## Title
Pediatric Tracheostomy Emergency Readiness Assessment Tool: International Consensus Recommendations.



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# Pediatric Tracheostomy Emergency Readiness Assessment Tool: International Consensus Recommendations

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## Abstract

**Objective:** To achieve consensus on critical steps and create an assessment tool for actual and simulated pediatric tracheostomy emergencies that incorporates human and systems factors along with tracheostomy-specific steps.

**Methods:** A modified Delphi method was used. Using REDCap software, an instrument comprising 29 potential items was circulated to 171 tracheostomy and simulation experts. Consensus criteria were determined *a priori* with a goal of consolidating and ordering 15 to 25 final items. In the first round, items were rated as "keep" or "remove". In the second and third rounds, experts were asked to rate the importance of each item on a 9-point Likert scale. Items were refined in subsequent iterations based on analysis of results and respondents' comments.

**Results:** The response rates were 125/171 (73.1%) for the first round, 111/125 (88.8%) for the second round, and 109/125 (87.2%) for the third round. 133 comments were incorporated. Consensus (>60% participants scoring ≥8, or mean score >7.5) was reached on 22 items distributed across three domains. There were 12, 4, and 6 items in the domains of tracheostomy-specific steps, team and personnel factors, and equipment respectively.

**Conclusions:** The resultant assessment tool can be used to assess both tracheostomy-specific steps as well as systems factors affecting hospital team response to simulated and clinical pediatric tracheostomy emergencies. The tool can also be used to guide debriefing discussions of both simulated and clinical emergencies, and to spur quality improvement initiatives.

### Keywords

airway management; Delphi Technique; healthcare quality assessments; patient safety; simulation; tracheostomy

## INTRODUCTION

Pediatric tracheostomy is associated with high morbidity and mortality, with complication rates ranging from 12.6% to 30% in children, and 5-year tracheostomy-associated mortality between 1% and 8%.[1–4] Accidental decannulation and tube obstruction are crisis scenarios

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Work for this project was primarily conducted in the Department of Otolaryngology at Montefiore Medical Center, Bronx, NY, USA (EBS, DWL, MMT, CJY).

**Level of Evidence:** Level 5

which require swift, coordinated, complex team-based care for effective management to prevent hypoxic brain injury and mortality.[5,6] Multiple surveys of non-otolaryngologist health care providers have demonstrated knowledge gaps and discomfort with tracheostomy care.[7–10] In response, educational programs including simulation training have demonstrated improvement in health care providers'[11–15] and caregivers'[16] knowledge, skills, and comfort with tracheostomy management. Hands-on nursing skills training programs have also been associated with decreases in severe complications[17,18] and ICU readmissions[19] in adult patients with tracheotomies. However, hospital team performance and emergency readiness for pediatric tracheostomy emergencies, such as accidental decannulation and tube obstruction, are understudied. This is likely due to the fact that studies targeting clinically significant but low-frequency events[20] may be under-powered to detect changes, and few of these studies move beyond learner-centered training, which is among the weakest educational interventions,[21] to the assessment, training, and refinement of teams and systems[22] to more fully realize the power of simulation to improve patient care.

*In situ simulation*, wherein medical teams operate in their actual clinical environments using tools and resources typically available to them to manage the scenario at hand, is a powerful quality improvement tool[23–29] ideally suited to assess systems readiness for high-stress, high-acuity, low-frequency scenarios.[30–35] Furthermore, the *in situ* setting recreates complex systems to detect latent safety threats (systems flaws which have the potential to combine to cause harm to patients and staff),[35–49] train interprofessional teams[36,37,50–55] and implement novel protocols.[41,56–58]

Although simulation has been employed as a quality improvement tool to identify systems errors pertinent to pediatric tracheostomy emergency management,[11,39,40] the lack of validated assessment tools for team performance[58] in response to a pediatric tracheostomy crisis scenario limits comparison of units and hospitals to one another and measurement of the effectiveness of interventions on tracheostomy emergency readiness. Remick et al. developed a survey[59] assessing pediatric emergency department readiness nationally and correlated these scores with clinical outcomes[60]; however, tracheostomy emergencies were not specifically addressed in their pediatric readiness survey.

The current project aims to address this gap. By developing a practical assessment tool for evaluation of provider readiness in pediatric tracheostomy emergency events and simulations, we expect to gain comprehensive insight into the complex multidisciplinary systems in which pediatric tracheostomy care is delivered. This tool will also serve as a valuable guide to debriefing both clinical and simulated tracheostomy emergency events.

Our objective was to survey tracheostomy and simulation experts to arrive at a consensus instrument which combines tracheostomy-specific (to evaluate discrete manual steps) and systems-based (to evaluate overall readiness and communication of hospital units) domains into a single pediatric tracheostomy emergency readiness assessment tool.

## METHODS

To create a tool with broad generalizability and applicability, we followed the initiative of Propst et al.[61] to survey a large international group of experts using a modified Delphi consensus process. The Delphi process, originally developed by the RAND Corporation in the 1950s to forecast the impact of technology on warfare, narrows down concepts through iterative rounds of questionnaires until consensus is achieved.[62] Using a modified Delphi process with input from our steering committee of authors, we planned a series of asynchronous surveys to promote inclusivity and geographic diversity.

Based on clinical experience and tracheostomy and simulation literature, five authors (EBS, EJP, KB, KJ, CJY) identified 29 items for potential inclusion in a pediatric tracheostomy emergency readiness assessment tool. These items were divided into three domains: “Systems factors: Communication and Team-work”, “Systems factors: Equipment”, and “Tracheostomy-specific steps”. Four of the authors (EJP, KB, KJ, CJY) are fellowship-trained pediatric otolaryngologists–head and neck surgeons. One author (EJP) has previously published stepwise approaches for trainees to learn how to perform tracheotomy and open airway surgery. Another author (KB) has expertise in the use of the modified Delphi consensus process. Authors KJ and CJY are healthcare simulation experts.

The list of items was entered into questionnaire format using Research Electronic Data Capture (REDCap).[63,64] REDCap was selected because iterative questionnaires can be answered and submitted directly via the email link through which they are received without respondents needing to download, complete, and upload files. Additionally, demographic data need only be collected once, with the first survey. Our aim was to make questionnaire completion simple and fast, thereby increasing the response rate and decreasing time to respond.

Approval was obtained from the institutional review board at Einstein-Montefiore (#2018–9241) and consent was obtained from all participants.

Experts in the field of pediatric tracheostomy were selected by reviewing membership lists of the American Society of Pediatric Otolaryngology, American Academy of Otolaryngology-Head and Neck Surgery (AAO-HNS) Pediatric Otolaryngology Education Committee, the Global Tracheostomy Collaborative, the International Pediatric Otolaryngology Group (IPOG), and by reviewing the list of pediatric otolaryngology faculty at academic institutions worldwide. Simulation experts were selected by reviewing membership lists of the AAO-HNS Simulation Education Committee, many of whom had expertise in medical education. Individuals with a strong publication record in pediatric tracheostomy and/or health care simulation were also included. To maintain geographic diversity, no more than five individuals from a single academic center were included. Individuals who were no longer practicing were excluded. Prospective participants were sent an email invitation with an embedded personalized link to their unique survey explaining the study purpose and methodology. Membership on the panel was kept anonymous from other experts. Given the amount of work and input required by each respondent, experts were offered authorship (pending journal editorial approval) if they completed all rounds of the survey, with priority determined by the order in which they responded (tracked by REDCap). Experts were contacted four times (invitation and three reminders) for each round.

