ORIGINAL ARTICLE

The who, where, and what of rapid sequence intubation: prospective observational study of emergency RSI outside the operating theatre

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Background: Emergency rapid sequence intubation (RSI) performed outside the operating room on emergency patients is the cornerstone of emergency airway management. Complication rates are unknown for this procedure in the United Kingdom and the factors contributing to immediate complications have not been identified.
Aims: To quantify the immediate complications of RSI and to assess the contribution made by environmental, patient, and physician factors to overall complication rates.
Methods: Prospective observational study of 208 consecutive adult and paediatric patients undergoing RSI over a six month period.
Results: Patients were successfully intubated by RSI in all cases. There were no deaths during the procedure and no patient required a surgical airway. Patient diagnostic groups requiring RSI are described. Immediate complications were hypoxaemia 19.2%, hypotension 17.8%, and arrhythmia 3.4%. Hypoxaemia was more common in patients with pre-existing respiratory or cardiovascular conditions than in patients with other diagnoses ($p<0.01$). Emergency department intubations were associated with a significantly lower complication rate than other locations (16.9%; $p=0.004$). This can be explained by the difference in diagnostic case mix. Intubating teams comprised anaesthetists, non-anaesthetists, or both. There were no significant differences in complication rates between these groups.
Conclusions: RSI has a significant immediate complication rate, although the clinical significance of transient events is unknown. The likelihood of immediate complications depends on the patient's underlying condition, and relevant diagnoses should be emphasised in airway management training. Complication rates are comparable between anaesthetists and non-anaesthetists. The significantly lower complication rates in emergency department RSI can be explained by a larger proportion of patients with comparatively stable cardiorespiratory function.

Emergency medical care begins with the airway. The cornerstone of emergency airway management is rapid sequence induction of anaesthesia with tracheal intubation (rapid sequence intubation, or RSI).[1] Originally described as an anaesthetic technique for patients undergoing surgery in the operating theatre,[2] emergency RSI outside the operating theatre (hereafter referred to as RSI) may be more challenging than its operating theatre counterpart because of the clinical condition of the patient, the experience and training of the clinician, and the availability of equipment and personnel to support the procedure. Few United Kingdom data exist regarding the complication rate of RSI and the diagnostic case mix of patients requiring RSI.[3] Such information might benefit trainers and trainees in the specialties responsible for emergency airway management. We aimed to prospectively evaluate RSI in a UK district hospital setting to identify (1) patient characteristics, (2) overall immediate complication rates, and (3) the contribution made to complication rates by the underlying diagnosis (patient factors), the hospital area in which RSI was performed (environment factors), and the prior anaesthetic training experience of the intubating doctor (physician factors).

METHODS

Patients and data collection

All RSIs performed by the critical care team on adults and children outside the operating theatre at Portsmouth Hospitals NHS Trust were identified prospectively between August 2000 and January 2001. Patients in cardiac or respiratory arrest who were intubated without drugs were excluded. Ethical approval was not sought as this was an observational study of existing practice. Data were recorded by the intubating team immediately or shortly after intubation on a standard data capture form, and entered into a Microsoft Access database. The ICU admission database was checked periodically for intubated patients to ensure inclusion of all eligible cases. Information recorded was age, sex, diagnosis, indication for intubation, anaesthetic experience of operator, and any supervisor, immediate complications, location within the hospital, and anaesthetic agents used for RSI. In addition we recorded the application of cricoid pressure, any monitoring used, the Cormack-Lehane laryngoscopy grade, the number of intubation attempts, the use of a tracheal introducer, and the need for repeat doses of anaesthetic agents. Immediate complications were defined as occurring at or shortly after induction of anaesthesia or tracheal intubation. They consisted of: arrhythmia, defined as a change from the original electrocardiographic rhythm, unless changing to a sinus rhythm; hypotension, defined as a post-induction systolic blood pressure value less than 95 mm Hg; and hypoxia, defined as oxygen saturation less than 90% measured by pulse oximetry. Recognised oesophageal or bronchial intubations were not considered complications unless they resulted in one of the aforementioned complications, in which case they were recorded as such. The questionnaire was kept simple to optimise compliance. The exact timing, severity, and duration of complications were not recorded.

