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ORIGINAL RESEARCH

Prospective observational study of the practice of endotracheal intubation in the emergency department of a tertiary hospital in Sydney, Australia

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Abstract

Objective: To describe the practice of endotracheal intubation in the ED of a tertiary hospital in Australia, with particular emphasis on the indication, staff seniority, technique, number of attempts required and the rate of complications.

Methods: A prospective observational study.

Results: Two hundred and ninety-five intubations occurred in 18 months. Trauma was the indication for intubation in 30.5% (95% CI 25.3–36.0) and medical conditions in 69.5% (95% CI 64.0–74.5). Emergency physicians were team leaders in 69.5% (95% CI 64.0–74.5), whereas ED registrars or senior Resident Medical Officers made the first attempt at intubation in 88.1% (95% CI 83.9–91.3). Difficult laryngoscopy occurred in 24.0% (95% CI 19.5–29.3) of first attempts, whereas first pass success occurred in 83.4% (95% CI 78.7–87.2). A difficult intubation occurred in 3.4% (95% CI 1.9–6.1) and all patients were intubated orally in five or less attempts. A bougie was used in 30.9% (95% CI 25.8–36.5) of first attempts, whereas a stylet in 37.5% (95% CI 32.1–43.3). Complications occurred in 29.0% (95% CI 23.5–34.1) of the patients, with desaturation the commonest in 15.7% (95% CI 11.9–20.5). Cardiac arrest occurred in 2.2% (95% CI 0.9–4.4) after intubation. No surgical airways were undertaken.

Conclusion: Although the majority of results are comparable with overseas data, the rates of difficult laryngoscopy and desaturation are higher than previously reported. We feel that this data has highlighted the need for practice improvement within our department and we would encourage all those who undertake emergent airway management to audit their own practice of this high-risk procedure.

Key words: *airway management, complication, emergency medicine, intubation, registry*.

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Introduction

Advanced airway management is an accepted core skill of emergency physicians (EPs) in Australasia.[1]

However, RSI is a high-risk procedure that has been shown to have an increased rate of severe complications – such as failed intubation, hypoxia, hypotension or surgical airway – when it takes place in the ED in comparison with the operating theatre.[2,3]

The reasons for this are multifactorial: the patients themselves, by needing emergent intubation, will often have substantial physiological and/or anatomical derangement; they might often have significant comorbidities and they are likely to be non-fasted. The need to maintain cervical immobility in a trauma patient will often make laryngoscopy more difficult.[4]

The recently published Fourth National Audit of Major Complications of Airway Management in the UK[5] reviewed 15 severe complications associated with airway management in the ED. The authors found that a high proportion of events occurred out of hours, without consultant supervision, or without the operators following standard airway management algorithms and 'failing to plan for failure'.

Several studies have been published that describe the performance of intubation in the EDs of North America[6,7] and the UK.[8–11]

However, there has been no data published regarding the success rates or complications that occur within the Australasian model of emergency management. This is surprising given the fact that there are significant differences in both emergency medicine training and the ED management of airways between Australasia, the USA[6,7] and the UK.[8,12]

The aim of this study was to describe the practice of intubation in the ED of a tertiary hospital in Australia, with particular emphasis on the indication, staff seniority, technique, number of attempts required and the rate of complications.

Methods

This prospective observational study was carried out from April 2010 to September 2011 in the ED of The Royal North Shore Hospital, a major trauma centre in Sydney, Australia. The ED has an annual census of approximately 60 000 patients with 20% paediatrics.

Permission for the study was granted by the Northern Sydney Local Health District Human Research Ethics Committee.

The sample size was based on inclusion of all patients requiring endotracheal intubation while they were in the ED. This included intubations performed without the use of drugs. The team leader or the intubator completed a data sheet (Figure S1) as close to the time of intubation as possible. Any missing data were established through interview with the staff involved or from the medical record. The register of controlled drugs was regularly reviewed to ensure all episodes of RSI were recorded.