During the first round, experts were instructed to rate each item on the survey as “keep” or “remove.” A section for comments and suggestions for adding, modifying, or combining items was provided after each of the three domains (Table I), along with a space to nominate other experts to participate. Responses were exported to a Microsoft Excel file, and two investigators (EBS and CJY) each independently reviewed responses and met on one occasion to incorporate suggestions. It was decided *a priori* that each task needed to have 50% of respondents rating it as “keep” for it to be included, although the steering committee of authors could elect to include items in the next round if it was felt that further clarification was needed. To decrease the flow of unwanted emails, it was decided that subsequent rounds would only be distributed to those who had completed the initial survey round. The large number of expert respondents and the potential risk of senior voices biasing others precluded group discussion between rounds. All participants’ input had equal weight, and opportunity was given to all to submit comments in the surveys.

During the second round, experts were instructed to rate the importance of each item using a 9-point Likert scale (1 = not at all important; 5 = neutral; 9 = extremely important) (Table II). Based on input from round one, the items were redistributed into two, instead of three domains. A line for comments and suggestions was included after each domain. Anonymous results were exported to an Excel file, and a mean score was determined for each item, with inclusion dependent on the degree of consensus reached.

Modified Delphi consensus criteria were developed *a priori* based on prior modified Delphi publications in the field,[61,65,66] and discussion among the primary authors (EBS, EJP, KB, KJ, DL, CJY). These differed from the American Academy of Otolaryngology consensus criteria with respect to treatment of outliers[67] due to the large number of experts (171) surveyed. Furthermore, to achieve a concise assessment tool of 15–25 items, we asked respondents to limit the number of items that they ranked highly, knowing this would likely result in excess heterogeneity in the composite ranking of survey items. It was thus decided that consensus could be achieved from such a large cohort by considering the mean score of each component on the survey, regardless of the number of outliers.

Based on these considerations, each item was determined to have (1) “Consensus” if either greater than 60% of responses scored it 8 or 9, or if the mean score was greater than 7.5; (2) “Near consensus” if greater than 40% of responses scored it 8 or 9, and a mean score greater than 5.0; (3) “No consensus” if criteria 1 or 2 were not met. We therefore decided *a priori* that any initial results from the second round that achieved “consensus” or “no consensus” would not be subject to further review unless the authors felt that there was a need for further clarification.

We decided to aim for 15 to 25 items in our final assessment tool to achieve a balance of having sufficient points such that the assessment tool would have discriminatory value, and not having too many as to pose an undue burden on the grader. This goal was shared with respondents to guide them toward ranking 15–25 items highly, and to decrease the overall duration of the study.

During the third round, experts were instructed to re-rank a subset of items that had achieved "near consensus" during round two (Table III). Any items failing to achieve "consensus" at this point were censored from the final assessment tool (Figure 1).

Descriptive statistics were generated via IBM SPSS Statistics for Windows, (Version 28.0.1.0) Armonk, NY, and Microsoft Excel (Version 2210), Redmond, WA.

## RESULTS

One hundred and seventy-one experts were contacted. Respondents from all rounds represented 12 countries and 83 institutions. Of the 125 respondents (90 male, 35 female), 114 were experts in airway management and 37 in health care simulation (including 26 in both).

The first round achieved a response rate of 125/171 (73.1%). Three items did not meet the threshold of 50%. Of these, one was dropped from the list. One was rephrased based on respondents' comments. One was kept based on clinical judgment of the authors, expecting it to achieve consensus in a later round. There were 56 missing responses out of 3,625 possible items (125 experts, 29 items) for a completion rate of 98.5%. There were 82 comments incorporated into the items to be used in the second phase (Table I). The time for completion of round 1 was 14 days.

In the second round, two domains of items were distributed (Table II), along with a final section asking for preference regarding terminology (tracheotomy vs. tracheostomy) and organization of assessment tool. The response rate was 111/125 (88.8%). There were 33 missing responses out of 3,330 possible items (111 experts, 30 items) for a completion rate of 99.0%. For the 28 assessment tool items, 21 reached consensus, 4 reached near consensus, and 3 items reached no consensus. Results of the final section showed 73 respondents preferred "tracheostomy," 14 preferred "tracheotomy," and 22 had no preference. Sixty-three (57.8%) voted for "Tracheostomy-specific steps" to be first in an assessment tool. There were 42 comments incorporated into the final assessment tool. The time for completion of round 2 was 16 days.

In the third round, respondents were shown graphs of the data from survey round two. These data were redistributed into three domains and color-coded to demonstrate which items had not achieved consensus (Figure 2). The response rate was 109/125 (87.2%). There were 0 missing responses out of 763 possible items (109 experts, 7 items) for a completion rate of 100%. One additional item achieved consensus, and six did not (Table III). There were nine comments. The time for completion of round 3 was 14 days.

## DISCUSSION

Pediatric tracheostomy emergencies are high-acuity, low frequency events. Following the work of Remick et al. in the PedsReady Initiative,[59] we believe that a proactive approach to pediatric emergency readiness is both necessary and effective to ensure patient safety. A pediatric tracheostomy emergency readiness assessment tool will allow accurate assessment of hospital's and individual units' capability of responding to these events, both through *in situ* simulation and through debriefing clinical events. While separate instruments and algorithms exist to audit tracheostomy-specific steps[68] for emergency management[40,69] and teamwork,[70] the tool developed in this study (Figure 3) measures both tracheostomy-specific and systems (communication, equipment, etc) factors. Furthermore, the incorporation of diverse expert opinion for its development establishes both face and content validity.

We obtained high response rates for all three rounds. Our response rate was 73.1% (125/171), 88.8% (111/125), and 87.2% (109/125) for rounds one, two, and three respectively. A response rate of 60% for survey research is considered acceptable by many biomedical journals.[71] In addition, >98% of items were completed for all submitted questionnaires for each round. We attribute this response rate to the selection of clinicians experienced in this area of medicine, ease of use of the REDCap questionnaire, assurance of anonymity, and offer of authorship. Furthermore, many comments attested to the high importance of this project to providers in the field. The time for completion of this study was 71 days, including time for data analysis between each round. We believe the above factors allowed for less fatigue and greater motivation, and the short interval between questionnaires kept the interest level high.

In the first survey, all but three items achieved >50% respondents ranking "keep." Edits made are explained in Table AI. Of note, "Appropriate PPE is donned in accordance with institutional protocols" was kept in through the next round despite its low "keep" response rate (48.4%). Several comments implied that respondents assumed that the survey was for a clinical checklist, as some experts opined that PPE "may not be feasible in every emergency" and may cause a dangerous delay of care in a critically ill patient. This was clarified in survey rounds two and three, and the item was ultimately omitted due to not reaching "consensus". The sequence of items was changed in survey two to reflect the more realistic chronology of a clinical scenario.

