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## Intubation Practices for Children in Emergency Departments and Intensive Care Units across Australia and New Zealand: A Survey of Medical Staff

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### Author Contributions:

SG was responsible for identifying the topic. SG and AS developed the initial survey with feedback and review by EL, BG, SRD and FEB. SG coordinated distribution of the survey and collection of responses. All authors distributed the survey to their department, and encouraged completion amongst their peer group. SG analysed the responses and drafted this manuscript with input from all other authors.

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All authors attest to the accuracy of the final manuscript and SG takes responsibility for the manuscript as a whole.

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**Data Availability:**

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## **ABSTRACT:**

### ***Introduction:***

Intubation of children in the emergency setting is a high risk, low incidence event. Standardisation of clinical practice has been hampered by a lack of high-quality evidence to support one technique over another.

### ***Objective:***

To determine clinician preference in intubation practice of children in emergency departments (EDs) and intensive care units (ICUs) in Australia and New Zealand to provide baseline information to allow future targeted research focused on improving the safety and efficacy of paediatric emergency airway management

### ***Methods:***

This study was a voluntary questionnaire undertaken by medical staff at registrar level or above in EDs and ICUs associated with the Paediatric Research in Emergency Departments International Collaborative (PREDICT) and Australia and New Zealand Intensive Care Society Paediatric Study Group (ANZICS PSG) research networks. Respondents reported on their individual intubation practices, with a focus on pre-oxygenation and apnoeic oxygenation techniques, and the use of video laryngoscopy.

### ***Results:***

A total of 502 clinicians were invited to complete the survey between May and October 2018 with 336 (66.9%) responding. There was marked variation in practice between ED clinicians and ICU clinicians in the techniques used for pre-oxygenation, the frequency of use of apnoeic oxygenation, and the reported use of video laryngoscopy.

### ***Conclusions:***

Within Australia and New Zealand there is considerable variation in paediatric emergency airway clinical practice, in particular with respect to pre-oxygenation, apnoeic oxygenation, and use of video laryngoscopy. Definitive clinical trials are required to best inform clinical practice in this area.

**Keywords:** intubation, airway management, paediatric, pre-oxygenation, apnoeic oxygenation.

## INTRODUCTION

Intubation of children in the emergency setting is a high risk, low incidence event. In addition to the anatomical and physiological challenges that some paediatric intubations pose, it is recognised that intubations in the Emergency Department (ED) and Intensive Care Unit (ICU) are, in general, higher risk than those in the controlled environment of the operating theatre (1). An Australian prospective study of all emergency intubations occurring in a tertiary paediatric ED showed that only 78% of intubation attempts were successful first time and of these, 14% had an adverse desaturation event (2). This high adverse event rate is consistent with other large international paediatric airway registry data showing a first pass success rate of just 60% and desaturation rate of 16% (3).

Following on from the publication of the results of the fourth national audit project of the Royal College of Anaesthetists (NAP4) in the United Kingdom (1) there has been a concentrated effort to improve intubation success in both adults and children through the introduction of various techniques and tools to improve the likelihood of successful intubation in emergent situations.

Some of these tools and techniques have been implemented with limited high-quality evidence to support their use, resulting in a diverse and inconsistent approach to airway management, largely guided by individual preference rather than evidence-based best practice. In the United Kingdom, a recently published survey has identified that many of the recommendations of NAP4 have not been translated into practice in paediatric and neonatal intensive care units (PICUs and NICUs) (4).

It has become increasingly clear that further research is required to help guide clinicians into better understanding best practice and provide a definitive evidence base for future guideline development. This study seeks to determine the reported current practice in paediatric intubation across Australia and New Zealand to provide baseline information to allow future targeted research focused on improving the safety and efficacy of paediatric emergency airway management.