Definitions

An episode of intubation was defined as the process of intubation for each patient, whereas an attempt at intubation was defined as a single passage of the laryngoscope blade past the lips. Difficult laryngoscopy was defined as Cormack and Lehane grade III or IV[13] and a difficult intubation as one that requires more than two attempts. However, there is variation in the literature regarding the definition of difficult intubation, with authors suggesting that more than two or three attempts be the cut-off.[3,7,14–16] We believe that more than two attempts should be appropriate as, if the first attempt is not successful, the second attempt should have been modified, using 30 s drills,[17] in such as way as to achieve success. We defined a novice intubator as having performed fewer than 10 intubations and an experienced intubator more than 100. Again, it should be noted that these criteria have not been consistently defined in the emergency medicine literature.[18–20] A failed airway was defined as one in which the initial method chosen for airway management, usually oral endotracheal intubation, is not successful and an alternative method must be undertaken.

A C-Mac video laryngoscope (Karl Storz GmbH & Co. KG, Tuttlingen, Germany) became available for use in the ED 6 months after the study commenced. This device uses a standard design Macintosh blade with a video camera located where the light source is positioned on a conventional blade. This means that the technique of laryngoscopy is the same for both devices and all intubators were encouraged to optimise their initial view under direct vision in order to maintain, or improve, their laryngoscopy skills. If the C-Mac was used for an intubation, the Cormack and Lehane grade using direct vision was recorded in order to make the data comparable with conventional laryngoscopy. Endotracheal tube placement was confirmed with waveform capnography according to departmental protocol.

Adverse airway manoeuvres were defined as external laryngeal manipulation, bag valve mask ventilation post induction, removal of cricoid pressure, Guedel or nasopharyngeal airway insertion or laryngeal mask airway (LMA) insertion. It was felt that their use reflected difficulty with laryngoscopy, even though a complication, as defined below, might not have occurred.

Complications were defined as peripheral oxygen saturation (SpO_2) <93%, even if the patient was hypoxic before intubation, bradycardia <60/min, hypotension requiring i.v. fluid, airway trauma, oesophageal or mainstem bronchial intubation, vomit appearing in the airway after induction, laryngospasm, equipment failure, medication error, cardiac arrest or the performance of a surgical airway.

All data were entered into Microsoft Excel 2010 (Microsoft, Redmond, WA, USA) and analysed using SPSS PASW version 18.0 (SPSS, Inc., Chicago, IL, USA). Descriptive statistics included median and interquartile range (IQR from the 25th to the 75th percentile). χ^2-test or, as appropriate, exact tests were used to compare groups of categorical data and to test for trends. Logistic regression analysis using the direct method was used to calculate the odds of success of intubation on first attempt. For all analyses, actual *P*-values were reported and all tests were two-tailed. Statistically significant differences were considered at the $P < 0.05$ level, and 95% confidence intervals (CI) were presented where possible.

Table 1. Diagnostic categories of patients requiring intubation ($n = 295$)

Diagnostic group	Diagnostic category	*n* (%; 95% CI)
Medical	Overdose/ingestion	47 (15.9; 12.2–20.5)
	Seizure	35 (11.9; 8.6–16.1)
	Stroke/ICH	35 (11.9; 8.6–16.1)
	Altered mental status – not overdose	29 (9.8; 6.9–13.8)
	Cardiac arrest	26 (8.8; 6.1–12.6)
	Respiratory failure	13 (4.4; 2.6–7.4)
	Sepsis	7 (2.4; 1.1–4.8)
	CHF	4 (1.4; 0.5–3.4)
	GI bleed	3 (1.0; 0.4–3.0)
	Anaphylaxis	1 (0.3; 0.1–2.0)
Trauma	Head injury – threatened airway	42 (14.2; 10.7–18.7)
	Combative/agitated due to trauma	24 (8.1; 5.5–11.8)
	Traumatic cardiac arrest	6 (2.0; 0.9–4.4)
	Head injury – airway not patent	5 (1.7; 0.7–3.9)
	Face/neck trauma	4 (1.4;0.5–3.4)
	Burn/inhalation	4 (1.4; 0.5–3.4)
	Shock due to trauma	3 (1.0; 0.4–3.0)
	Airway obstruction	3 (1.0; 0.4–3.0)
	Penetrating trauma	2 (0.7; 0.2–2.4)
Other	Other†	2 (0.7; 0.2–2.4)

†*One patient developed laryngospasm during procedural sedation for removal of a pharyngeal foreign body and the other was intubated to facilitate removal of a penile foreign body. CHF, congestive heart failure; GI, gastrointestinal; ICH, intracranial haemorrhage.*

Results

During the 18-month period, 295 episodes of intubation occurred in 287 patients. One patient self-extubated 2 h after being intubated for an overdose but then required re-intubation; the remainder of the repeat intubations were recurrent overdoses. The total number of attempts at intubation was 357.