In the second survey round, four items reached "near consensus" and three reached "no consensus". Of note, several respondents commented that they would have ranked all items high, but limited their choices based on our instructions. Based on comments and the clinical judgment of the authors, it was decided to include all seven of these items in survey round three. Survey items were returned to the original distribution between three domains, named "Tracheostomy-specific steps", "Team and Personnel", and "Equipment".

In the third survey round, one item reached consensus: "There is a clear team leader." Responses and comments for items that did not reach consensus were acknowledged as important for preventing further adverse events, but not of highest priority for inclusion in a concise tool. Most of the items that did not reach consensus were in one of the two domains that addressed systems factors (Table AII). This may reflect a task or procedural emphasis within otolaryngology. This may also underscore a trend among individual health care providers to underestimate the importance of surrounding systems factors which influence team performance, or lack of consensus as to which specific systems factors are most impactful. Even a well-trained team may fail to effectively respond to a pediatric tracheostomy emergency due to systems errors such as lack of equipment availability or communication breakdown such as lack of a clear team leader. While some items such as donning appropriate PPE are not included in our final assessment tool (Figure 3), we maintain that such systems factors remain important considerations for patient and clinician safety.

Tracheostomy emergencies are complex, low-frequency, and often life-threatening events. This tool can be used to assess pediatric tracheostomy emergency readiness from a systems perspective and can highlight safety concerns as targets for interventions before they reach a patient. We anticipate that use of this assessment tool (Figure 3) will foster a culture of safety[29,34] and engagement, wherein multidisciplinary teams composed of key stakeholders will be empowered in their work to improve pediatric tracheostomy emergency care and safety.

Reliance on expert opinion was both a strength and limitation of this study. To balance initial item and author selection by the primary authors, we allowed respondents to submit suggestions for additional items and authors to be considered and included.

Future multi-institutional studies of this pediatric tracheostomy emergency scenario assessment tool are required for refinement of this pilot instrument. These include investigating construct validity, including the degree to weight individual items and domains in overall scoring, ease of use, acceptability, and generalizability for debriefing simulated and clinical events. We anticipate that this tool can be used for immediate diagnostic evaluation of systems readiness as well as measurement of the impact of quality improvement implementation measures over time. Broad and structured dissemination of this tool is required to permit independent evaluations, and to measure correlations between pediatric tracheostomy emergency readiness and clinical outcomes.

## CONCLUSION

Consensus has been reached on factors to include in an assessment tool for pediatric tracheostomy emergency readiness. This was made possible using the modified Delphi consensus process described herein. These items can now be considered to create and validate a pediatric tracheostomy emergency readiness assessment tool that incorporates tracheostomy-specific and systems factors.

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# APPENDIX

### TABLE AI.

Emendations to survey items between survey rounds.

| Location | Initial text | Updated text | Rationale/comments |
|---|---|---|---|
| Changes from Survey #1 | Team members call out next steps<br>Team factor: Closed loop communication with callbacks | Team utilizes closed loop communication (verbal confirmation of issued instructions in real time) | Redundancy of having 2 separate items. Clarification of "closed loop communication" |
| | Head tilt/Jaw thrust<br>Towel roll/Shoulder roll | Optimize position (e.g., Head-Tilt/Jaw- Thrust/Shoulder-Roll) | Items were all in 1 category of optimization of patient position |
| | – | Following debrief, learning goals are disseminated to relevant providers | Added based on comments |

| Location | Initial text | Updated text | Rationale/comments |
| --- | --- | --- | --- |
| Changes from Survey #2 | Team calls for airway expert help | Call for airway expert help | Moved from systems factors: communication and teamwork domain to tracheostomy specific steps |
| | Check for spontaneous breathing | Check for spontaneous breathing (i.e., EtCO2) | Clarification |
| | Ensure trach ties are tight | Ensure trach ties are appropriately tight | Confusion regarding degree of tightness required |
| | If trach tube dislodged, correctly replace trach tube | If dislodgement or obstruction not relieved by suctioning, then correctly replace trach tube | Clarified based on comments |

**TABLE AII.**

Items which did not achieve consensus

| | |
| --- | --- |
| 1 | Team utilizes closed loop communication (verbal confirmation of issued instructions in real time) |
| 2 | Following debrief, learning goals are disseminated to relevant providers |
| 3 | There is a runner assigned (to obtain supplies) |
| 4 | Appropriate PPE is donned in accordance with institutional protocol |
| 5 | Confirm trach flanges flush with skin (remove gauze/drain sponges/skin barriers) |
| 6 | Ensure trach ties are appropriately tight |

## BIBLIOGRAPHY

1. Sakai M, Kou YF, Shah GB, Johnson RF. Tracheostomy demographics and outcomes among pediatric patients ages 18 years or younger-United States 2012. Laryngoscope. 2019;129(7):1706–1711. Epub 20181115. 10.1002/lary.27463 [PubMed: 30443915]
2. D'Souza JN, Levi JR, Park D, Shah UK. Complications following pediatric tracheotomy. JAMA Otolaryngol Head Neck Surg. 2016;142(5):484–488. 10.1001/jamaoto.2016.0173. [PubMed: 27055048]
3. Dal'Astra AP, Quirino AV, Caixeta JA, Avelino MA. Tracheostomy in childhood: review of the literature on complications and mortality over the last three decades. Braz J Otorhinolaryngol. 2017;83(2):207–214. Epub 20160506. 10.1016/j.bjorl.2016.04.005 [PubMed: 27256033]
4. Davidson C, Jacob B, Brown A, et al. Perioperative outcomes after tracheostomy placement among complex pediatric patients. Laryngoscope. 2021; 131(8):E2469–E2474. Epub 20210119. 10.1002/lary.29402 [PubMed: 33464608]
5. Brenner MJ, Pandian V, Milliren CE, et al. Global tracheostomy collaborative: data-driven improvements in patient safety through multi-disciplinary teamwork, standardisation, education, and patient partnership. Br J Anaesth. 2020;125(1):e104–e118. Epub 20200523. 10.1016/j.bja.2020.04.054 [PubMed: 32456776]
6. Cook TM, Woodall N, Harper J, Benger J, Fourth National Audit P. Major complications of airway management in the UK: results of the fourth National Audit Project of the Royal College of Anaesthetists and the difficult airway society. Part 2: intensive care and emergency departments. Br J Anaesth. 2011;106(5):632–642. Epub 20110329. 10.1093/bja/aer059. [PubMed: 21447489]
7. Casserly P, Lang E, Fenton JE, Walsh M. Assessment of healthcare professionals' knowledge of managing emergency complications in patients with a tracheostomy. Br J Anaesth. 2007;99(3):380–383. Epub 20070703. 10.1093/bja/aem167 [PubMed: 17609249]
8. Garner JM, Shoemaker-Moyle M, Franzese CB. Adult outpatient tracheostomy care: practices and perspectives. Otolaryngol Head Neck Surg. 2007; 136(2):301–306. 10.1016/j.otohns.2006.08.023. [PubMed: 17275559]