## METHODS

Between May and October 2018, a voluntary questionnaire was undertaken by medical staff at registrar level or above in EDs and ICUs across the Paediatric Research in Emergency Departments International Collaborative (PREDICT) and the Australia and New Zealand Intensive Care Society Paediatric Study Group (ANZICS PSG) research networks. Invitations to participate were sent to research leads in EDs (mixed and paediatric) and ICUs across the PREDICT and ANZICS PSG research networks. Eleven EDs were invited to participate, with nine departments (four mixed, five paediatric) accepting the invitation. Ten ICUs were invited to participate, with eight departments accepting the invitation. The questionnaire was distributed online by an email invitation to participate, sent from a local site representative. Approval to conduct the study was obtained from the Gold Coast Hospital and Health Service Human Research Ethics Committee and Research Governance Office (HREC/17/QGC/276).

### *Survey development and conduct*

Two separate questionnaires were distributed. Firstly, a hospital questionnaire containing a series of questions relating to specific hospital procedures, equipment and processes was distributed to a single lead clinician at each participating department to be completed. Secondly, a clinician questionnaire

containing a series of questions relating to individual practice and preferences in technique, process and equipment used in the intubation of children was distributed to all consultants and registrars in each participating department.

The survey was distributed to lead investigators in each participating department who then distributed it to medical staff within their unit. The survey was constructed on an online proprietary survey website ([www.surveymonkey.com](http://www.surveymonkey.com)). Responses were anonymous and not identifiable by site. Survey participation was voluntary, and consent was implied by its completion.

### **Definitions**

For the purposes of the analysis, routine clinician practice was interpreted as an intervention or procedure being reported as undertaken “always” or “most of the time.”

Preoxygenation was defined as the delivery of high concentration oxygen, by any means, to the patient before the induction of anaesthesia. Apnoeic oxygenation was defined as the provision of passive oxygenation during and throughout the intubation attempt. Apnoeic oxygenation did not include the provision of respiratory support in the period between induction of anaesthesia and the beginning of the intubations attempt where oxygenation was not continued throughout the intubation procedure.

### **Analysis**

Statistical analyses were performed using IBM SPSS Statistics for Windows, version 24 (IBM Corp., Armonk, N.Y., USA). The data are summarised as frequency (n) and percentage (%) for univariate and bivariate analysis, along with 95% confidence intervals (CIs). Proportions were compared using Chi-squared test.

## **RESULTS**

Of the 502 medical staff invited to participate 336 (66.9%) responded. Respondent profiles are shown in Table 1.

Paediatric intubation is a rare clinical event with 145 (43.2%) respondents reporting that they would intubate a child at most once per year. Frequency of paediatric intubation is more common amongst ICU clinicians when compared to ED clinicians (Figure 1).

### **Intubation Checklists**

The routine use of an intubation checklist was not significantly different between ICU and ED clinicians (difference 9.1%, 95% CI -4.8% to 20.5%,  $p = 0.07$ ), nor between mixed ED and paediatric ED (difference 1.4%, 95% CI -7.2% to 10.8%,  $p = 0.74$ ), Table 2.

### **Video Laryngoscopy**

There was a significant variation amongst clinicians in the use of video laryngoscopy (VL) in ED and ICU (Table 2). The routine use of VL was more common in ED clinicians (36.1%, 95% CI 30.2 to 42.5%) than in ICU clinicians (16.4%, 95% CI 8.8 to 27.0%, difference 19.7%, 95% CI 8.1% to 28.9%,  $p = 0.002$ ). ED clinicians practicing in mixed ED were significantly more likely to routinely use VL compared to those in paediatric ED (difference 32.4%, 95% CI 20.7% to 42.4%,  $p < 0.001$ ).