Patients

The male-to-female ratio was 1.7:1 with a median age (IQR) in years of 52.0 (32.0–72.0) and a median adult weight (IQR) of 75.0 kg (60.0–80.0). Eleven (3.7% [95% CI 2.1–6.6]) patients had an estimated weight of more than 109 kg.

Table 1 shows the breakdown of patients into diagnostic categories. Trauma was the overall indication for intubation in 90/295 patients (30.5% [95% CI 25.3–36.0]), whereas medical indications comprised 205/295 (69.5% [95% CI 64.0–74.5]). The proportion of patients with abnormal vital signs immediately before induction of anaesthesia can be seen in Table 2.

Staff

Table 2 also shows that the majority of team leaders were EPs, whereas Figure 1 shows the seniority of the intubator at each attempt at intubation. An anaesthetist (registrar or consultant) performed 29/357 (8.1% [95% CI 5.7–11.4]) of all attempts, whereas EPs made only 45/357 attempts (12.6% [95% CI 9.6–16.5]).

Drugs

Table 3 shows the drugs used for induction of anaesthesia, as well as the median doses in mg/kg of estimated

Table 2. Results: patient vital signs before induction, team leader, laryngoscopy and adjunct use

	Criterion assessed	*n* (%; 95% CI)
Vital signs before induction (non-arrested patients)	Pulse >100	82/224 (36.6; 30.6–43.1)
	SBP <90	13/224 (5.8; 3.4–9.7)
	SpO_2 <93%	23/224 (10.3; 6.9–14.9)
	GCS <9	190/252 (75.4; 69.7–80.3)
Seniority of team leader	EP team leader	205/295 (69.5; 64.0–74.5)
	ED registrar team leader	90/295 (30.5; 25.5–36.0)
Laryngoscope (all attempts)	Macintosh	191/357 (53.5; 48.3–58.6)
	C-Mac video laryngoscope	164/357 (45.9; 40.8–51.1)
	McCoy	2/357 (0.6; 0.2–2.0)
Laryngoscopy	Difficult laryngoscopy on first attempt	69/288 (24.0; 19.5–29.3)
	Success at first attempt	246/295 (83.4; 78.7–87.2)
	Success at second attempt	38/295 (12.9; 9.5–17.2)
	Success at third attempt	6/295 (2.0; 0.9–4.4)
	Success at fourth attempt	3/295 (1.0; 0.4–3.0)
	Success at fifth attempt	1/295 (0.3; 0.1–1.9)
Use of adjuncts	Bougie used on first attempt	88/285 (30.9; 25.8–36.5)
	Stylet used on first attempt	107/285 (37.5; 32.1–43.3)
	Neither used on first attempt	90/285 (31.6; 26.5–37.2)
	Adjunct use on all attempts	243/348 (69.8; 64.8–74.4)

EP, emergency physician; GCS, Glasgow Coma Scale; SBP, systolic blood pressure; SpO_2, peripheral oxygen saturation.

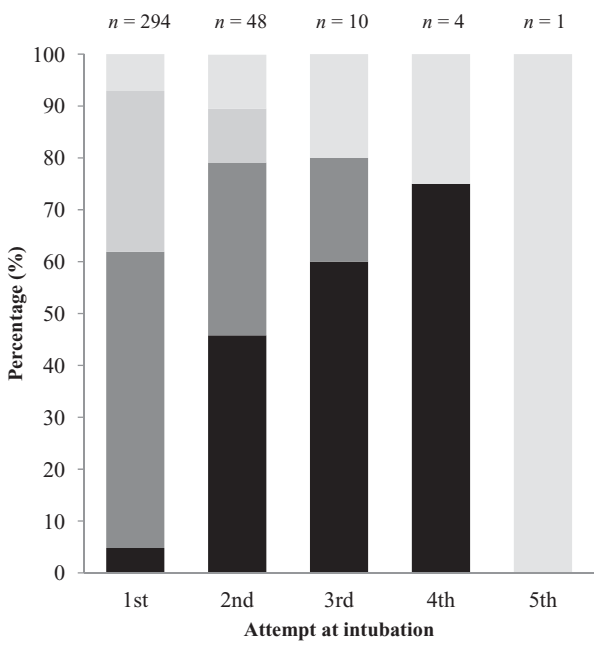

Figure 1. Graph to show the breakdown of seniority of intubator for each attempt at intubation. ▫ Anaesthetist; ▫ ED senior Resident Medical Officer; ■ ED registrar; ■ ED consultant.

body weight. Data on drug administration were absent for 13/295 (4.4% [95% CI 2.6–7.4]) episodes of intubation.