9. Smith-Miller C Graduate nurses' comfort and knowledge level regarding tracheostomy care. J Nurses Staff Dev. 2006;22(5):222–229; quiz 30–1. 10.1097/00124645-200609000-00003 [PubMed: 17019276]
10. Pritchett CV, Foster Rietz M, Ray A, Brenner MJ, Brown D. Inpatient nursing and parental comfort in managing pediatric tracheostomy care and emergencies. JAMA Otolaryngol Head Neck Surg. 2016;142(2):132–137. 10.1001/jamaoto.2015.3050. [PubMed: 26720101]
11. Ahmed ST, Yang C, Deng J, et al. Implementation of an online multimedia pediatric tracheostomy care module for healthcare providers. Laryngoscope. 2021;131(8):1893–1901. Epub 20210118. 10.1002/lary.29400 [PubMed: 33459406]
12. Dorton LH, Lintzenich CR, Evans AK. Simulation model for tracheotomy education for primary health-care providers. Ann Otol Rhinol Laryngol. 2014;123(1):11–18. 10.1177/0003489414521144 [PubMed: 24574418]
13. Mehta K, Mosha MH, Kavanagh KR. A targeted tracheostomy care educational initiative to augment resuscitation training in the pediatric setting. Int J Pediatr Otorhinolaryngol. 2020;133:109944. Epub 20200213. 10.1016/j.ijporl.2020.109944 [PubMed: 32087480]
14. Mehta K, Schwartz M, Falcone TE, Kavanagh KR. Tracheostomy care education for the nonsurgical first responder: a needs-based assessment and quality improvement initiative. OTO Open. 2019;3(2):2473974X19844993. Epub 20190424. 10.1177/2473974X19844993.
15. Davis KA, Edgar-Zarate CL, Bonilla-Velez J, Atkinson TN, Tulunay-Ugur OE, Agarwal A. Using didactics and simulation to enhance comfort, knowledge, and skills of nonsurgical trainees caring for patients with tracheostomy and laryngectomy. Simul Healthc. 2019;14(6):384–390. 10.1097/SIH.0000000000000392. [PubMed: 31804423]
16. Prickett K, Deshpande A, Paschal H, Simon D, Hebbar KB. Simulation-based education to improve emergency management skills in caregivers of tracheostomy patients. Int J Pediatr Otorhinolaryngol. 2019;120:157–161. Epub 20190125. 10.1016/j.ijporl.2019.01.020. [PubMed: 30818130]
17. Hettige R, Arora A, Ifeacho S, Narula A. Improving tracheostomy management through design, implementation and prospective audit of a care bundle: how we do it. Clin Otolaryngol. 2008;33(5):488–491. 10.1111/j.1749-4486.2008.01725.x. [PubMed: 18983388]
18. Sodhi K, Shrivastava A, Singla MK. Implications of dedicated tracheostomy care nurse program on outcomes. J Anesth. 2014;28(3):374–380. Epub 20131006. 10.1007/s00540-013-1718-1. [PubMed: 24097169]
19. Green A, Edmonds L. Bridging the gap between the intensive care unit and general wards-the ICU liaison nurse. Intensive Crit Care Nurs. 2004; 20(3):133–143. 10.1016/j.iccn.2004.02.007. [PubMed: 15157931]
20. Ong T, Liu CC, Elder L, et al. The trach safe initiative: a quality improvement initiative to reduce mortality among pediatric tracheostomy patients. Otolaryngol Head Neck Surg. 2020;163(2):221–231. Epub 20200324. 10.1177/0194599820911728. [PubMed: 32204663]
21. Hettinger AZ, Fairbanks RJ, Hegde S, et al. An evidence-based toolkit for the development of effective and sustainable root cause analysis system safety solutions. J Healthc Risk Manag. 2013;33(2):11–20. 10.1002/jhrm.21122. [PubMed: 24078204]
22. Holden RJ, Carayon P, Gurses AP, et al. SEIPS 2.0: a human factors framework for studying and improving the work of healthcare professionals and patients. Ergonomics. 2013;56(11):1669–1686. 10.1080/00140139.2013.838643 Epub 2013 Oct 3.. [PubMed: 24088063]
23. Phrampus PE. Simulation and integration into patient safety systems. Simul Healthc. 2018;13(4):225–226. 10.1097/SIH.0000000000000332. [PubMed: 30074580]
24. Cox T, Seymour N, Stefanidis D. Moving the needle: Simulation's impact on patient outcomes. Surg Clin North Am. 2015;95(4):827–838. Epub 20150422. 10.1016/j.suc.2015.03.005. [PubMed: 26210974]
25. Kearney JA, Deutsch ES. Using simulation to improve systems. Otolaryngol Clin N Am. 2017;50(5):1015–1028. Epub 20170708. 10.1016/j.otc.2017.05.011.
26. Petrosoniak A, Auerbach M, Wong AH, Hicks CM. In situ simulation in emergency medicine: moving beyond the simulation lab. Emerg Med Australas. 2017;29(1):83–88. Epub 20161017. 10.1111/1742-6723.12705. [PubMed: 27748042]

27. Deutsch ES, Patterson MD. Simulation saves the day (and patient). Otolaryngol Clin N Am. 2019;52(1):115–121. Epub 20180922. 10.1016/j.otc.2018.08.005.

28. Sollid SJM, Dieckman P, Aase K, Soreide E, Ringsted C, Ostergaard D. Five topics health care simulation can address to improve patient safety: results from a consensus process. J Patient Saf. 2019;15(2):111–120. 10.1097/PTS.0000000000000254. [PubMed: 27023646]

29. Brazil V, Purdy EI, Bajaj K. Connecting simulation and quality improvement: how can healthcare simulation really improve patient care? BMJ Qual Saf. 2019;28(11):862–865. Epub 20190718. 10.1136/bmjqs-2019-009767.

30. Katznelson JH, Wang J, Stevens MW, Mills WA. Improving pediatric preparedness in critical access hospital emergency departments: impact of a longitudinal In situ simulation program. Pediatr Emerg Care. 2018;34(1): 17–20. 10.1097/PEC.0000000000001366. [PubMed: 29232353]

31. Whitfill T, Gawel M, Auerbach M. A simulation-based quality improvement initiative improves pediatric readiness in community hospitals. Pediatr Emerg Care. 2018;34(6):431–435. 10.1097/PEC.0000000000001233. [PubMed: 28719479]

32. Abulebda K, Whitfill T, Montgomery EE, et al. Improving pediatric readiness in general emergency departments: a prospective interventional study. J Pediatr. 2021;230:230–237 e1. Epub 20201031. 10.1016/j.jpeds.2020.10.040. [PubMed: 33137316]

33. Crofts JF, Lenguerrand E, Bentham GL, et al. Prevention of brachial plexus injury-12 years of shoulder dystocia training: an interrupted time-series study. BJOG. 2016;123(1):111–118. Epub 20150217. 10.1111/1471-0528.13302. [PubMed: 25688719]

34. Patterson MD, Geis GL, Falcone RA, LeMaster T, Wears RL. In situ simulation: detection of safety threats and teamwork training in a high risk emergency department. BMJ Qual Saf. 2013;22(6):468–477. Epub 20121220. 10.1136/bmjqs-2012-000942.