### **Preoxygenation**

Preoxygenation techniques used by ED and ICU clinicians are significantly different (Table 3). In ICU a bag and mask system (either self-inflating or anaesthetic style) is used by 80.2% of respondents (65/81, 95% CI 69.9% to 88.3%), compared with 45.6% of ED clinicians (103/226, 95% CI 39.0% to 52.3%; difference 34.6%, 95% CI 22.7% to 44.2%,  $p < 0.001$ ). A variety of alternative preoxygenation techniques were reported to be used by ED clinicians as a preferred pre-oxygenation technique (Table 3) including non-rebreather masks (47/226, 20.8%, 95% CI 15.7% to 26.4%) and standard nasal prongs (30/226, 13.3%, 95% CI 9.1% to 18.4%).

Positive end-expiratory pressure (PEEP) was more commonly used during preoxygenation by ICU clinicians (45/71, 63.4%, 95% CI 51.1% to 74.5%) compared with ED clinicians (89/234, 38.0%, 95% CI 31.8% to 44.6%; difference 25.4%, 95% CI 12.1% to 37.2%,  $p < 0.001$ ).

Adequacy of preoxygenation was assessed by respondents by the measured oxygen saturations (257/305, 84.2%), the length of time that preoxygenation was been provided for (200/305, 65.5%) and/or by clinical gestalt (105/305, 34.4%). The measured fraction of expired oxygen ( $FeO_2$ ) was reported as being used by only 21/305 (6.8%) respondents.

#### **Apnoeic Oxygenation**

There was significant variation in the use of apnoeic oxygenation (Table 2) between ED clinicians (79.4%, 95% CI 73.5% to 84.4%) and ICU clinicians (8.5%, 95% CI 3.2% to 17.5%; difference 70.9%, 95% CI 60.5% to 77.5%,  $p < 0.0001$ ). The routine use of apnoeic oxygenation was also significantly different between paediatric ED (70.2%, 95% CI 61.0% to 79.5%) and mixed ED clinicians (85.8%, 95% CI 78.7% to 91.2%; difference 15.6%, 95% CI 4.8% to 26.7%,  $p = 0.004$ ).

The preferred technique for the provision of apnoeic oxygenation differed between ED and ICU clinicians (Table 3) with standard nasal prongs being preferred by ED clinicians (159/208, 75.7%, 95% CI 69.3% to 81.4%) when compared to ICU clinicians (17/52, 32.7%, 95% CI 20.3% to 47.1%; difference 43.0%, 95% CI 28.1% to 55.4% ,  $p < 0.001$ ). In contrast, high flow nasal oxygen was the preferred technique by ICU clinicians (29/52, 55.8%, 95% CI 41.3 to 69.5%) compared to ED clinicians (41/208, 19.5%, 95% CI 14.4% to 25.5%; difference 36.3%, 95% CI 21.6% to 49.8%,  $p < 0.001$ ).

#### **Post Intubation Care**

Endotracheal intubation was confirmed using waveform capnography by 94.6% (283/299, 95% CI 91.5% to 96.9%) of respondents. Recruitment manoeuvres are not routinely performed by most respondents (243/299, 81.3%, 95% CI 76.8% to 85.5%). There was no difference in post intubation care between clinician groups.

#### **Difficult Airway and Failed Intubation**

Most respondents would usually *consider* abandoning their intubation attempt when the oxygen saturations fall below 90% (49.1%, 145/295); however, only 22.3% (66/296, 95% CI 17.6% to 27.0%) *would* abandon the attempt at this level. When the oxygen saturations fall below 80%, 66.6% (197/296, 95% CI 61.2% to 71.9%) would abandon the attempt, and at saturations of 70% 226/296 (76.3%, 95% CI 71.5% to 81.2%) of respondents would abandon the attempt. There was no difference in difficult airway and failed intubation approaches between clinician groups.

A broad range of difficult or failed airway equipment was available in all departments surveyed.

#### **Quality Assurance and Audit**

Of the departments that participated in this survey, 8/17 (47%) had a clinical practice guideline for intubation. Intubation checklists were used in 15/17 (88%) departments, with a paediatric specific checklist used in 12/17 (71%) departments. An airway procedures and outcomes registry is kept in 8/17 (47%) departments. Formal credentialing of all medical staff performing airway procedures occurred in only 4/17 (24%) departments, with a further 3/17 (18%) departments credentialing junior medical staff only.

