred focus throughout all discussions. The PICU parent experience was further explored with a discussion of the lived experience, led by the parent representative at the commencement of the meeting. Nonvoting participants were involved in the panellist meeting and discussion but did not rate individual scenarios. The resulting panel was a professional group with a wide range of skills and insights.

2.4. Case scenario development

Clinical scenarios were constructed by experts in PICU medicine and based on data from systematic reviews. Scenarios included indications based on the (i) mode of ventilation, (ii) age, and (iii) use for specific reasons (i.e., high-risk patient populations). This approach is reflective of the complex nature of the clinical environment and patient cohort. Our conceptual framework is available

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(under review with ACC, development paper submitted with results paper [1 of 2]).

Within each main population category, a standardised approach was used to capture the majority of clinical scenarios without making the list of indications excessive. This approach led to the creation of four broad clinical scenarios regarding the possible use of ETS for paediatric patients within the following cohorts: (i) general diagnosis, (ii) management of a cardiovascular disease, (iii) management of a severe traumatic brain injury (TBI), and (iv) respiratory disease. Complex clinical scenarios (e.g., determination of neurological brain death) were additionally addressed with focused indications and preference questions.

An important focus during the clinical scenario revision process was to harmonise indications such that the wording of indications was similar to other guidelines[17,18] or registries.[19] The clinical scenarios were modified on the basis of discussion and review by senior PICU clinicians (including experts in cardiac and neuro critical care) and feedback from independent national and international reviewers. This ensured that scientific content, indications, and contextual factors were considered and adequately represented.

2.5. Appropriateness rating by expert panel

Two rounds of appropriateness rating of the clinical scenarios were completed (November 2020 and February 2021). In the RAND/UCLA method, an appropriate intervention is one where the expected benefit, combined with clinical judgement, exceeds the anticipated negative consequence by a sufficiently wide margin for a specific clinical scenario (irrespective of cost).[11] The intervention is then generally considered acceptable care and a reasonable approach for the clinical scenario.

The expert panel scored each indication using an adaptation of existing rubrics[11,20] as follows:

- Median score 7 to 9: appropriate intervention for specific indication (the intervention **is** generally acceptable and **is** a reasonable approach for the indication);
- Median score 4 to 6: uncertain for specific indication (intervention **may** be generally acceptable and **may** be a reasonable approach for the indication). Uncertainty also implies that more research and/or patient information is needed to classify the indication definitively.
- Median score 1 to 3: inappropriate intervention for that indication (intervention **is not** generally acceptable and **is not** a reasonable approach for the indication).

In round 1, panellists independently rated the clinical scenarios using an interactive, electronic form. As previously described (https://doi.org/10.1016/j.aucc.2021.10.006, development paper submitted with results paper [1 of 2]), panellists received the literature review, definitions of terms, a rating document, and instructions for rating. Panellists returned the completed form to the investigator group via email. Returned forms were collated in a master document.

Owing to COVID-19 restrictions, round 2 appropriateness ratings occurred online using Microsoft Teams®. Experts were provided with their scores and a blinded summary of their peers' scores from round 1. Following discussion, panel members were then asked to independently rerate the appropriateness of clinical scenarios.

The level of agreement among panellists[11] was analysed based on the rule for a panel of 11–13 members. As such, agreement was defined as an indication where ≤three panellists rate outside the 3-point region containing the median score. Disagreement was defined as where at least four panellists' ratings fell in both the appropriate and inappropriate categories.

3. Results of ratings

A total of 901 clinical scenarios were developed for panellist review in round 1. In round 1, 188 (21%) scenarios were rated as appropriate, 80 (9%) as inappropriate, and 587 (42%) as uncertain. Disagreement was evident in 46 clinical scenarios (5%).

During round 2 discussions, panellists removed 340 scenarios. Indications for suction were collapsed from three to two (because they were considered duplicative), and high-frequency oscillation ventilation (HFOV) as a mode of ventilation was removed for some patient populations (because they were considered not clinically applicable, e.g., patients with a severe TBI). In round 2, 234 clinical scenarios were added (e.g., presuction and postsuction bagging) and a further 14 clinical scenarios adapted (e.g., the appropriateness of deep suction applied by an advanced practitioner). This left 809 scenarios to review. In round 2, panellists rated 148 scenarios as appropriate (19%), 94 as inappropriate (11%), and 542 as uncertain (67%), disagreeing on 24 scenarios (3%). The discussion and clarifications in round 2 increased the proportion of clinical scenarios rated as uncertain (from 42% to 68%) and reduced those with disagreement (from 5% to 3%).

3.1. Endotracheal suction appropriate use criteria (by population)

The final ratings for ETS interventions are presented using visual representations (flow diagrams; Figs. 1–5), organised by population. Appropriate indications are presented as green (bolded), inappropriate as red (underlined), and uncertain presented as yellow (italics), and disagreement is presented as black. The final rating reflects the median score of the 12 expert panel members. Supplementary material 3 to 6 present the subspecialty populations' appropriateness ratings.

3.1.1. The appropriateness of endotracheal suction interventions in paediatric patients with a general diagnosis

The PAWS recommendations for ETS interventions in paediatric patients with a general diagnosis across clinical indications are summarised in Fig. 1. Within this population, the panel considered neonates who have endotracheal tubes with smaller internal diameters, reduced respiratory drive, and poor lung compliance.[21,22] This population has an increased risk of respiratory and haemodynamic instability (systemic hypertension) with suction,[22,23] particularly following 0.9% saline administration.[4,24,25] The panel therefore rated 0.9% saline instillation as inappropriate in this age group and uncertain across all other age groups. These recommendations reflect current uncertainty regarding the risk versus benefit of 0.9% saline instillation during suction in the general paediatric intensive care population.[8,26–28] Disagreement was evident in two clinical scenarios related to presuction bagging (endotracheal tube to anaesthetic bag hand ventilation) in children requiring suction for respiratory indications. Appropriate use recommendations for children with systemic therapeutic anticoagulation are listed by indication in Supplementary material 3.