Laryngoscopy

Table 2 shows that the majority of patients had laryngoscopy performed with either a conventional Macintosh blade or a C-Mac video laryngoscope. As can also be seen from Table 2, laryngoscopy was found to be difficult in 24.0%, yet success within one or two attempts occurred in 96.3% of patients. The Cormack and Lehane grade of laryngoscopy was missing for 7/295 (2.4% [95% CI 1.2–4.8]). A difficult intubation occurred on 10/295 (3.4% [95% CI 1.9–6.1]) occasions: the breakdown into success at each attempt can be seen in Table 2. All patients were intubated by oral endotracheal intubation; there were no failed airways.

When further evaluated for prior experience, it was found that novice intubators were almost four times more likely to encounter a grade III or IV view at laryngoscopy (OR: 4.0; 95% CI: 1.7–4.9; $P = 0.002$). However, there was no association between a poor view at laryngoscopy and the seniority of intubator or the indication for intubation. Furthermore, novice intubators achieved first pass success in 14/24 (58.3% [95% CI 38.9–75.5]) patients, those with 10–100 prior intubations in 118/143

Table 3. Drugs used for induction of anaesthesia in 282 patients

Drug	*n* (%)	Median dose (mg) (IQR)	Median dose (mg/kg) (IQR)
Thiopentone	215 (72.9)	200.0 (125.0–250.0)	2.9 (1.8–3.6)
Ketamine	25 (8.5)	100.0 (75.0–150.0)	1.3 (0.9–1.7)
Propofol	17 (5.8)	70.0 (50.0–100.0)	1.0 (0.7–1.6)
Fentanyl	3 (1.0)	80.0 (65.0–140.0)	1.9 (0.8–2.9)
Midazolam†	1 (0.3)	–	–
No sedative given	21 (7.1)	–	–
Suxamethonium	256 (86.8)	100.0 (100.0–150.0)	1.7 (1.4–2.0)
Rocuronium	9 (3.1)	50.0 (50.0–100.0)	0.80 (0.7–1.3)
No paralytic given	17 (5.8)	–	–

†*A single 4 mg dose was given; estimated weight of this patient was not recorded.*

Table 4. Incidence of airway manoeuvres and complications among 276 patients

Manoeuvres	*n* (%; 95% CI)	Complications	*n* (%; 95% CI)
None performed	234 (84.8; 80.1–88.5)	None occurred	196 (71.0; 65.4–76.1)
ELM performed	28 (10.1; 7.1–14.3)	Desaturation – SpO_2 <93%	43 (15.6; 11.8–20.3)
BVM ventilation after failed attempt	14 (5.1; 3.0–8.3)	Hypotension – requiring i.v. fluid	11 (4.0; 2.2–7.0)
Cricoid pressure removed	12 (4.3; 2.5–7.5)	Oesophageal intubation	11 (4.0; 2.2–7.0)
Guedel/NPA inserted post induction	8 (2.9; 1.5–5.6)	Mainstem bronchial intubation	11 (4.0; 2.2–7.0)
LMA inserted post induction	2 (0.7; 0.2–2.6)	Cardiac arrest	6 (2.2; 1.0–4.7)
		Equipment failure	5 (1.8; 0.8–4.2)
		Bradycardia <60/min	2 (0.7; 0.2–2.6)
		Laryngospasm	2 (0.7; 0.2–2.6)
		Vomit – no aspiration	2 (0.7; 0.2–2.6)
		Other	2 (0.7; 0.2–2.6)
		Dental trauma due to intubation	1 (0.4; 0.1–2.0)
		Medication error	1 (0.4; 0.1–2.0)
		Airway trauma by intubator	0 (0.0; 0.0–1.4)
		Vomit – with aspiration	0 (0.0; 0.0–1.4)
		Surgical airway	0 (0.0; 0.0–1.4)

BVM, bag valve mask; ELM, external laryngeal manipulation; LMA, laryngeal mask airway; NPA, nasopharyngeal airway; SpO_2, peripheral oxygen saturation.