Training and definitions

Intubations were performed by members of the critical care team. This comprised junior and senior grade doctors specialising or temporarily training in critical care medicine, from career backgrounds in anaesthesia, internal medicine, or emergency medicine. Before the study period all six new senior house officers (SHO) received training in emergency airway management consisting of a two week orientation in the operating theatre and a tutorial and moulages on airway management. During the study period each RSI was undertaken with close supervision until such time as the trainee was deemed competent and thus capable of independent practice. Senior assistance was always available on the hospital site.

Inexperienced junior doctors were supervised by members of the team with more RSI experience gained either from anaesthetic training or prior experience in critical care or emergency medicine, or both. For the purpose of the study, an anaesthetist was defined as a doctor with at least six months' prior training in a pure anaesthesia post. A non-anaesthetist was defined as a doctor whose intubation skills were acquired in the intensive care unit or emergency department environment, or both, and who had not been employed as a trainee in anaesthesia at any time. An unsuccessful intubation attempt (UIA) was recorded when another doctor was required to complete the procedure. A failed intubation was defined as an inability of the critical care team to intubate the trachea via direct laryngoscopy so that it was necessary to either get senior anaesthetic help to secure the airway, or to proceed to an emergency surgical airway.

Statistical analysis

Results were analysed using the χ^2 test. A result was deemed significant if a p value of <0.05 was found.

RESULTS

Patient characteristics

Two hundred and eleven patients met the inclusion criteria. Insufficient data were recorded on three cases, leaving 208 patients included for analysis, of which 106 were male. The age range was from 3 months to 86 years, median age 59 years. There were 12 paediatric cases, age less than 16 years (5.8%). Table 1 lists the diagnoses.

Table 2 shows the major indications for RSI. It should be noted that some patients had more than one indication for intubation

Location

Patients were intubated on the intensive care unit (ICU), the emergency department (ED), and general medical and surgical wards, including the medical assessment unit (wards). Table 3 shows the numbers of RSI done in different locations in the hospital.

Procedure

Preoxygenation was recorded in 206 of 208 (99%) cases. Cricoid pressure was recorded in 201 of 208 (97%) cases. Three of seven cases in which cricoid pressure was omitted were paediatric cases. In all cases patients were monitored during the procedure with 3-lead electrocardiography, pulse oximetry, and blood pressure measurement via a non-invasive cuff or an arterial catheter. Table 4 lists the anaesthetic induction agents used. Suxamethonium was used for neuromuscular paralysis in 200 patients (96%). Vecuronium was used for paralysis at induction in five (2.4%)

Table 1 Recorded diagnoses for patients requiring emergency RSI

Respiratory n = 60		**Neurological (non-traumatic) n = 35**		**Trauma n = 25**	
Pneumonia	21	Seizure disorder	8	RTA—unspecified	13
COPD	12	Intracerebral haemorrhage	7	Head injury—unspecified	5
ARDS	6	Post-arrest coma	5	Skull fracture	2
Asthma	3	Subarachnoid haemorrhage	5	C2 fracture	1
Respiratory failure—unspecified	3	Subdural haematoma	3	Fall from height—unspecified	1
Failed extubation	4	Encephalitis	2	Cerebral contusion	1
Respiratory tract infection	2	Intracerebral event	2	Chest trauma	1
Retained secretions	2	Meningitis	2	Facial fracture	1
Pneumothorax	2	Extradural haematoma	1		
Respiratory arrest	2				
Pancreatitis	1				
Lung collapse	1				
Obstructive sleep apnoea	1				
Sepsis n = 24		**Overdose n = 22**		**Cardiovascular n = 12**	
Abdominal	8	Amitriptyline	12	Tachyarrhythmia	5
Unspecified	7	Benzodiazepine	12	Acute pulmonary oedema	4
Meningococcal	6	Alcohol	2	Hypovolaemia	1
SBE	1	Multiple	2	Cardiogenic shock	1
Necrotising fasciitis	1	Insulin	1	Unspecified	1
Septic arthritis	1	Promethazine	1		
		Barbituate	1		
		Unspecified	1		
Abdominal n = 12		**Airway at risk n = 7**		**Metabolic n = 6**	
Pancreatitis	3	Oesophageal varices	3	Diabetic ketoacidosis	2
Post-abdominal aortic aneurysm repair	2	Airway burn	2	Rhabdomyolysis	1
Ischaemic bowel	2	Tracheostomy problem	2	Hyponatraemia	1
Postoperative haemorrhage	1			Hepatic encephalopathy	1
Postoperative—unspecified	1			Lactic acidosis	1
Perforated viscus	1				
Infarcted bowel	1				
Obstruction	1				
Renal n = 3		**Unknown n = 2**			
Acute renal failure	2				
Microscopic angiitis	1				