35. Reason J Human error: models and management. BMJ. 2000;320(7237): 768–770. 10.1136/bmj.320.7237.768. [PubMed: 10720363]

36. Greer JA, Haischer-Rollo G, Delorey D, et al. In-situ Interprofessional perinatal drills: the impact of a structured debrief on maximizing training while sensing patient safety threats. Cureus. 2019;11(2):e4096. Epub 20190219. 10.7759/cureus.4096. [PubMed: 31032156]

37. Couto TB, Barreto JKS, Marcon FC, Mafra A, Accorsi TAD. Detecting latent safety threats in an interprofessional training that combines in situ simulation with task training in an emergency department. Adv Simul (Lond). 2018;3:23. Epub 20181123. 10.1186/s41077-018-0083-4. [PubMed: 30505467]

38. Kobayashi L, Parchuri R, Gardiner FG, et al. Use of in situ simulation and human factors engineering to assess and improve emergency department clinical systems for timely telemetry-based detection of life-threatening arrhythmias. BMJ Qual Saf. 2013;22(1):72–83. Epub 20121011. 10.1136/bmjqs-2012-001134.

39. Ahmed ST, Cusumano C, Shah SJ, Ma A, Jafri FN, Yang CJ. Response to "mitigating tracheostomy-related latent safety threats through In situ simulation: catch them before they fall". Otolaryngol Head Neck Surg. 2021;164(6):1358. 10.1177/0194599820977193. [PubMed: 34060377]

40. Shah SJ, Cusumano C, Ahmed S, Ma A, Jafri FN, Yang CJ. In situ simulation to assess pediatric tracheostomy care safety: a novel multicenter quality improvement program. Otolaryngol Head Neck Surg. 2020;163(2): 250–258. Epub 20200526. 10.1177/0194599820923659. [PubMed: 32450759]

41. Aljahany M, Alassaf W, Alibrahim AA, et al. Use of In situ simulation to improve emergency department readiness for the COVID-19 pandemic. Prehosp Disaster Med. 2021;36(1):6–13. Epub 20201021. 10.1017/S1049023X2000134X. [PubMed: 33081859]

42. Jee M, Khamoudes D, Brennan AM, O'Donnell J. COVID-19 outbreak response for an emergency department using In situ simulation. Cureus. 2020;12(4):e7876. Epub 20200428. 10.7759/cureus.7876 [PubMed: 32489730]

43. Walsh BM, Gangadharan S, Whitfill T, et al. Safety threats during the Care of Infants with hypoglycemic seizures in the emergency department: a multicenter, simulation-based prospective cohort study. J Emerg Med. 2017;53(4):467–474 e7. Epub 20170824. 10.1016/j.jemermed.2017.04.028. [PubMed: 28843460]

44. Burton KS, Pendergrass TL, Byczkowski TL, et al. Impact of simulation-based extracorporeal membrane oxygenation training in the simulation laboratory and clinical environment. Simul Healthc. 2011;6(5):284–291. 10.1097/SIH.0b013e31821dfcea. [PubMed: 21642905]
45. Walker ST, Sevdalis N, McKay A, et al. Unannounced in situ simulations: integrating training and clinical practice. BMJ Qual Saf. 2013;22(6):453–458. Epub 20121204. 10.1136/bmjqs-2012-000986.
46. Yajamanyam PK, Sohi D. In situ simulation as a quality improvement initiative. Arch Dis Child Educ Pract Ed. 2015;100(3):162–163. Epub 20150407. 10.1136/archdischild-2014-306939. [PubMed: 25852214]
47. Minor S, Green R, Jessula S. Crash testing the dummy: a review of in situ trauma simulation at a Canadian tertiary Centre. Can J Surg. 2019; 62(4):243–248. 10.1503/cjs.008918. [PubMed: 31348631]
48. Petrosoniak A, Fan M, Hicks CM, et al. Trauma resuscitation using in situ simulation team training (TRUST) study: latent safety threat evaluation using framework analysis and video review. BMJ Qual Saf. 2021;30(9): 739–746. Epub 20201023. 10.1136/bmjqs-2020-011363.
49. Kjaergaard-Andersen G, Ibsgaard P, Paltved C, Irene JH. An in situ simulation program: a quantitative and qualitative prospective study identifying latent safety threats and examining participant experiences. Int J Qual Health Care. 2021;33(1):1–7. 10.1093/intqhc/mzaa148. [PubMed: 33432980]
50. Long AM, Lefebvre CM, Masneri DA, et al. The Golden opportunity: multidisciplinary simulation training improves trauma team efficiency. J Surg Educ. 2019;76(4):1116–1121. Epub 20190131. 10.1016/j.jsurg.2019.01.003. [PubMed: 30711425]
51. Steinemann S, Berg B, Skinner A, et al. In situ, multidisciplinary, simulation-based teamwork training improves early trauma care. J Surg Educ. 2011;68(6):472–477. Epub 20110803. 10.1016/j.jsurg.2011.05.009. [PubMed: 22000533]
52. Miller D, Crandall C, Washington C 3rd, McLaughlin S. Improving teamwork and communication in trauma care through in situ simulations. Acad Emerg Med. 2012;19(5):608–612. 10.1111/j.1553-2712.2012.01354.x. [PubMed: 22594369]
53. Saqe-Rockoff A, Ciardiello AV, Schubert FD. Low-Fidelity, In-situ pediatric resuscitation simulation improves RN competence and self-efficacy. J Emerg Nurs. 2019;45(5):538–544 e1. Epub 20190412. 10.1016/j.jen.2019.02.003. [PubMed: 30987773]
54. Tsai AC, Krisciunas GP, Brook C, et al. Comprehensive emergency airway response team (EART) training and education: impact on team effectiveness, personnel confidence, and protocol knowledge. Ann Otol Rhinol Laryngol. 2016;125(6):457–463. Epub 20151209. 10.1177/0003489415619178. [PubMed: 26658070]
55. Kurup V, Matei V, Ray J. Role of in-situ simulation for training in healthcare: opportunities and challenges. Curr Opin Anaesthesiol. 2017; 30(6):755–760. 10.1097/ACO.0000000000000514. [PubMed: 28968283]
56. Johnson K, Geis G, Oehler J, et al. Simulation to implement a novel system of care for pediatric critical airway obstruction. Arch Otolaryngol Head Neck Surg. 2012;138(10):907–911. 10.1001/2013.jamaoto.216. [PubMed: 23069820]
57. Kennedy C, Doyle NM, Pedigo R, Toy S, Stoner A. A novel approach to operating room readiness for airborne precautions using simulation-based clinical systems testing. Paediatr Anaesth. 2022;32(3):462–470. 10.1111/pan.14386. [PubMed: 34953096]
58. Rosen MA, Salas E, Wilson KA, et al. Measuring team performance in simulation-based training: adopting best practices for healthcare. Simul Healthc. 2008;3(1):33–41. 10.1097/SIH.0b013e3181626276. [PubMed: 19088640]
59. Remick K, Gausche-Hill M, Joseph MM, et al. Pediatric readiness in the emergency department. Pediatrics. 2018;142(5):e20182459. 10.1542/peds.2018-2459. [PubMed: 30389843]
60. Remick K, Smith M, Newgard CD, et al. Impact of individual components of emergency department pediatric readiness on pediatric mortality in US trauma centers. J Trauma Acute Care Surg. 2022;94:417–424. 10.1097/TA.0000000000003779. [PubMed: 36045493]