3.1.2. The appropriateness of endotracheal suction interventions in paediatric patients admitted for the management of cardiovascular disease (including acquired conditions, e.g., cardiac tumour, cardiac failure)

The PAWS recommendations for ETS interventions in paediatric patients admitted for the management of cardiovascular disease are outlined in Fig. 2. Disagreement was evident in two clinical

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Fig. 1. Appropriate use criteria for endotracheal suction interventions in paediatric patients with a general diagnosis. Bag_{pre} = bagging (anaesthetic bag to endotracheal tube) pre endotracheal suction; CMV = conventional mechanical ventilation; $O_{2\ pre}$ = presuction oxygenation; iSLN = instillation of 0.9% saline; OPN = open suction; CLD = closed suction; $O_{2\ post}$ = postsuction oxygenation; PEEP = positive end-expiratory pressure; Bag_{post} = bagging after endotracheal suction.

scenarios related to postsuction bagging. The panel considered the impact of ETS intervention use in neonates following high-risk surgical procedures such as the classic Norwood or Norwood-Sano procedure, pulmonary artery banding, and the modified Blalock–Taussig shunt. Given the high rate of adverse events associated with ETS in this cohort,[29,30] closed suction was recommended as appropriate.[31–34] All other interventions were rated as uncertain due to a lack of high-quality evidence.[2,10,35] Appropriate use recommendations for children in the following subspecialty populations are listed in Supplementary material 4:

i. Low-risk and stable haemodynamics following cardiac surgery;
ii. High-risk and/or unstable haemodynamics following cardiac surgery; and
iii. High-risk cardiovascular conditions, patients with severe cardiac conditions with a high degree of instability;
iv. Pulmonary hypertension;
v. On extracorporeal membrane oxygenation.

3.1.3. The appropriateness of endotracheal suction interventions in paediatric patients admitted for the management of a severe TBI

The PAWS recommendations for ETS interventions in paediatric patients admitted for the management of severe TBI are outlined in Fig. 3. Closed suction was rated as appropriate across all age groups and indications with the exception of neonates (rated uncertain) reflecting the perceived increased risk of haemodynamic complications following open suction.[36] For nonrespiratory indications, panellists rated the use of 0.9% saline as inappropriate in neonates, infants, and children. Instillation of 0.9% saline is associated with an increased risk of postsuction complications including desaturation and hypotension.[3,24,25] Appropriate use recommendations for children in the following subspecialty populations are listed in Supplementary material 5:

i. Paediatric patients with raised intracranial pressure following TBI;
ii. Paediatric patients with a hypoxic brain injury;
iii. Paediatric patients post neurovascular procedure/neurosurgery; and
iv. Paediatric patients following neurological determination of death.

3.1.4. The appropriateness of endotracheal suction interventions in paediatric patients with a respiratory diagnosis

The PAWS recommendations for ETS interventions in paediatric patients with a respiratory diagnosis and highly infectious respiratory disease are described in Fig. 4. Disagreement was evident in one scenario: the application of postsuction bagging. Panellists considered the negative effects open suction has on lung volume and oxygenation indices[37–39] in children undergoing HFOV, rating prebagging (requiring circuit disconnection) as inappropriate (except in neonates – rated uncertain) and closed suction as appropriate across all age groups and indications. Suctioning an intubated patient with a highly infectious respiratory disease (e.g., coronavirus disease 2019) is an aerosol-generating procedure and is therefore at a high risk of spreading infection.[40–42] Panellists recommended the use of closed suction and no intervention which