## DISCUSSION

This survey of reported paediatric emergency intubation practice in Australia and New Zealand EDs and ICUs has highlighted several practices, processes and techniques where there is variation not only between individual physicians, but also between critical care specialties. While this variation is not entirely unexpected, this variation supports the need for further research to guide clinicians into being able to adopt best practice techniques into routine practice.

The use of intubation checklists has been widely advocated for many years, particularly in emergency medicine practice. The use of an intubation checklist for adult emergency medicine is almost universal in Australia and New Zealand (5). Although there is a large body of research concerning the use of an intubation checklist and its impact on outcomes the true impact of intubation checklists is uncertain as these tend to be introduced with a wide variety of other quality co-interventions (6-11). Further, the exact composition, format, timing and use of checklists varies significantly between clinicians and departments. In addition, there is a common perception that using an intubation checklist in situations where the patient is critically unwell takes too long to complete. However, it is these exact patients that are at highest risk for an intubation related adverse event and are potentially likely to benefit the most from robust planning and a shared team approach to intubation which a well-designed and delivered checklist may deliver.

The wide variation in pre-oxygenation techniques in emergency medicine (Table 3) is an unexpected finding. Less than half of ED clinicians reported using a bag-mask system, which would be considered the gold standard technique by anaesthetists. In contrast three quarters of ICU clinicians reported using a bag-mask system. The reasons for this variation in practice are unclear, but some hypotheses include variations in available equipment, familiarity with anaesthetic style circuits and lack of evidence to support one modality over another. The widespread use of non-rebreather masks and nasal prongs at flow rates of  $\leq 15\text{L}/\text{min}$  for preoxygenation is likely to represent the adoption of adult practices translated to the paediatric population. Data to support these techniques in the paediatric populations is limited, with recent adult studies suggesting that these techniques may not achieve optimal preoxygenation (12-14).

The adequacy of preoxygenation was only objectively measured by the fraction of expired oxygen ( $\text{FeO}_2$ ) in a very small number of respondents (7%). Most modern monitors in ED and ICU have this capability, yet its routine use outside of the operating theatre remains limited. Several respondents commented that they would use  $\text{FeO}_2$  if it were available to them in this setting. Further research into the feasibility of introducing  $\text{FeO}_2$  measurement in the emergency and ICU setting is warranted.

The routine use of apnoeic oxygen in ED clinicians is significantly different to that of ICU clinicians (79.4% and 8.5% respectively). This again most likely represents a translation of adult practice into paediatric patients in the emergency setting. The topic has been an area of intense interest in adult emergency literature, with five systematic reviews on the topic since 2016 (15-19). These reviews

conclude that there are few high-quality randomised studies investigating the use of apnoeic oxygenation. Amongst the data available there is a strong trend toward benefit, with a lower rate of oxygen desaturation during intubation in patients who receive apnoeic oxygenation; however, there is a high degree of heterogeneity in methods, outcomes and patient populations the studies included in these reviews. No systematic reviews of apnoeic oxygenation in paediatric patients have been identified. The use of humidified high flow apnoeic oxygenation has been identified as a high priority research topic by a recent Delphi survey of paediatric emergency physicians in Australia and New Zealand (20), and is the topic of a currently recruiting randomised controlled trial (21). Randomised control trials investigating the role of low flow oxygen during apnoea are needed.

The availability and use of VL during paediatric intubation is an evolving topic. Over recent years, the availability of paediatric sized VL blades has increased. The routine use of VL is promoted in some facilities to ensure competence with equipment in routine situations, thus being more familiar with the device when a difficult airway is encountered. There is limited data to support the routine use of VL in paediatric patients, with published meta-analysis suggested that VL is associated with longer time to intubation with no significant difference in rate of successful intubation (22). Further research is warranted investigating the role of VL in paediatric emergency and intensive care settings and exploring the role and efficacy of VL in outside of the operating theatre setting.