(82.5% [95% CI 75.5–87.9]) and experienced intubators in 114/127 (89.8% [95% CI 83.3–93.9]). Compared with novices, those that have prior experience of 10–100 intubations are three and a half times more likely to perform a successful intubation on the first attempt (OR: 3.5; 95% CI: 1.4–8.9; $P = 0.007$). Success on the first attempt is further improved by almost sixfold for experienced intubators (OR: 5.8; 95% CI: 2.2–15.4; $P < 0.0001$).

Adjuncts

Table 2 describes the adjuncts used to facilitate intubation. Data on adjunct use are missing for nine (2.5% [95% CI 1.3–4.7]) of the first attempts. The use of a stylet, compared with no adjunct, increased the odds of success on the first attempt by almost fivefold (OR: 4.9; 95% CI: 0.9–23.7; $P = 0.05$). The use of bougie, compared with no adjunct, increased the odds of success on the first attempt by 1.2-fold (OR: 1.2; 95% CI: 0.3–4.5; $P = 0.80$).

Airway manoeuvres and complications

Data on airway manoeuvres and complications were available for 276/295 (93.6% [95% CI 90.2–95.8]) episodes of intubation. Table 4 shows the rate with which specific airway manipulations and complications occurred. The rate of complications did not increase between midnight and 8.00 hours, despite 60/295 (20.3% [95% CI 16.1–25.3]) intubations occurring between these hours ($P = 0.858$) when our department does not routinely have an EP present.

Six patients (2.2% [95% CI 0.9–4.4]) were documented to have had cardiac arrest after induction. These cases were independently reviewed at the departmental morbidity and mortality meeting and no significant issues pertaining to the RSIs were reported: see Table 5 for details.

Discussion

This is the first descriptive study of intubation in an Australian ED.

The vast majority (88.1%) of first attempts at intubation were undertaken by registrars or senior Resident Medical Officers. The corollary of this is that only 13% of all the attempts at intubation were undertaken by EPs. This equates to three attempts at intubation per full time equivalent per annum, which again raises the question of 'skill fade'.[18] However, the frequency of intubation required to maintain the skill has not been quantified and it has been suggested that high-fidelity mannequin simulation and operating theatre time might help to improve skill retention.[18]

Of all the 357 attempts at intubation, only 30 (8.5%) were performed by anaesthetic registrars or consultants. This is in contrast to the UK, where it is estimated that up to 80% are performed by anaesthetists[21] but similar to the USA, where approximately 13% are performed by anaesthetists and other non-emergency staff.[7]

The first pass success rate of novice intubators was 58.3%. Although this is comparable with previously published data,[22] we feel that this is too low to be acceptable. The aim of improving first pass success should remain paramount[18,23] as it is accepted that multiple attempts at intubation are associated with a significant increase in complications.[24]

In comparison with other studies, difficult laryngoscopy occurred considerably more frequently, but the first pass success rate of 83.4% is similar (see Table 6). Furthermore, only 3.3% of our patients required three or more attempts, which is again similar to previous findings.[6,8]

Bougies were used to assist intubation in 35.3% of all attempts. This is much more frequently than has been previously published. In a Scottish study,[25] a bougie was used in only 6% by emergency staff and 11% by anaesthetic staff. Although our study is observational in nature and not powered to account for the vast number of variables associated with intubation in the ED, the finding of an increased chance of first pass success if an adjunct, such as a bougie or stylet, is used makes sense and is supported by a large body of literature.[4,26,27]

Table 5. Details of patients who suffered cardiac arrest after RSI

Case No.	Patient	Diagnosis	Comments
1	81 years, male	Aortic dissection with tamponade. Collapsed with hemiplegia	Unsurvivable pathology. No issues found.
2	52 years, female	Cardiogenic shock from viral myocarditis	Had ROSC after CPR. No issues found.
3	57 years, female	Acute renal failure, cardiogenic shock	Had ROSC after CPR. No issues found.
4	40 years, male	Poly trauma, including massive chest injuries	Thiopentone 125 mg used as induction agent in hypovolaemic shock.
5	64 years, male	Fall, massive head injuries. GCS 3 on scene	Unsurvivable injuries. No issues found.
6	61 years, male	Out-of-hospital cardiac arrest, numerous episodes of CPR before and after induction	Survived to cardiac catheter laboratory. No issues found.