61. Propst EJ, Wolter NE, Ishman SL, et al. Competency-based assessment tool for pediatric tracheotomy: international modified Delphi consensus. Laryngoscope. 2020;130(11):2700–2707. Epub 20191210. 10.1002/lary.28461. [PubMed: 31821571]

62. Nasa P, Jain R, Juneja D. Delphi methodology in healthcare research: how to decide its appropriateness. World J Methodol. 2021;11(4):116–129. 10.5662/wjm.v11.i4.116. [PubMed: 34322364]

63. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Conde, research electronic data capture (REDCap) – a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform. 2009;42(2):377–381. [PubMed: 18929686]

64. Harris PA, Taylor R, Minor BL, et al. REDCap consortium, the REDCap consortium: building an international community of software partners. J Biomed Inform. 2019;95:103208. 10.1016/j.jbi.2019.103208. [PubMed: 31078660]

65. Kamal AN, Dhar SI, Bock JM, et al. Best practices in treatment of laryngopharyngeal reflux disease: a multidisciplinary modified Delphi study. Dig Dis Sci. 2022. 10.1007/s10620-022-07672-9 Epub ahead of print..

66. Dowling E, Larson D, Carlson ML, Price DL. Development and validation of instrument for operative competency assessment in selective neck dissection. Ann Otol Rhinol Laryngol. 2023;132(2):173–181. 10.1177/00034894221081101. [PubMed: 35249359]

67. Rosenfeld RM, Nnacheta LC, Corrigan MD. Clinical consensus statement development manual. Otolaryngol Head Neck Surg. 2015;153(2 Suppl): S1–S14. [PubMed: 26527615]

68. Poeppelman RS, Coles MT, Heater T, et al. Assessing competence with a task trainer: validity evidence for novel tracheostomy care skills assessment tool. Simul Healthc. 2022;17(4):220–225. 10.1097/SIH.0000000000000597 Epub 2021 Jul 28.. [PubMed: 34319269]

69. Doherty C, Neal R, English C, et al. Paediatric working Party of the National Tracheostomy Safety P. multidisciplinary guidelines for the management of paediatric tracheostomy emergencies. Anaesthesia. 2018; 73(11):1400–1417. Epub 20180731. 10.1111/anae.14307. [PubMed: 30062783]

70. Cooper S, Cant R, Connell C, et al. Measuring teamwork performance: validity testing of the TEAM emergency assessment measure (TEAM) with clinical resuscitation teams. Resuscitation. 2016;101:97–101. 10.1016/j.resuscitation.2016.01.026 Epub 2016 Feb 11. [PubMed: 26875992]

71. Livingston EH, Wislar JS. Minimum response rates for survey research. Arch Surg. 2012;147(2):110. 10.1001/archsurg.2011.2169. [PubMed: 22351903]

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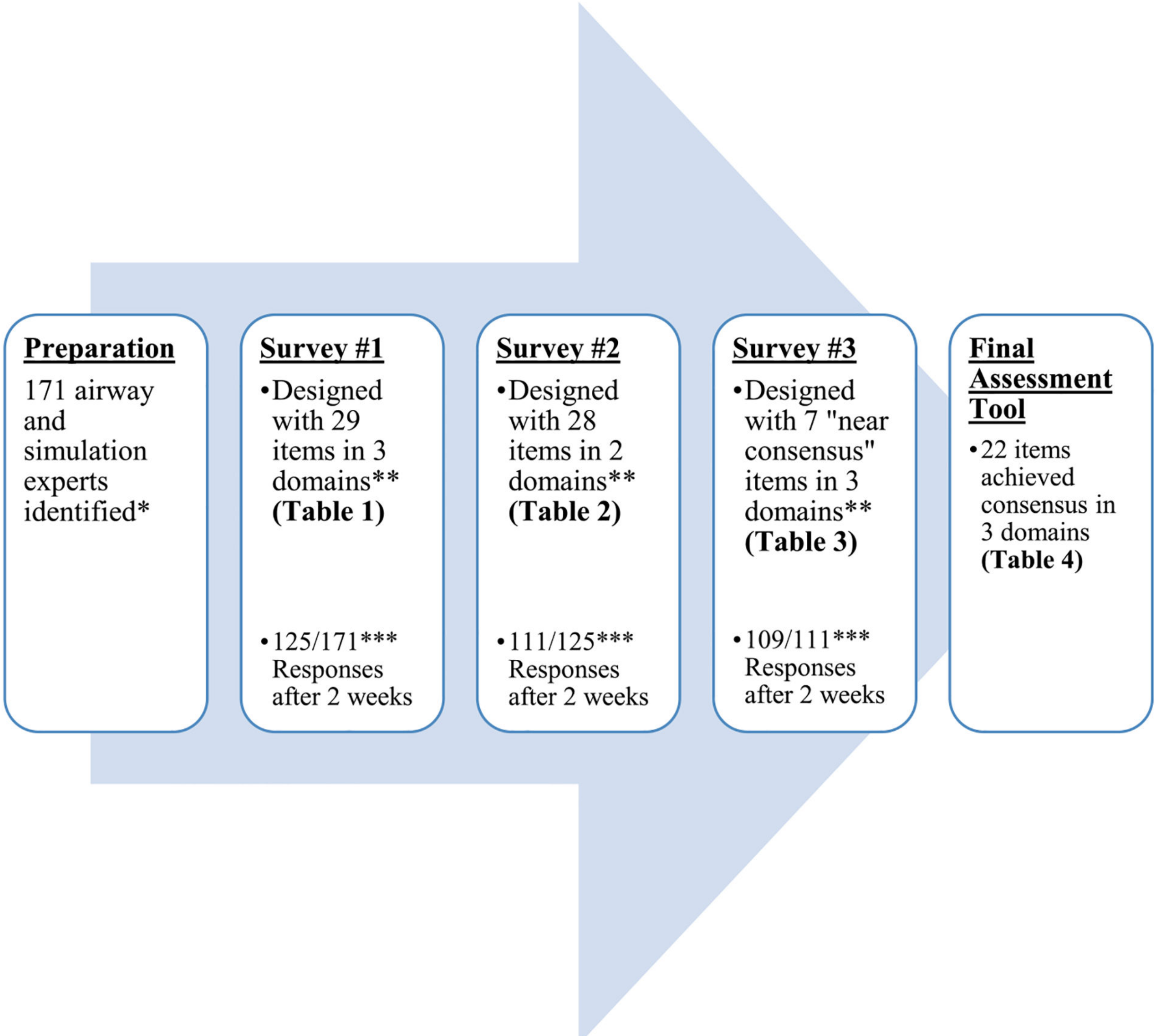


**Fig. 1.**

Flowsheet of Methods. *Experts identified from rosters of AAO-HNS, ASPO, IPOG, GTC, and peer nominations. **Feedback from survey comments were incorporated into each subsequent round. ***Each survey was distributed only to those who had engaged with the prior survey.