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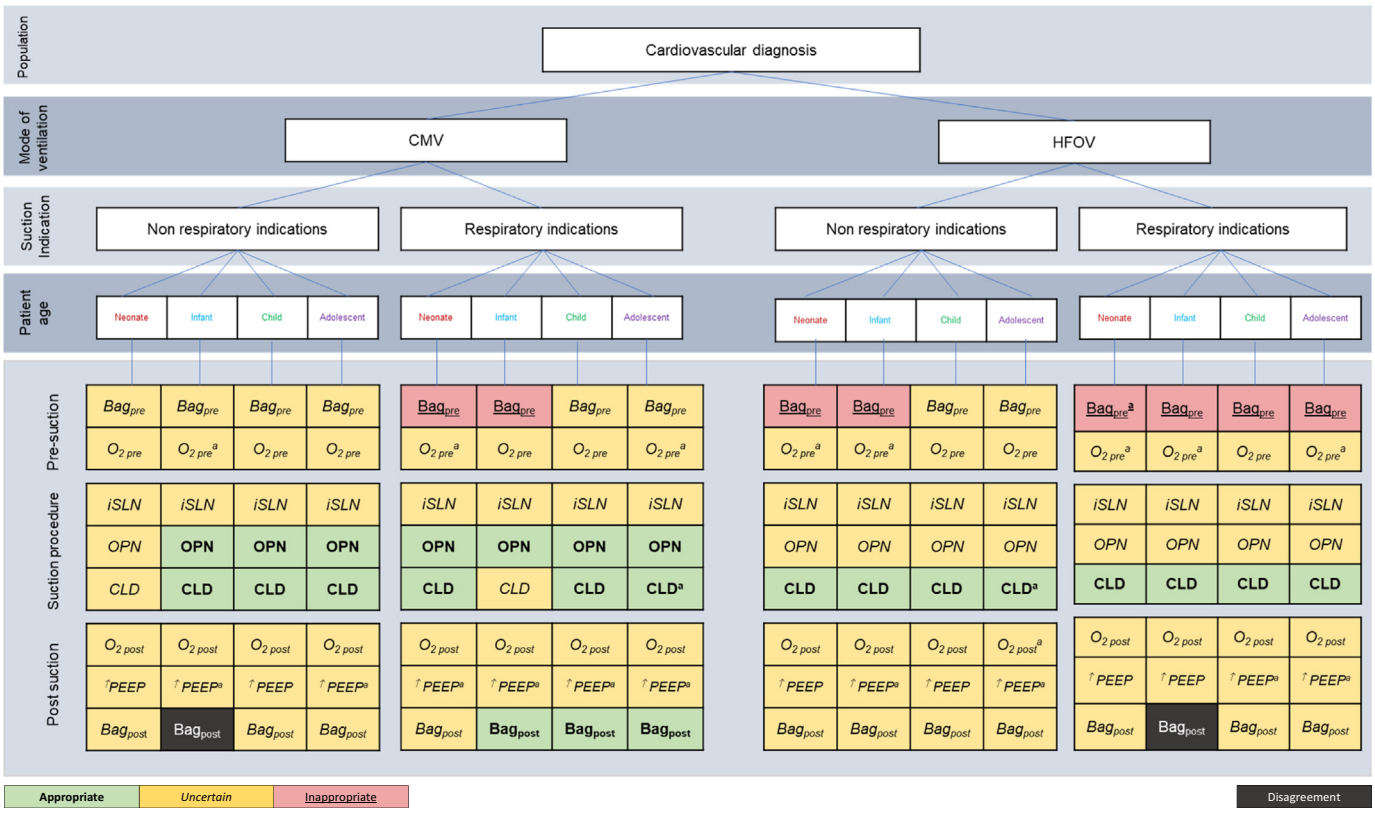

Fig. 2. Appropriate use criteria for endotracheal suction interventions in paediatric patients admitted for the management of cardiovascular disease. Bag_{pre} = bagging (anaesthetic bag to endotracheal tube) pre endotracheal suction; CMV = conventional mechanical ventilation; HFOV = high-frequency oscillation ventilation; $O_{2\ pre}$ = presuction oxygenation; iSLN = instillation of 0.9% saline; OPN = open suction; CLD = closed suction; $O_{2\ post}$ = postsuction oxygenation; PEEP = positive end-expiratory pressure; Bag_{post} = bagging after endotracheal suction; [a] = agreement.

required circuit disconnection. There was consideration that although the PICU clinicians perform ETS with high-level personal protective equipment, ETS is a high-risk procedure for airborne and droplet transmission of respiratory particles.[42] Therefore, closed-suction systems that permit the removal of tracheobronchial secretions without disconnecting ventilatory circuits are desirable.[43]

Appropriate use recommendations for children in the following subspecialty populations are listed in Supplementary material 6:

i. Paediatric patients with acute respiratory distress syndrome;
ii. Paediatric patients with acute respiratory distress syndrome, nursed in a prone position.

3.2. Additional ratings

3.2.1. Appropriateness of deep suction

In general, the appropriateness of deep suction to the point of resistance (i.e., the carina) was rated as inappropriate (median 2). When applied by an advanced healthcare practitioner or in children with a respiratory diagnosis, the appropriateness of deep suction was rated uncertain (median 5). When applied in circumstances of suspected endotracheal tube occlusions, deep suction was rated appropriate (median 7). Panellists acknowledged this was a painful and distressing procedure.

3.2.2. Appropriateness of MAP manipulation

Across all clinical scenarios, the appropriateness of MAP manipulation before ETS in patients receiving HFOV was rated as uncertain (median rating for all scenarios fell between 4 and 6). No disagreement was evident across ratings.

3.2.3. Preference for clinically indicated suction versus routine suction

Table 1 outlines panellists' preference for clinically indicated versus routine suction for each indication (1 = preference for clinically indicated, 9 = strongly prefer routine suction). In general, the use of clinically indicated ETS was preferred in most scenarios (with little variation in ratings) with the exception of patients on extracorporeal membrane oxygenation or following neurological determination of death.

4. Discussion

This study developed appropriate use criteria for ETS interventions in mechanically ventilated children. The intent of the PAWS guideline (ETS appropriate use criteria) is to inform the rational use of ETS interventions, namely avoidance of inappropriate interventions and use of appropriate interventions, thereby contributing to improved clinical outcomes in children. The results of our study add insight to current clinical data and ETS standards[2,18,58] and importantly, highlight areas of uncertainty in practice for future investigation.

ETS is one of the most common airway interventions ventilated children receive, yet the optimal method both in terms of effectiveness and minimising risk is unclear. We identified substantial uncertainty (542 of 796 scenarios, 67%) regarding the appropriate use of ETS interventions across clinical scenarios and PICU populations. This ongoing uncertainty has a profound impact on day-

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Fig. 3. Appropriate use criteria for endotracheal suction interventions in paediatric patients admitted for management of a severe traumatic brain injury. Bag_{pre} = bagging (anaesthetic bag to endotracheal tube) pre endotracheal suction; CMV = conventional mechanical ventilation; $O_{2\ pre}$ = presuction oxygenation; iSLN = instillation of 0.9% saline; OPN = open suction; CLD = closed suction; $O_{2\ post}$ = postsuction oxygenation; PEEP = positive end-expiratory pressure; Bag_{post} = bagging after endotracheal suction; [a] = agreement.

to-day ETS practice, evidenced by variable ETS practices across health services,[62] clinician uncertainty,[63] and high rates of ETS complications.[3] Interestingly we identified minimal disagreement (3%) among ratings yet considerable uncertainty, which suggests there are insufficient data to inform expert opinion regarding the interventions. These findings are unsurprising given many respiratory interventions lack efficacy data to support their application.[64,65] Whilst we used the RAND/UCLA to help overcome this challenge, it is clear rigorous data are needed to support clinical decision-making regarding ETS in the PICU. Revisions of the PAWS guideline will be required in future to incorporate new evidence (studies assessing the application of an intervention or the guideline in clinical practice), with iterations hopefully adding clarity to areas of current uncertainty.