Table 2 Major indications for emergency RSI

Indication	Number (% of total)
GCS<8	67 (26.3)
Falling GCS	30 (11.8)
Hypoxia	67 (26.3)
Respiratory failure	40 (15.7)
Transfer*	19 (7.5)
Multiple injuries	9 (3.5)
Other	23 (9.0)

*Transfer refers to patients who require intubation to avoid potential airway compromise during interhospital or intrahospital transfer, for example, to the CT scanner.

Table 4 Agents used for anaesthetic induction in emergency RSI

Induction agent	Number of patients (%)
Propofol	103 (49.5)
Thiopentone	86 (41.3)
Etomidate	12 (5.8)
Midazolam	3 (1.4)
Ketamine	2 (1.0)
None*	2 (1.0)

*No induction agent, but paralysing agent used—that is, in cases where patient has a GCS 3 but not arrested.

and atracurium in three (1.4%) cases. Opioid agents (fentanyl, alfentanil) were used in 38 cases (18.2%), in patients from all diagnostic groups. A tracheal introducer (gum elastic bougie) was used in 53 cases (25.5%). Two or more laryngoscopy attempts were required in 37 (17.8%) cases. A repeat dose of induction agent was administered in 11 (5.3%) cases. No patients were pre-treated with a defasciculating dose of a neuromuscular blocker.

Intubating doctor

Intubating teams were categorised in three groups: group A consisted of anaesthetists unsupervised or supervised by another anaesthetist; group NA consisted of non-anaesthetists unsupervised or supervised by another non-anaesthetist; and group M (mixed) consisted of non-anaesthetists supervised by anaesthetists. Most of the first attempts were made by SHOs, and most supervisors were middle grade doctors (specialist registrar or clinical fellow). Fifty one patients (24.5%) were intubated by group A, 82 (39.4%) by group NA, and 75 (36.1%) by group M. The indications for intubation were similar for the three groups (see table 5), although a smaller percentage of group M patients required intubation for coma, and a greater percentage for respiratory failure. Group A patients were less likely to require intubation for hypoxia. However, only the difference in number of patients intubated for coma reached significance ($p = 0.008$).

Table 6 shows the Cormack-Lehane grades of laryngoscopic view. A grade III or IV view was more likely in group M, although similar between groups NA and A ($p = 0.02$, χ^2). The likelihood of an UIA was greater in groups NA and M; $p = 0.007$ and $p = 0.04$ respectively (table 7).

Immediate complications

No deaths occurred during RSI and no patient required a surgical airway. There were no failed intubations. There were no awake nasotracheal or fibreoptic intubations and no patient required inhalational anaesthesia for an anticipated difficult airway. Immediate complication rates were: hypoxaemia 40 of 208 (19.2%), hypotension 37 of 208 (17.8%), and arrhythmia 7 of 208 (3.4%). Hypoxemia was more prevalent in patients intubated for respiratory disorders (25 of 60, 42%) and for cardiovascular problems or septic shock (10 of 36, 28%) than in patients with other diagnoses (11 of 112, 10%). There was no statistical difference in the incidence of hypoxemia between respiratory and cardiovascular patients, but both these groups differed significantly from other patients ($p<0.01$, χ^2).

Figure 1 shows the complication rate according to geographical area within the hospital. Patients intubated in the ED had significantly fewer complications ($p = 0.0004$).

The differences in complication rates between physician groups A, NA, and M were compared using χ^2 analysis (table 8). Complication rates were greater for group M but the apparent difference did not reach significance ($p = 0.232$). Hypoxia occurred more frequently in groups NA and M. The rates of hypotension were similar in all of the groups, and arrhythmias were uncommon.

To assess whether immediate complication rates were determined principally by the clinical condition of the patient (patient factors), we calculated the complication rates for each diagnostic group (table 9) and used these data to provide expected complication rates for the case mix in each location, and for each physician group. Table 10 shows the comparison between observed and expected complication rates. There were no statistical differences between the observed and expected complication rates for each location ($p = 0.13$) or for each intubating physican group ($p = 0.23$).