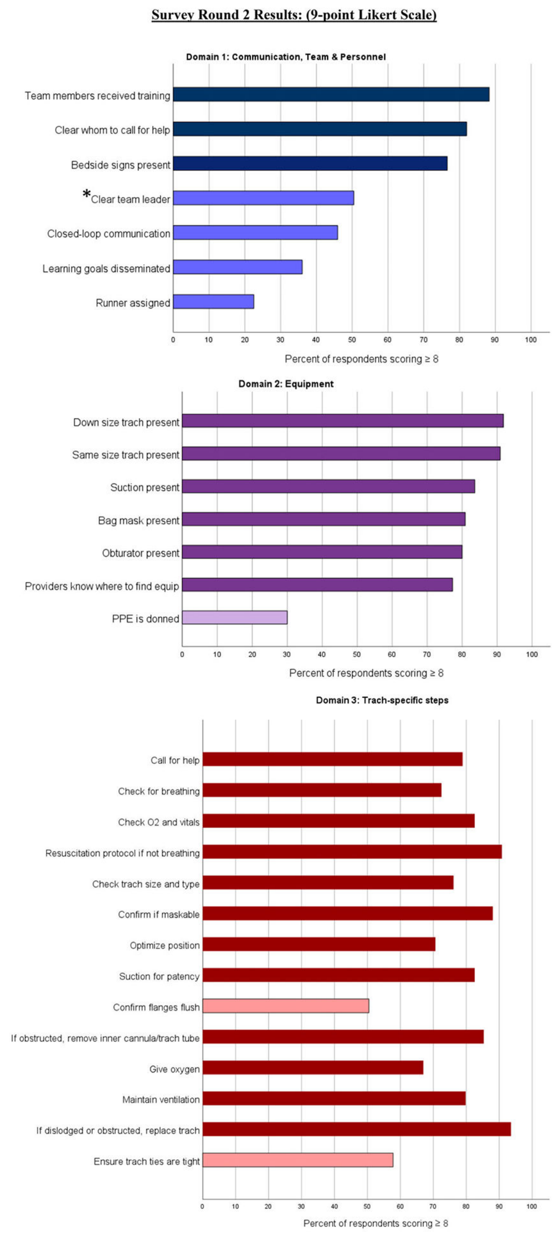


**Fig. 2.**

Results of Survey 2: Light-shaded bars represent items below the threshold of “consensus”. List of items in Domains 1 and 2 are reordered according to the y-axis values. Items in Domain 3 were not reordered to maintain the clarity of step-wise maneuvers necessary in this category. *Clear Team Leader achieved consensus in round 3, despite not achieving consensus in round 2.

| **Domain 1: Trach-Specific Steps** | | **Domain 2: Team and Personnel** | |
|---|---|---|---|
| Call for airway expert help | | Team members have received adequate tracheostomy training in accordance with institutional protocols | |
| Check for spontaneous breathing (i.e. EtCO2) | | It is clear whom to call for Expert Airway Help (e.g. Airway team, ENT, Anesthesia, etc) | |
| Check oxygen levels and vitals | | Bedside signs are present including date, size, type of trach tube | |
| Resuscitation protocol if no signs of breathing | | There is a clear team leader | |
| Check the trach tube size and type | | *Sub-Score B:* | |
| Confirm whether patient is maskable (not a critical airway) | | **Domain 3: Equipment** | |
| Optimize Position (e.g. Head-Tilt / Jaw-Thrust / Shoulder-Roll) | | Same size trach tube readily accessible at bedside | |
| Suction trach tube to assess patency | | Next size smaller trach tube readily accessible at bedside | |
| If obstructed, then remove inner cannula (if applicable) or entire trach tube | | Correct size suction catheter at bedside | |
| Administer oxygen via mask | | Obturator at bedside | |
| If dislodgment or obstruction not relieved by suctioning, then correctly replace trach tube | | Bag-mask at bedside | |
| Maintain ventilation | | Providers know where to find airway/tracheostomy equipment in their setting (e.g. supply closet, code cart, nursing station, etc.) | |
| *Sub-Score A:* | | *Sub-Score C:* | |
| | | **Total Score:** | |

**Fig. 3.**

Pediatric Tracheostomy Emergency Readiness Assessment Tool. Items are to be scored with a binary “Yes” or “No” via checks. Each domain’s completed steps should be summed to generate a composite “Sub-Score” for that domain.

**TABLE I.**

Pediatric Tracheostomy Emergency Readiness Assessment Tool – Survey Round 1.

| | Systems Factors: Communication and Teamwork | # Respondents | # (%) Marking keep |
|---|---|---|---|
| | ***We are aiming for approximately 5 items in this section/domain for the final assessment tool.*** | | |
| 1 | Team calls for airway expert help | 125 | 107(85.6) |
| 2 | It is clear whom to call for airway expert help (e.g., ENT, Anesthesia, etc) | 125 | 119 (95.2) |
| 3 | There is a clear team leader | 124 | 95 (76.6) |
| 4 | Runner assigned (to obtain supplies not immediately at bedside) | 124 | 66 (53.2) |
| 5 | Bedside signs are present including date, size, type of trach tube | 124 | 119 (96.0) |
| 6 | Team members call out next steps | 124 | 53 (42.7) |
| 7 | Team factor: Closed loop communication with callbacks | 124 | 91 (73.4) |
| 8 | Team members have received adequate tracheostomy training in accordance with institutional protocols | 124 | 114 (91.9) |
| | Comments about factors in this domain, or other factors to add | 18 | |
| | **Systems Factors: Equipment and Infection Control** | | |
| | ***We are aiming for approximately 5 items in this section/domain for the final assessment tool.*** | | |
| 1 | Same size trach tube readily accessible at bedside | 122 | 117 (95.9) |
| 2 | Next size smaller trach tube readily accessible at bedside | 122 | 121 (99.2) |
| 3 | Correct size suction catheter at bedside | 122 | 113 (92.6) |
| 4 | Obturator at bedside | 122 | 112 (91.8) |
| 5 | Bag-mask at bedside | 122 | 108(88.5) |
| 6 | Providers know where to find necessary equipment | 122 | 97 (79.5) |
| 7 | Appropriate PPE is donned in accordance with institutional protocols | 122 | 59 (48.4) |
| | Comments about factors in this domain, or other factors to add | 20 | |
| | **Tracheostomy-Specific Steps** | | |
| | ***We are aiming for approximately 10 items in this section/domain for the final assessment tool.*** | | |
| 1 | Check for spontaneous breathing | 124 | 109(87.9) |
| 2 | Resuscitation protocol if no signs of breathing | 121 | 110 (90.9) |
| 3 | Confirm whether patient is maskable (not a critical airway) | 121 | 117 (96.7) |
| 4 | Check the trach tube size | 121 | 105(86.8) |
| 5 | Head tilt/Jaw thrust | 124 | 61 (49.2) |
| 6 | Towel roll/Shoulder roll | 121 | 74 (61.2) |