Overall, the rated indications focused on children of any age and the use of closed suction were viewed favourably by the rating panel. Open suction was more likely to be rated uncertain for higher acuity populations, as were interventions which were perceived to involve "breaking the circuit" (e.g., pre and post suction bagging). Unsurprisingly, there was agreement from the panel that use of open suction and presuction and postsuction bagging (endotracheal tube to anaesthetic bag) was inappropriate in scenarios involving children with highly infectious respiratory disease.[43] With increased support for closed suction systems,[31,32,34,66] our findings support the implementation of closed systems in the PICU, particularly during peak influenza (or respiratory virus) seasons or during communicable disease outbreaks. Closed systems aid in the reduction of circuit disruptions and aerosolisation of infectious particles, which have safety implications for staff and visitors, particularly during peak influenza seasons or during communicable disease outbreaks. However, caution is required with a paucity of clinical trial data to support the safety and effectiveness of this intervention in the PICU, and further investigation is warranted.

Unsurprisingly, clinically indicated suction was preferred over routine suction, with suction need indicated by signs including visible, audible, or palpable secretions, increased inspiratory pressure, and reduced tidal volumes[13]—with or without accompanying evidence of diffusion impairment (e.g., reduced oxygen saturations). This finding is important as it can be used to support clinical practice recommendations binationally. Such recommendations can be further supported by the published Endotracheal Suction Assessment Tool,[14,15] a pragmatic tool developed to support PICU clinicians' assessment of need for clinically indicated suction.

4.1. Use of ETS appropriate use criteria to improve care

Our rating process used available evidence supplemented by expert opinion to determine whether the net benefit or risk of an intervention makes it reasonable to perform in a certain clinical scenario. We anticipate our criteria to be useful for clinicians and healthcare services that care for intubated and ventilated paediatric patients. For example, panellists were also more likely to prefer clinically indicated suction than routine ETS,[67] an important finding for policy makers. However, implementation studies evaluating the clinical application of the PAWS are needed to determine (i) whether the majority of clinical scenarios can be classified by the criteria and (ii) the effect of implementing the appropriate use criteria on practice change (e.g., reduction in inappropriate/rarely appropriate care).

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Fig. 4. A: Appropriate use criteria for endotracheal suction interventions in paediatric patients with a respiratory disease. B: Appropriate use criteria for endotracheal suction interventions in paediatric patients with highly infectious respiratory disease. CMV = conventional mechanical ventilation; HFOV = high-frequency oscillation ventilation; Bag_{pre} = bagging (anaesthetic bag to endotracheal tube) pre endotracheal suction; $O_{2\ pre}$ = presuction oxygenation; iSLN = instillation of 0.9% saline; OPN = open suction; CLD = closed suction; $O_{2\ post}$ = postsuction oxygenation; PEEP = positive end-expiratory pressure; Bag_{post} = bagging after endotracheal suction; [a] = agreement.

Implementation evaluation could be guided by an implementation framework such as the Consolidated Framework for Implementation Research[68] and explore the processes involved in delivering the intervention (e.g., clinician acceptability of guideline). Clinical evaluation could examine relevant clinical endpoints (e.g., development of a ventilator-associated condition), whereas cost-effectiveness evaluation could evaluate macro and micro health service outcomes (e.g., duration of ventilation). This evaluation is important with a recent meta-analysis (18 studies) of appropriate use criteria for cardiology finding implementation of appropriate use criteria was associated with a reduction in inappropriate care (odds ratio: 0.62, 95% confidence interval: 0.49–0.78).[69] Based on international examples of implementation of the PAWS, ETS appropriate use criteria in the PICU may be best achieved by testing small changes sequentially (e.g., one group of appropriate use criteria recommendations at a time) to better determine cause and effect relationships and through the use of a quality implementation science framework or model.[69]

Formal stakeholder engagement is crucial to promote sustainable uptake as geographic variability exists in ETS practices,

Table 1
Preference ratings for clinically indicated suction versus routine suction across clinical scenarios.

Clinical scenario	Median rating		
	1–3	4–6	7–9
Patients with a general diagnosis	1[a]		
Systemic therapeutic anticoagulation	1[a]		
Cardiovascular	1[a]		
Low-risk and stable haemodynamics after cardiac surgery	1[a]		
Neonatal patients with high-risk and/or unstable haemodynamics after cardiac surgery	1[a]		
High-risk cardiovascular conditions	1[a]		
Cardiovascular patients with pulmonary hypertension	1[a]		
Extracorporeal membrane oxygenation		5	
Severe traumatic brain injury	2[a]		
Raised intracranial pressure after TBI	1[a]		
Hypoxic brain injury	1[a]		
Post neurovascular procedure/neurosurgery	1[a]		
Certified neurological death		5[d]	
Respiratory	2[a]		
Patients with acutes respiratory distress syndrome	1[a]		
Patients with PARDS nursed prone	2		
Patients requiring long-term ventilation	1[a]		
Patients requiring ventilation for palliative care	1[a]		
Patients requiring ventilation for transport	3		

1 = preference for clinically indicated suction, 9 = preference for routine suction. a = agreement; d = disagreement.
NB: A preference question is rated differently to an appropriateness rating. In this clinical scenario, a score of 1 equates to a panellist's preference for clinically indicated suction, and conversely, a rating of 9 equates to a preference for routine suction.
TBI = traumatic brain injury. PARDS: paediatric acute respiratory distress syndrome.