DISCUSSION

Rapid sequence intubation is the cornerstone of emergency airway management, and constitutes a necessary skill in the repertoire of any resuscitation specialist. Traditionally delegated to the anaesthetist, this technique has proved to be safe in the hands of other specialists after appropriate training.[4–7] The Portsmouth model mirrors Australasian and North

Table 3 Numbers of RSI and diagnostic groups according to location within the hospital

Intensive care unit		Emergency department		Wards	
n = 79		n = 77		n = 52	
Respiratory	40	Neurological	21	Respiratory	16
Sepsis	13	Trauma	21	Neurological	12
Abdominal	10	Overdose	21	Sepsis	9
Cardiovascular	5	Respiratory	3	Cardiovascular	5
Trauma	3	Airway at risk	3	Abdominal	2
Airway at risk	3	Metabolic	3	Airway at risk	2
Neurological	2	Cardiovascular	2	Renal	2
Metabolic	1	Sepsis	2	Metabolic	2
Renal	1	Unknown	1	Overdose	1
Unknown	1	Renal	0	Trauma	1
Overdose	0	Abdominal	0	Unknown	0

Table 5 Indication for intubation for each physician group

Indication	Group A number (%)	Group NA number (%)	Group M number (%)
GCS<8	20 (39.2)	35 (42.7)	12 (16.0)
Hypoxia	12 (23.5)	26 (31.7)	29 (38.7)
Falling GCS	8 (15.7)	11 (13.4)	11 (14.7)
Respiratory failure	8 (15.7)	13 (15.9)	19 (25.3)
Transfer	4 (7.8)	6 (7.3)	9 (12.0)
Multiple injuries	3 (5.9)	3 (3.7)	3 (4.0)
Other	9 (17.6)	7 (8.5)	7 (9.3)
Total in group	51	82	75

Table 6 Cormack-Lehane grade of laryngoscopy view

Cormack-Lehane grade	Group A number (%)	Group NA number (%)	Group M number (%)
I	39 (76.5)	56 (68.3)	43 (57.3)
II	7 (13.7)	20 (24.4)	17 (22.7)
III	2 (3.9)	5 (6.1)	15 (20)
IV	2 (3.9)	0 (0)	0 (0)
Not stated	1 (2.0)	1 (1.2)	0 (0)
Total in group	51	82	75

Group M was more likely to get a difficult laryngoscopy view (Cormack-Lehane grades of III/IV); χ^2 gives a value of $p = 0.02$.

American practice by training intensive care doctors in RSI without insisting on prior anaesthetic experience. These data suggest that with appropriate supervision mechanisms in place, doctors from disciplines other than anaesthesia can safely perform RSI in less than ideal circumstances, namely outside the operating theatre, in patients with critical illness.

In some critically ill patients, RSI may result in a deterioration of the patient's physiological condition, while in others the particular clinical problem(s) may necessitate adjustments to the technique and agents used. It is therefore essential that physicians performing RSI are adept at understanding and managing the underlying medical problems in addition to being competent at airway management. Our description of the diagnostic case mix in patients requiring RSI may assist those specialists performing RSI, namely critical care physicians, emergency physicians, and anaesthetists, in emphasising these conditions within training programmes.

In our study, the high rates of pre-oxygenation, cricoid pressure, and correct monitoring with the administration of induction and paralysing agents show that RSI was performed in correct sequence according to recommended practice.[8] The frequent use of a bougie more probably reflects the habits and preference of the physician than any procedural difficulty, attributable in part to the emphasis placed on its use during the training period. Although some authors have included the use of a bougie among markers of difficult intubation,[9] others routinely recommend its use for all RSI.[10]

Difficult laryngoscopy resulting in a poor view (grade 3 or 4) occurs in up to 8.5% of operative general anaesthetics,[9] compared with 12% in our study. As laryngoscopy views may be dependent on the skill of the intubator, our results for inexperienced intubators therefore compare quite favourably with those reported from the operating theatre. Failed intubation requiring an alternative device or technique to direct laryngoscopy occurs in up to 0.3% of general anaesthetics[9]; in our study there were no failed intubations, confirming a similar low rate for RSI.