The collection of airway outcomes and adverse event data is reported in half of the departments surveyed. At present this data is collected locally, with variable data elements collected at each hospital, leading to inconsistent data collection and outcome reporting. Given the strong collaborative relationships across the paediatric ED and ICU research networks in Australasia and the relative rarity of paediatric intubations in ED and mixed ICU, consideration should be given to the development of a multisite paediatric airway registry for both ED and ICU intubations with the aim of providing regional outcome data to inform future research priorities as well as national guideline development.

## **STRENGTHS AND LIMITATIONS:**

This survey provides insight in the self-reported intubation practices of clinicians across two acute care speciality groups in Australia and New Zealand. Although there may be differences in the reported practice of clinicians and their actual practice the results highlight differences in attitudes to commonly applied techniques and highlights the paucity of high-quality evidence to guide clinical practice. The survey had a response rate of two thirds, and thus the results may not be representative. However, this is unlikely as the survey involved 17 departments across both countries.

Sites invited to participate are members of either PREDICT or ANZICS PSG research networks, this may introduce some bias as these sites have a demonstrated involvement in research or quality improvement and are more likely to be tertiary referral centres. While the survey includes some mixed adult and paediatric emergency departments, they are all tertiary centres, and this may not represent practice in other metropolitan, regional or rural non-tertiary mixed emergency departments. The survey has captured only paediatric intensive care units and does not include adult units who may sometimes manage children. Despite this limitation, variations in practice are evident within this sample. This variation is unlikely to be reduced by increasing the number of participating departments, although the nature and extent of those variations cannot be extrapolated from the data presented. The variations observed can be used as a basis for future prospective observational or interventional studies involving paediatric intubation across all EDs and ICUs.

**CONCLUSIONS:**

This survey highlights the self-reported variations in clinical practice in the intubation of children in the emergency and intensive care settings in Australia and New Zealand. While there is unlikely to be a one-size-fits-all approach to paediatric airway management, there is a paucity of high-quality evidence to support clinicians in adopting a best practice approach resulting in a broad variation in practice amongst clinicians and clinical speciality groups. Collection of prospective airway procedures data and outcomes in a paediatric airway registry across ED and ICU in Australian and New Zealand would be of benefit in better understanding clinical practice, as well as guide future research and guideline and airway bundle development. Targeted research into preoxygenation techniques, the role and method of apnoeic oxygenation, and the role of VL in paediatric intubation is warranted.

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**Table 1: Respondent Characteristics**

		Clinical level			
		Consultant	Fellow	Registrar	Total
		n	n	n	n
Primary area of clinical practice	Mixed Emergency Medicine	89	10	50	149
	Paediatric Emergency Medicine	64	9	38	111
	Mixed Intensive Care Medicine	13	0	6	19
	Paediatric Intensive Care Medicine	33	7	17	57
Total		199	26	111	336