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influenced by units' historic practices and regional differences in children's health. In future, institutions may take advantage of advances in electronic medical records to implement appropriate use criteria. ETS appropriate use criteria could be integrated into clinical workflows using clinical analytics to facilitate data-driven decision-making. Such systems would support appropriate ETS intervention selection through real-time appropriate use criteria benefit versus risk calculations for the individual child and assist in the tracking of practice and clinical outcome patterns over time.

4.2. Implications for future research

This work and our previous systematic reviews[10,17,70] demonstrate the need for robust high-level evidence to determine the safety and effectiveness of routinely used ETS interventions. As ETS typically involves the delivery of several interventions, a platform trial would be an efficient strategy for evaluating multiple treatments, or different treatment combinations.[71] For example, PEEP recruitment manoeuvres may assist overburdened respiratory muscles to better cope with ETS—preventing alveolar derecruitment; however, the benefits of this intervention may be maximised when used in combination with 0.9% saline instillation (secretion clearance) and closed suction (decreased lung volume loss). Trials need to include larger sample sizes based on sample size calculations, optimal and well-described protocols (dose/response), responsive outcome measures (e.g., impedance, compliance, and resistance), and longer-term data capture including measures of morbidity (e.g., ventilator associated infection). Best evidence needs to go beyond the 'typical' PICU patient and address a more customised approach (precision medicine) to airway clearance and secretion drainage. One example of this is respiratory subpopulations where mucous production has switched from healthy to pathologic. It is likely that implementation studies of the PAWS guideline will also identify gaps, both from omissions to initial criteria and subsequent advances in PICU care. Finally, international studies that measure intervention delivery beyond the local healthcare context would be valuable and aid generalisability.

4.3. Strengths and limitations

Our study has limitations. First, we were unable to convene a face-to-face meeting in Round 2, as per RAND/UCLA methods, owing to COVID-19 and travel/social distancing restrictions, and the meeting was moved to an online platform. This change may have reduced discussion and questions among panellists on the day. Furthermore, an additional limitation of the virtual meeting was our inability to cross-check completion by the panel contemporaneously.

Despite this, our study has strengths. An important focus across scenario development and defining key terms was harmonising these elements with existing PICU guidelines, registries, and ventilation guidelines.[18,19,53,72,73] The goal of relating indications to the available evidence was to contribute to increased efforts to standardise language around paediatric ventilation and ETS. Further engagement of a broad range of multidisciplinary specialists with extensive experience contributed to the rigour of the recommendations. Broad binational representation was also possible owing to the meeting been convened online. Finally, the current COVID-19 pandemic may have impacted the results of this study, with some panellists reporting an increased use of closed suction due to a heightened awareness of virus transmission.

5. Conclusion

The PAWS guideline is valuable across a broad range of contexts, including guiding care of individual critically ill patients, educating staff, and informing policy decisions regarding ETS. Our appropriate use criteria reflect the critical care literature as well as expert consensus and are intended to evaluate the appropriate use of ETS interventions applied in specific paediatric (including newborn) clinical scenarios. They are not a substitute for sound clinical judgment and practice experience in circumstances where there is substantial variation between the appropriate use rating and what the clinician believes is the best recommendation for the patient. Despite this, the ETS appropriate use criteria can be used to reduce practice variation and support clinical decision-making to optimise the ETS procedure. Further work is needed to test the effect of implementing the PAWS guideline in clinical practice on important patient, cost-effectiveness, and implementation outcomes.

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Conflict of Interest

The authors have no conflicts of interest to disclose.

CRediT authorship contribution statement

Jessica Schults: Conceptualisation, Funding acquisition, Methodology, Investigation, Data curation, Writing – original draft, Visualisation. **Karina Charles**: Methodology, Investigation, Resources, Data curation, Writing – original draft, Visualisation, Project administration. **Debbie Long**: Conceptualisation, Funding acquisition, Methodology, Writing – review and editing. **Georgia Brown**: Investigation, Writing – review and editing. **Beverley Copnell**: Investigation, Writing – review and editing. **Peter Dargaville**: Investigation, Writing – review and editing. **Kylie Davies**: Investigation, Writing – review and editing. **Simon Erikson**: Investigation, Writing – review and editing. **Kate Forrest**: Investigation, Writing – review and editing. **Jane Harnischfeger**: Investigation, Writing – review and editing. **Adam Irwin**: Investigation, Writing – review and editing. **Tina Kendrik**: Investigation, Writing – review and editing. **Anna Lake**: Investigation, Writing – review and editing. **George Ntoumenopoulos**: Investigation, Writing – review and editing. **Michaela Waak**: Investigation, Writing – review and editing. **Mark Woodard**: Investigation, Writing – review and editing. **Lyvonne Tume**: Methodology, Writing – review and editing. **Marie Cooke**: Conceptualisation, Methodology, Writing – review and editing. **Marion Mitchell**: Conceptualisation, Methodology, Writing – review and editing. **Lisa Hall**: Conceptualisation, Funding acquisition, Methodology, Writing – review and editing. **Amanda Ullman**: Conceptualisation, Funding acquisition, Methodology, Validation, Writing – review and editing.