Prior training in a formal anaesthesia post did not significantly affect complication rates, although there were more episodes of hypoxia when intubation was attempted by non-anaesthetists. This may be a true difference underestimated by a type II error because of inadequate patient numbers, but more probably reflects the pathology of the patients as is suggested from table 10; groups NA and M performed RSI on patients whose indication for intubation was either hypoxia or respiratory failure more often than group A, suggesting poorer respiratory reserve and hence a greater tendency to desaturate after the onset of suxamethonium induced apnoea despite maximal pre-oxygenation. UIA rates were higher in the non-anaesthetic groups NA and M ($p = 0.04$). This is unsurprising in that these groups contained the novice intubators who were starting their airway management training, whereas all doctors from group A had completed a minimum of six months of anaesthesia training. In group NA, any UIAs were subsequently successfully completed by more experienced non-anaesthetists. In our study non-anaesthetists were more likely to successfully intubate when alone or supervised by another non-anaesthetist (group NA) than when supervised by an anaesthetist (group M). One should be cautious in interpreting this finding as no standard criteria for supervisor intervention were agreed before the study: anaesthetists may simply

Table 7 Difficulties in RSI according to physician group

Difficulty	Group A number (%)	Group NA number (%)	Group M number (%)
>1 attempt at laryngoscopy	4 (7.8)	11 (13.4)	22 (29.3)
UIA*	2 (3.9)	9 (10.8)	15 (20)

*UIA, unsuccessful intubation attempt. Groups NA and M have a higher incidence of multiple attempts and UIAs. χ^2 analysis shows these differences are significant ($p = 0.007$ and $p = 0.04$ respectively).

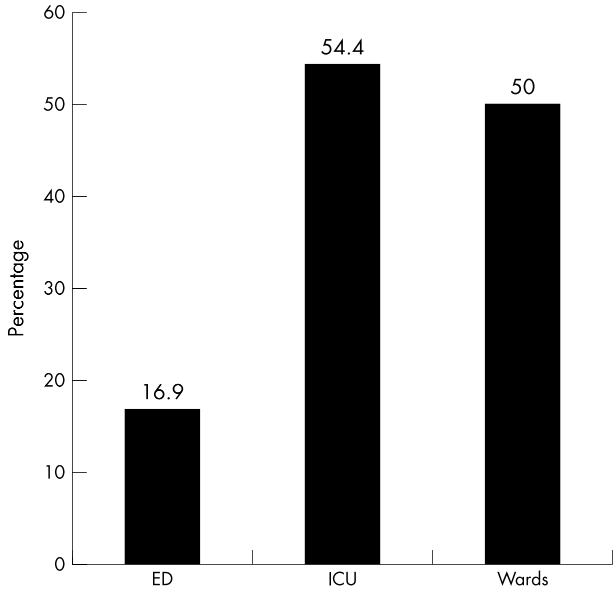

Figure 1 RSI complication rates according to location in hospital. The complication rate is significantly lower for RSI in the ED; χ^2 test gives p = 0.0004.

feel the need to take over sooner than non-anaesthetist supervisors.

It is not known how often immediate hypotension and hypoxaemia occur in the operating theatre setting. Our data show fairly high overall immediate complication rates for RSI (35%) in our critically ill patient population, although the design of the data collection form did not permit recording of the duration of hypoxia, hypotension, or arrhythmia, and it is unknown whether such transient events lead to any adverse clinical outcomes. However, such complications could potentially exacerbate such conditions as traumatic brain injury or myocardial ischaemia. On the other hand, the most probable explanation for the hypoxemia and hypotension recorded during RSI in our study is that such complications resulted from the pre-existing respiratory and circulatory compromise that led to the need for urgent intubation in the first place. Table 9 shows that the incidence of hypoxia was 42% in patients with prior respiratory dysfunction, but only 4.3% in patients with neurological problems, overdose, or other diagnoses that would not be expected to interfere significantly with pulmonary function. Similar differences between patient groups can be demonstrated for hypotension. This suggests that the process of RSI was efficiently managed by our intubating doctors and that complications depended primarily on the prior condition of the patients. Furthermore, our definitions of hypoxia and hypotension in this patient group might be considered strict.