**Table 2: Use of intubation related procedures/interventions by respondent clinical practice**

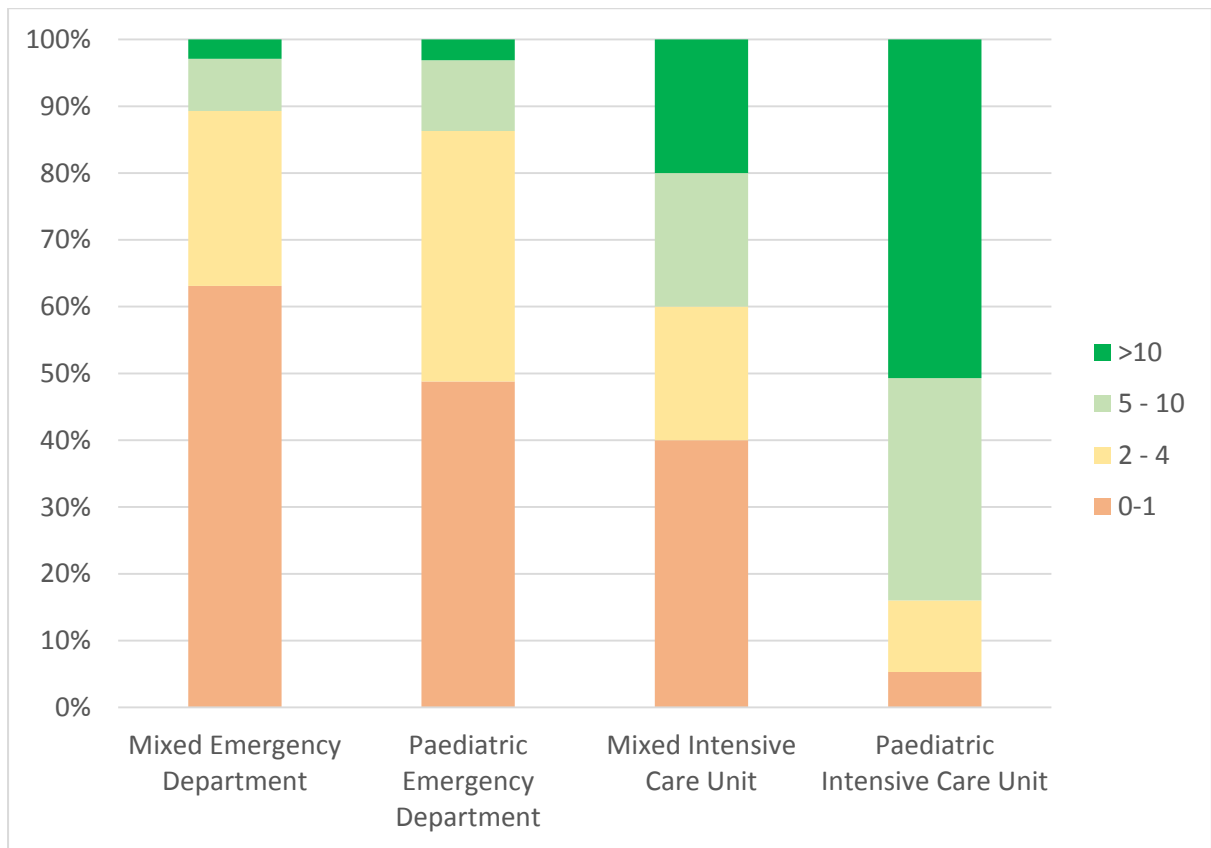
		Mixed Emergency Medicine		Paediatric Emergency Medicine		Paediatric Intensive Care Medicine		Mixed Intensive Care Medicine	
		n % (95% CI)		n % (95% CI)		n % (95% CI)		n % (95% CI)	
Do you use an intubation checklist when intubating children?	<b>Routinely</b>	126 85.7% (79.0% to 90.1%)	91 84.3% (76.0% to 90.6%)	44 77.2% (64.2% to 87.3%)	13 72.2% (46.5% to 90.3%)				
	<b>Not Routinely</b>	21 14.3% (9.1% to 21.0%)	17 15.7% (9.4% to 24.0%)	13 22.8% (12.7% to 35.8%)	5 27.8% (9.7% to 53.5%)				
Do you use a video laryngoscope when intubating children?	<b>Routinely</b>	72 49.7% (41.3% to 58.1%)	18 17.3% (10.6% to 26.0%)	7 12.5% (5.2% to 24.1%)	5 29.4% (10.3% to 56.0%)				
	<b>Not Routinely</b>	73 50.3% (41.9% to 58.7%)	86 82.7% (74.0% to 89.4%)	49 87.5% (75.9% to 94.8%)	12 70.6% (44.0% to 89.7%)				
Do you provide PEEP during the preoxygenation phase when intubating children?	<b>Routinely</b>	45 33.1% (25.3% to 41.7%)	44 44.9% (34.8% to 55.3%)	34 60.7% (46.8% to 73.5%)	11 73.3% (44.9% to 92.2%)				
	<b>Not Routinely</b>	91 66.9% (58.3% to 74.7%)	54 55.1% (44.7% to 65.2%)	22 39.3% (26.5% to 53.2)	4 26.7% (7.8% to 55.1%)				
Do you provide apnoeic oxygenation during intubation attempts?	<b>Routinely</b>	115 85.8% (78.7% to 91.2%)	66 70.2% (59.9% to 79.2%)	4 7.1% (2.0% to 17.3%)	2 13.3% (1.7% to 40.5%)				
	<b>Not Routinely</b>	19 14.2% (8.8% to 21.3%)	28 29.8% (20.8% to 40.1%)	52 92.9% (82.7% to 98.0%)	13 86.7% (59.5% to 98.3%)				