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Appendix A. Supplementary data

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References

[1] Davies K, Bulsara MK, Ramelet AS, Monterosso L. Audit of endotracheal tube suction in a pediatric intensive care unit. Clin Nurs Res 2017;26(1):68–81. https://doi.org/10.1177/1054773815598272 [published Online First: 2015/08/09].
[2] Tume L, Copnell B. Endotracheal suctioning of the critically ill child. J Pediatr Intensive Care 2015;4(2):56–63. https://doi.org/10.1055/s-0035-1556747.
[3] Schults J, Long DA, Mitchell M, et al. Adverse events and practice variability associated with paediatric endotracheal suction: an observational study. Aust Crit Care 2020;33(4):350–7. https://doi.org/10.1016/j.aucc.2019.08.002.
[4] Schults JA, Cooke M, Long DA, Schibler A, Ware RS, Charles K, et al. Normal saline and lung recruitment with pediatric endotracheal suction: a pilot, factorial, randomized controlled trial. Aust Crit Care 2021;34(6):530–8.
[5] Willson DF. Why bother? The new paradigm of pediatric "Ventilator-Associated condition". Crit Care Med 2019;47(7):1009–10. https://doi.org/10.1097/ccm.0000000000003788 [published Online First: 2019/06/18].
[6] Aelami M, Lotfi M, Zingg W. Ventilator-associated pneumonia in neonates, infants and children. Antimicrob Resist Infect Control 2014;3(1):30. https://doi.org/10.1186/2047-2994-3-30.
[7] Willson DF, Hall M, Beardsley A, Hoot M, Kirby A, Hays S, et al. Pediatric ventilator-associated events: analysis of the pediatric ventilator-associated infection data. Pediatr Crit Care Med 2018;19(12):e631–6. https://doi.org/10.1097/pcc.0000000000001723.
[8] Schults JA, Cooke M, Long D, Mitchell M. "When no-one's looking," the application of lung recruitment and normal saline instillation with paediatric endotracheal suction: an exploratory study of nursing practice. Aust Crit Care 2019;32(1):13–9. https://doi.org/10.1016/j.aucc.2018.03.002 [published Online First: 2018/05/13].
[9] Tume L. Endotracheal suction in high risk patients. Eur J Pediatr 2016;175(11):1404–5. https://doi.org/10.1007/s00431-016-2785-8.
[10] Schults JA, Mitchell ML, Cooke M, Long D, Ferguson A, Morrow B, et al. Endotracheal suction interventions in mechanically ventilated children: an integrative review to inform evidence-based practice. Aust Crit Care 2020:S1036–7314. https://doi.org/10.1016/j.aucc.2020.05.003 [published Online First: 2020/08/09].
[11] Fitch K, Bernstein SJ, Aguilar MD, Burnand B, LaCalle J, Lazaro P, et al. The RAND/UCLA appropriateness method user's manual. RAND Corporation; 2001.
[12] Davies K, Bulsara MK, Ramelet AS, Monterosso L. Content validity testing of the ESAT((c)): a decision aid tool for performing endotracheal suction in children. Aust Crit Care 2018;31(1):23–30. https://doi.org/10.1016/j.aucc.2017.01.006 [published Online First: 2017/03/04].
[13] Davies K, Monterosso L, Bulsara M, Ramelet AS. Clinical indicators for the initiation of endotracheal suction in children: an integrative review. Aust Crit Care 2015;28(1):11–8. https://doi.org/10.1016/j.aucc.2014.03.001 [published Online First: 2014/04/29].
[14] Davies K, Monterosso L, Leslie G. Determining standard criteria for endotracheal suctioning in the paediatric intensive care patient: an exploratory study. Intensive Crit Care Nurs 2011;27(2):85–93. https://doi.org/10.1016/j.iccn.2011.01.002 [published Online First: 2011/03/05].
[15] Davies K, Bulsara MK, Ramelet AS, Monterosso L. Reliability and criterion-related validity testing (construct) of the Endotracheal Suction Assessment Tool (ESAT(c)). J Clin Nurs 2018;27(9–10):1891–900. https://doi.org/10.1111/jocn.14269 [published Online First: 2018/01/19].
[16] Higgins JPT, Green S, editors. Cochrane handbook for systematic reviews of interventions version 5.1.0. The Cochrane Collaboration; 2011 [updated March 2011].
[17] Schults J, Cooke M, Long D, Mitchell M. Normal saline and lung recruitment with pediatric endotracheal suction: a review and critical appraisal of practice recommendations. Dimens Crit Care Nurs 2020;39(6):321–8. https://doi.org/10.1097/DCC.0000000000000442.
[18] American Association for Respiratory Care. AARC Clinical Practice Guidelines. Endotracheal suctioning of mechanically ventilated patients with artificial airways 2010. Respir Care 2010;55(6):758–64.
[19] ANZICS Centre for Outcome and Resource Evaluation. Report of the Australian and New Zealand paediatric intensive care registry 2017. Victoria, AUS: ANZICS CORE; 2017. p. 28.
[20] A report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force American Society of Echocardiography American Heart Association American Society of Nuclear Cardiology Heart Failure Society of America et al. ACCF/ASE/AHA/ASNC/HFSA/HRS/SCAI/SCCM/SCCT/SCMR 2011 appropriate use criteria for echocardiography. J Am Soc Echocardiogr 2011;24(3):229–67. https://doi.org/10.1016/j.echo.2010.12.008 [published Online First: 2011/02/23].
[21] Hoellering AB, Copnell B, Dargaville PA, Mills JF, Morley CJ, Tingay DG. Lung volume and cardiorespiratory changes during open and closed endotracheal suction in ventilated newborn infants. Arch Dis Child Fetal Neonatal Ed 2008;93(6):F436–41. https://doi.org/10.1136/adc.2007.132076 [published Online First: 2008/02/29].