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| | | | |
|---|---|---|---|
| 7 | Check oxygen levels and vitals | 124 | 117 (94.4) |
| 8 | Administration of oxygen via mask | 124 | 96 (77.4) |
| 9 | Maintain ventilation | 121 | 101 (83.5) |
| 10 | Suction trach tube to assess patency | 121 | 115 (95.0) |
| 11 | Confirm trach flanges flush with skin (remove gauze/drain sponges/skin barriers) | 121 | 71 (58.7) |
| 12 | If obstructed, then remove inner cannula (if applicable) or entire trach tube | 121 | 113 (93.4) |
| 13 | If trach tube dislodged, correctly replace trach tube | 121 | 118 (97.5) |
| 14 | Ensure trach ties are tight | 121 | 68 (56.2) |
| | Comments about factors in this domain, or other factors to add | 28 | |
| | Expert nomination: Colleague in tracheostomy or health care simulation, please submit their name and email. | 16 | |

**TABLE II.**

Pediatric Tracheostomy Emergency Readiness Assessment Tool – Survey Round 2.

| | Systems Factors: Teamwork, Communication, and Equipment | | | |
|---|---|---|---|---|
| | ***We aim to include 10–15 items total from this domain.*** | **# Respondents** | **Mean likert score (SD)** | **Consensus[a]** |
| 1 | Team members have received adequate tracheostomy training in accordance with institutional protocols | 111 | 8.45 (0.94) | Yes |
| 2 | Bedside signs are present including date, size, type of trach tube | 111 | 8.17(1.17) | Yes |
| 3 | It is clear whom to call for Expert Airway Help (e.g., Airway team, ENT, Anesthesia, etc) | 111 | 8.31 (0.95) | Yes |
| 4 | There is a clear team leader | 111 | 7.25 (1.58) | Near |
| 5 | There is a runner assigned (to obtain supplies) | 111 | 6.26 (1.67) | No |
| 6 | Team utilizes closed loop communication (verbal confirmation of issued instructions in real time) | 111 | 7.35 (1.38) | Near |
| 7 | Same size trach tube readily accessible at bedside | 110 | 8.59 (0.73) | Yes |
| 8 | Next size smaller trach tube readily accessible at bedside | 111 | 8.64 (0.74) | Yes |
| 9 | Correct size suction catheter at bedside | 111 | 8.33 (1.22) | Yes |
| 10 | Obturator at bedside | 111 | 8.2 (1.43) | Yes |
| 11 | Bag-mask at bedside | 111 | 8.26 (1.39) | Yes |
| 12 | Providers know where to find airway/tracheostomy equipment in their setting (e.g., supply closet, code cart, nursing station, etc.) | 111 | 8.22 (1.01) | Yes |
| 13 | Appropriate PPE is donned in accordance with institutional protocols | 111 | 6.36 (2) | No |
| 14 | Following debrief, learning goals are disseminated to relevant providers | 111 | 6.83 (1.68) | No |
| | Comments about factors in this domain, or other factors to add | 15 | | |
| | **Tracheostomy-Specific Steps** | | | |
| | ***We aim to include 10–15 items from this domain.*** | | | |
| 1 | Call for airway expert help | 109 | 8.2 (1.16) | Yes |
| 2 | Check for spontaneous breathing (i.e., EtCO2) | 109 | 8.2 (0.97) | Yes |
| 3 | Check oxygen levels and vitals | 109 | 8.42 (0.94) | Yes |
| 4 | Resuscitation protocol if no signs of breathing | 109 | 8.64 (0.82) | Yes |
| 5 | Check the trach tube size and type | 109 | 8.22 (1.07) | Yes |
| 6 | Confirm whether patient is maskable (not a critical airway) | 109 | 8.5 (0.81) | Yes |
| 7 | Optimize Position (e.g., Head-Tilt / Jaw-Thrust / Shoulder-Roll) | 109 | 8.06 (1.04) | Yes |
| 8 | Suction trach tube to assess patency | 109 | 8.38 (0.94) | Yes |
| 9 | Confirm trach flanges flush with skin (remove gauze/drain sponges/skin barriers) | 109 | 7.49 (1.47) | Near |
| 10 | If obstructed, then remove inner cannula (if applicable) or entiretrach tube | 109 | 8.39 (0.89) | Yes |

| | | | | |
|---|---|---|---|---|
| 11 | Administer oxygen via mask | 109 | 7.82 (1.47) | Yes |
| 12 | Maintain ventilation | 109 | 8.34 (1.16) | Yes |
| 13 | If dislodgment or obstruction not relieved by suctioning, then correctly replace trach tube | 109 | 8.68 (0.66) | Yes |
| 14 | Ensure trach ties are appropriately tight | 109 | 7.49 (1.58) | Near |
| | Comments about factors in this domain, or about their order | 16 | | |
| Please answer these final questions. | | | | |
| 1 For an assessment tool that would be used to assess and debrief both simulated and clinical events, which domain would you prefer to have listed first? | | | | |
| | Teamwork & Communication | 39 | | |
| | Trach-specific steps | 63 | | |
| | No preference / Not sure | 7 | | |
| 2 Which term do you prefer? | | | | |
| | Tracheotomy | 14 | | |
| | Tracheostomy | 73 | | |
| | No preference | 22 | | |
| 3 General comments about this survey | | 11 | | |

[a] "Consensus" if either greater than 60% of responses scored it 8 or 9, or if the mean score was greater than 7.5; "Near consensus" if fewer than 40% of responses scored it 8 or 9, and a mean score greater than 5.0; "No consensus" if neither criteria is met.

**TABLE III.**

Pediatric Tracheostomy Emergency Readiness Assessment Tool – Survey Round 3[a]

| | | # Respondents | Mean likert score (SD) | Consensus |
|---|---|---|---|---|
| **Systems Factors: Communication, Team, and Personnel Factors** | | | | |
| 1[b] | There is a clear team leader (Mean 7.25; SD 1.587) | 109 | 7.68 (1.34) | Yes |
| 2[b] | Team utilizes closed loop communication (verbal confirmation of issued instructions in real time) (Mean 7.35; SD 1.386) | 109 | 7.39 (1.33) | No |
| 3[b] | Following debrief, learning goals are disseminated to relevant providers (Mean 6.83; SD 1.683) | 109 | 6.56 (1.79) | No |
| 4[b] | There is a runner assigned (to obtain supplies) (Mean 6.26; SD 1.683) | 109 | 5.75 (1.92) | No |
| **Systems Factors: Equipment** | | | | |
| 1[b] | Appropriate PPE is donned in accordance with institutional protocol (Mean 6.36; SD 2.008) | 109 | 5.75 (1.79) | No |
| **Tracheostomy-Specific Steps** | | | | |
| 1[b] | Confirm trach flanges flush with skin (remove gauze/drain sponges/skin barriers) (Mean 7.49; SD 1.476) | 109 | 6.47 (1.72) | No |
| 2[b] | Ensure trach ties are appropriately tight (Mean 7.49; SD 1.591) | 109 | 7.43 (1.48) | No |
| | Any comments on this survey | 16 | | |

[a]This final survey was administered for items that achieved “no consensus or near consensus” in survey 2. Participants were given graphs with results from round 2.

[b]The mean and standard deviation of items from survey - round 2 was provided to survey respondents for survey - round 3.