<b>Do you perform recruitment manoeuvres after intubation?</b>	<b>Routinely</b>	19	18	17	2
		14.2% (8.8% to 21.3%)	19.1% (11.8% to 28.6%)	30.4% (18.8% to 44.1%)	13.3% (1.7% to 40.5%)
	<b>Not Routinely</b>	115	76	39	13
		85.8% (78.7% to 91.2%)	80.9% (71.4% to 88.2%)	69.6% (55.9% to 81.2%)	86.7% (59.5% to 98.3%)

**Table 3: Preoxygenation and Apnoeic Oxygenation techniques by respondent clinical practice.**

		Emergency Medicine		Intensive Care Medicine			
		n % (95% CI)		n % (95% CI)			
What is your preferred pre-oxygenation technique?	<b>Anaesthetic Bag-Mask Circuit</b>	71	61	31.4%	(25.4% to 37.9%)	75.3%	(64.5% to 84.2%)
	<b>Self-inflating Bag-Valve Mask</b>	32	4	14.2%	(9.9% to 19.4%)	4.9%	(1.4% to 12.2%)
	<b>Standard Nasal Prongs</b>	30	4	13.3%	(9.1% to 18.4%)	4.9%	(1.4% to 12.2%)
	<b>Nasal High Flow (at least 2L/kg/minute)</b>	18	1	8.0%	(4.8% to 12.3%)	1.2%	(0.0% to 6.7%)
	<b>Nasal High Flow (less than 2L/kg/min)</b>	1	0	0.4%	(0.0% to 2.4%)	0.0%	(0.0% to 4.5%)*
	<b>Non-rebreathing face mask</b>	47	3	20.8%	(15.7% to 26.47%)	3.7%	(0.8% to 10.4%)
	<b>Face mask and nasal prongs in combination</b>	9	0	4.0%	(1.8% to 7.4%)	0.0%	(0.0% to 4.5%)*
	<b>Other</b>	18	8	8.0%	(4.8% to 12.3%)	9.9%	(4.4% to 18.5%)
What is your preferred apnoeic oxygenation technique?	<b>Nasal High Flow (at least 2L/kg/minute)</b>	41	29	19.5%	(14.4% to 25.5%)	55.8%	(41.3% to 69.5%)
	<b>Nasal High Flow (less than 2L/kg/min)</b>	8	6	3.8%	(1.7% to 7.4%)	11.5%	(4.4% to 23.4%)
	<b>Standard Nasal Prongs</b>	159	17	75.7%	(69.3% to 81.4%)	32.7%	(20.3% to 47.1%)
	<b>Other</b>	2	0	1.0%	(0.1% to 3.4%)	0.0%	(0.0% to 6.8%)*

\* One-sided 97.5% confidence interval



**FIGURE 1:** Reported annual frequency of paediatric intubation by each respondent, reported by primary clinical environment.