[22] Bruschettini M, Zappettini S, Moja L, Calevo M. Frequency of endotracheal suctioning for the prevention of respiratory morbidity in ventilated newborns. Cochrane Database Syst Rev 2016;3. https://doi.org/10.1002/14651858.CD011493.pub2.
[23] Shorten DR, Byrne PJ, Jones RL. Infant responses to saline instillations and endotracheal suctioning. J Obstet Gynecol Neonatal Nurs 1991;20(6):464–9. https://doi.org/10.1111/j.1552-6909.1991.tb01712.x.
[24] Owen EB, Woods CR, O'Flynn JA, Boone MC, Calhoun AW, Montgomery VL. A bedside decision tree for use of saline with endotracheal tube suctioning in children. Crit Care Nurse 2016;36(1):e1–10. https://doi.org/10.4037/ccn2016358 [published Online First: 2016/02/03].
[25] Ridling DA, Martin LD, Bratton SL. Endotracheal suctioning with or without instillation of isotonic sodium chloride solution in critically ill children. Am J Crit Care 2003;12(3):212–9 [published Online First: 2003/05/20].
[26] McKinley DF, Kinney SB, Copnell B, Shann F. Long-term effects of saline instilled during endotracheal suction in pediatric intensive care: a randomized trial. Am J Crit Care 2018;27(6):486–94. https://doi.org/10.4037/ajcc2018615.
[27] Caruso P, Denari S, Ruiz SA, Demarzo SE, Deheinzelin D. Saline instillation before tracheal suctioning decreases the incidence of ventilator-associated pneumonia. Crit Care Med 2009;37(1):32–8. https://doi.org/10.1097/CCM.0b013e3181930026 [published Online First: 2008/12/04].
[28] Halm MA, Krisko-Hagel K. Instilling normal saline with suctioning: beneficial technique or potentially harmful sacred cow? Am J Crit Care 2008;17(5):469–72 [published Online First: 2008/09/09].
[29] Tume LN, Baines P, Guerrero R, Johnson R, Ritson P, Scott E, et al. Patterns of instability associated with endotracheal suctioning in infants with single-ventricle physiology. Am J Crit Care 2017;26(5):388–94. https://doi.org/10.4037/ajcc2017844 [published Online First: 2017/09/03].
[30] Tume LN, Baines PB, Guerrero R, Hurley MA, Johnson R, Kalantre A, et al. Pilot study comparing closed versus open tracheal suctioning in postoperative neonates and infants with complex congenital heart disease. Pediatr Crit Care Med 2017;18(7):647–54. https://doi.org/10.1097/pcc.0000000000001192 [published Online First: 2017/05/11].
[31] Choong K, Chatrkaw P, Frndova H, Cox P. Comparison of loss in lung volume with open versus in-line catheter endotracheal suctioning. Pediatr Crit Care Med 2003;4(1):69–73. https://doi.org/10.1097/01.pcc.0000043415.55312.62 [published Online First: 2003/03/27].
[32] Evans J, Syddall S, Butt W, Kinney S. Comparison of open and closed suction on safety, efficacy and nursing time in a paediatric intensive care unit. quiz 75-6 Aust Crit Care 2014;27(2):70–4. https://doi.org/10.1016/j.aucc.2014.01.003 [published Online First: 2014/03/19].
[33] Morrow BM, Mowzer R, Pitcher R, Argent A. Investigation into the effect of closed-system suctioning on the frequency of pediatric ventilator-associated pneumonia in a developing country. Pediatr Crit Care Med 2012;13(1):e25–32. https://doi.org/10.1097/PCC.0b013e31820ac0a2 [published Online First: 2011/02/02].
[34] Chegondi M, Francis T, Lin WC, Naqvi S, Raszynski A, Totapally BR. Effects of closed endotracheal suctioning on systemic and cerebral oxygenation and hemodynamics in children. Pediatr Crit Care Med 2018;19(1):e23–30. https://doi.org/10.1097/pcc.0000000000001377 [published Online First: 2017/12/01].
[35] Fisk AC. The effects of endotracheal suctioning in the pediatric population: an Integrative Review. Dimens Crit Care Nurs 2018;37(1):44–56. https://doi.org/10.1097/dcc.0000000000000275 [published Online First: 2017/12/02].
[36] Tume LN, Baines PB, Lisboa PJ. The effect of nursing interventions on the intracranial pressure in paediatric traumatic brain injury. Nurs Crit Care 2011;16(2):77–84. https://doi.org/10.1111/j.1478-5153.2010.00412.x [published Online First: 2011/02/09].
[37] Tingay DG, Copnell B, Mills JF, Morley CJ, Dargaville P. Effects of open endotracheal suction on lung volume in infants receiving HFOV. Intensive Care Med 2007;33(4):689–93. https://doi.org/10.1007/s00134-007-0541-2 [published Online First: 2007/03/03].
[38] Samransamruajkit R, Rassameehirun C, Pongsanon K, Huntrakul S, Deerojanawong J, Sritippayawan S, et al. A comparison of clinical efficacy between high frequency oscillatory ventilation and conventional ventilation with lung volume recruitment in pediatric acute respiratory distress syndrome: a randomized controlled trial. Indian J Crit Care Med 2016;20(2):72–7. https://doi.org/10.4103/0972-5229.175940 [published Online First: 2016/04/15].
[39] van Veenendaal MB, Miedema M, de Jongh FH, van der Lee JH, Frerichs I, van Kaam AH. Effect of closed endotracheal suction in high-frequency ventilated premature infants measured with electrical impedance tomography. Intensive Care Med 2009;35(12):2130–4. https://doi.org/10.1007/s00134-009-1663-5 [published Online First: 2009/09/24].
[40] Vargas M, Servillo G. Closed-suction system for intubated COVID-19 patients with the use of an ultrasound probe cover. Anesthesiology 2020;133(3):687–9. https://doi.org/10.1097/aln.0000000000003431.
[41] Vargas M, Servillo G. Improving staff safety during tracheostomy in COVID-19 patients. Head Neck 2020;42(6):1278–9. https://doi.org/10.1002/hed.26163 [published Online First: 2020/04/10].