CPR, cardiopulmonary resuscitation; GCS, Glasgow Coma Scale; ROSC, return of spontaneous circulation; RSI, rapid sequence intubation.

Table 6. Results from other studies on ED airway management

	Number	Cormack and Lehane grade I–II	First pass success	Complications (overall)	Hypotension	Hypoxia	Cardiac arrest	Oesophageal intubation
Kerslake[10]	2542	1355 (92.0%)	1458 (87.0%)	203 (12.0%)	88 (5.0%)	43 (3.0%)	13 (1.0%)	NR
Walls[7]	8937	NR	7269 (81.0%)	1041 (12.0%)	126 (1.0%)	NR	36 (0.4%)	264 (3.0%)
Stevenson[8]	199	166 (91.0%)	173 (87.0%)	42 (21.0%)	24 (12.0%)	21 (11.0%)	2 (1.0%)	6 (3.0%)
Current study	295	219 (76.0%)	246 (83.4%)	80 (28.5%)	11 (4.0%)	43 (15.7%)	6 (2.2%)	11 (4.0%)

NR, not reported.

Despite its emphasis in difficult airway guidelines, a LMA was placed only once in the 10 patients who went on to have more than two attempts at intubation. This was also found by the NEAR Investigators[3] who, using data from 7712 intubations, found the LMA was not used in any of the 33 failed RSIs. However, seven fibre-optic intubations and 26 surgical airways were performed on this group. The cause for such underuse is unclear, but possibilities include failure to plan for failure or inexperience with its use. This again highlights the need for all staff to have regular airway simulation training.

The complication rate demonstrated in this series is high but consistent with previous studies, as can be seen from Table 6. The rate of desaturation is high at 15.6%, but it must be noted that 23 patients (10.3%) had oxygen saturations below 93% after preoxygenation. These figures would be likely to improve with the adoption of more sophisticated preoxygenation and apnoeic oxygenation techniques that have recently been described.[28]

Even though a number of agents were used for sedation and paralysis, the majority of patients were anaesthetised and paralysed with thiopentone and suxamethonium. From our study we have demonstrated that these agents are safe and provide consistent intubation conditions.

Limitations

This study was carried out at a single institution and so the results cannot be felt to be representative of all EDs in Australasia. Furthermore, the study was observational in nature and required that the intubator complete the form. Reporter bias would tend to improve glottic visualisation and underreport complications. Data entry was not always contemporaneous, but in all cases, attempts at improving accuracy were made by interviewing the intubator and reviewing the medical records. Despite these efforts, it was still not possible to completely capture all the data for every intubation. However, it is unlikely that any episode of RSI was not recorded, because of regular review of the controlled drugs register.

Recommendations

Regular audit of ED airway management has been called for many times.[5,7,29] We hope that by publishing this article, others will question their own practice of intubation and will undertake a similar audit: our revised data collection sheet is available online as Figure S2. In the future, multicentre data collection would ideally be Internet-based, allowing comparison and audit of individual, departmental and interdepartmental practice. Furthermore, site-specific data could be used to help tailor a RSI protocol that is appropriate for the specific skill mix and equipment available in the department in question.

This call to arms has been made before, but in the era of the electronic medical record, it should be a far more achievable goal.

Conclusion

In our institution, ED staff manage the majority of intubations with EPs usually acting as team leader and the registrars performing the majority of the laryngoscopies. Although most of the results are comparable with overseas data, the rates of difficult laryngoscopy and desaturation are higher than previously reported.

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Author contributions

TF devised and developed the project, developed the data collection form, was involved in data collection and wrote the first draft of the manuscript. NA was involved in data collection and edited the manuscript. KH provided statistical support and edited the manuscript. JV provided advice on project development and edited the manuscript.

Competing interests

None declared.

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Supporting Information

Additional Supporting information may be found in the online version of this article:

Figure S1. RNSH Emergency Department Airway Registry.
Figure S2. Australia & New Zealand ED Airway Registry.