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[42] Cook TM. Personal protective equipment during the coronavirus disease (COVID) 2019 pandemic - a narrative review. Anaesthesia 2020;75(7):920–7. https://doi.org/10.1111/anae.15071 [published Online First: 2020/04/05].
[43] Imbriaco G, Monesi A. Closed tracheal suctioning systems in the era of COVID-19: is it time to consider them as a gold standard? J Infect Prevent 2020;22(1):44–5. https://doi.org/10.1177/1757177420963775.
[53] Pediatric Acute Lung Injury Consensus Conference Group. Pediatric acute respiratory distress syndrome: consensus recommendations from the pediatric acute lung injury consensus conference. Pediatr Crit Care Med 2015;16(5):428–39. https://doi.org/10.1097/pcc.0000000000000350 [published Online First: 2015/02/04].
[58] Royal Children's Hospital. Endotracheal tube suction ventilated neonate: clinical guideline. Melbourne: Royal Children's Hospital; 2016. Available from: https://www.rch.org.au/rchcpg/hospital_clinical_guideline_index/Endotracheal_tube_suction_of_ventilated_neonates/ [Accessed 20 June 2019].
[62] Kelleher J, Bhat R, Salas AA, Addis D, Mills EC, Mallick H, et al. Oronasopharyngeal suction versus wiping of the mouth and nose at birth: a randomised equivalency trial. Lancet 2013;382(9889):326–30. https://doi.org/10.1016/s0140-6736(13)60775-8 [published Online First: 2013/06/07].
[63] Schults J, Cooke M, Long D, Mitchell M. Who makes the decision?: a qualitative exploration of PICU nurses use of lung recruitment strategies following endotracheal suction. Pediatr Crit Care Med 2018;19(6):240.
[64] Zimmerman JJ, Anand KJS, Meert KL, Willson D, Newth CJ, Harrison R, et al. Research as a standard of care in the PICU. Pediatr Crit Care Med 2016;17(1):e13–21. https://doi.org/10.1097/PCC.0000000000000562.
[65] Curley M. Respiratory research in the critically ill pediatric patient: why is it so difficult? Respir Care 2011;56(9):1247. https://doi.org/10.4187/respcare.01255.
[66] Morrow BM. Closed-system suctioning: why is the debate still open? Indian J Med Sci 2007;61(4):177–8 [published Online First: 2007/04/03].
[67] Lema-Zuluaga GL, Fernandez-Laverde M, Correa-Varela AM, Zuleta-Tobón JJ. As-needed endotracheal suctioning protocol vs a routine endotracheal suctioning in Pediatric Intensive Care Unit: a randomized controlled trial. Colomb Méd (Cali, Colombia) 2018;49(2):148–53. https://doi.org/10.25100/cm.v49i2.2273 [published Online First: 2018/08/15].
[68] Keith RE, Crosson JC, O'Malley AS, Cromp D, Taylor EF. Using the Consolidated Framework for Implementation Research (CFIR) to produce actionable findings: a rapid-cycle evaluation approach to improving implementation. Implement Sci 2017;12(1):15. https://doi.org/10.1186/s13012-017-0550-7.
[69] Winchester DE, Merritt J, Waheed N, Norton H, Manja V, Shah N, et al. Implementation of appropriate use criteria for cardiology tests and procedures: a systematic review and meta-analysis. Eur Heart J Qual Care Clin Outcomes 2021;7(1):34–41. https://doi.org/10.1093/ehjqcco/qcaa029 [published Online First: 2020/04/02].
[70] Schults J, Mitchell ML, Cooke M, Schibler A. Efficacy and safety of normal saline instillation and paediatric endotracheal suction: an integrative review. Aust Crit Care 2018;31(1):3–9. https://doi.org/10.1016/j.aucc.2017.02.069 [published Online First: 2017/03/30].
[71] Berry SM, Connor JT, Lewis RJ. The platform trial: an efficient strategy for evaluating multiple treatments. J Am Med Assoc 2015;313(16):1619–20. https://doi.org/10.1001/jama.2015.2316.
[72] Khemani RG, Smith LS, Zimmerman JJ, Erikson S, Pediatric Acute Lung Injury Consensus Conference Group. Pediatric acute respiratory distress syndrome: definition, incidence, and epidemiology: proceedings from the pediatric acute lung injury consensus conference. Pediatr Crit Care Med 2015;16(5 Suppl 1):S23–40. https://doi.org/10.1097/pcc.0000000000000432 [published Online First: 2015/06/04].
[73] Kneyber MCJ, de Luca D, Calderini E, Jarreau PH, Javouhey E, Lopez-Herce J, et al. Recommendations for mechanical ventilation of critically ill children from the paediatric mechanical ventilation consensus conference (PEMVECC). Intensive Care Med 2017;43(12):1764–80. https://doi.org/10.1007/s00134-017-4920-z [published Online First: 09/22].

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