Intubation in the emergency department was associated with a lower immediate complication rate (13%). This probably reflects the case mix of patients with relative cardiovascular stability and normal respiratory function such as comatose head injured or poisoned patients requiring airway protection, compared with less stable patients on the intensive care unit or wards with conditions such as respiratory failure or sepsis. This is consistent with previous work showing that comparatively small numbers of ED patients require intubation for hypoxia.[3]

Our study suggests that the training and supervision provided to non-anaesthetic members of the critical care team is successful and allows us to safely practice RSI throughout the hospital. Other factors such as location seem not to have a significant impact provided proper training has been given, and senior support and proper equipment are available. Diagnosis seems to have more of a bearing on immediate complication rates than whether the doctor has had formal training in anaesthesia.

Our study contains several weaknesses. Firstly, the simple data collection form did not permit the recording of the severity or duration of hypoxia or hypotension.

Secondly, accurate data collection relied on the honesty of the intubator. Thirdly, the researchers were not blinded to any aspect of the data. Fourthly, the comparison between groups NA, A, and M inevitably entailed comparing experienced intubators (anaesthetists) with novices (new junior ICU doctors) and the combinations of each that made up the team in our institution for each intubation were uncontrolled and varied randomly from day to day. To adequately compare anaesthetists with non-anaesthetists a formal clinical trial would be necessary. However, aside from the practical difficulties of executing such a trial, evidence from abroad confirming the safety of RSI performed by non-anaesthetists (and supported by the results of this study in the UK) should obviate the need for such research. Rather, we would agree with previous suggestions that training programmes for non-anaesthetists should be defined and standardised to optimise the safe and timely securing of the airway in emergency situations rather than debating which specialists should do it.[11] The recent formation of a joint working party to develop an airway management training programme for emergency physicians is an important first step towards this.[12] Critical care and emergency physicians should take the lead in focusing training, taking into account the patient and environmental factors that may increase the risk of immediate complications in RSI. The cooperation and expert guidance from experienced anaesthetist colleagues in this endeavour will be invaluable, and continual evaluation and quality assurance must accompany this practice.

In conclusion, RSI can be performed safely in critically ill patients by non-anaesthetists when appropriate training and supervision are available. The clinical condition of the patient determines the likelihood of immediate complications after RSI. Emergency department RSI is associated with a lower incidence of immediate complications compared with those on the intensive care unit or wards, which can be explained by the difference in case mix.

Table 8 Complication rates of RSI performed by each physician group

	Group A number (%)	Group NA number (%)	Group M number (%)
Arrhythmia	2 (3.9)	2 (2.4)	3 (4.0)
Hypoxaemia	7 (13.7)	18 (22.0)	22 (28.6)
Hypotension	8 (15.7)	16 (19.5)	13 (16.9)
Number of complicated RSIs	17 (33.3)	28 (34.2)	37 (49.3)
Total in group	51	82	75

There is no difference between the complication rates between the groups (χ^2 analysis gives a p value = 0.232).

Table 9 Complication rates according to diagnostic category

Diagnosis (n)	Complications			Number of intubations per category with at least one complication (%)
	Desaturation	Hypotension	Arrhythmia	
Respiratory (60)	25	16	3	35 (58)
Neurological (35)	1	3	1	5 (14)
Trauma (25)	3	1	1	5 (20)
Sepsis (24)	6	8	0	13 (54)
Overdose (22)	0	0	0	0 (0)
Cardiovascular (12)	4	3	0	6 (50)
Abdominal (12)	4	2	2	5 (42)
Airway at risk (7)	1	0	0	1 (14)
Metabolic (6)	1	1	0	2 (33)
Renal (3)	1	1	0	1 (33)
Unknown (2)	0	0	0	0 (0)
Total				73 (35.1%)

Table 10 Using the complication rates for each diagnostic group we predicted the complication rate expected in each location and for each physician group

A Observed and expected complication rates for each location

	ICU	ED	Wards
Expected number of complications	40	9	21
Expected rate of complication %	50.6	11.7	40.4
Observed rate of complication %	54.4	16.0	50.0
χ^2 gives a p=01.3			

B Observed and expected complication rates for each physician group

	Group A	Group NA	Group M
Expected number of complications	18	27	28
Expected rate of complication %	35.3	32.9	37.3
Observed rate of complication %	33.3	34.1	49

χ^2 gives a p=0.23.

Contributors

Dr Cliff Reid designed the study and the data collection form and revised the initial draft. Dr Louisa Chan was responsible for data collection, data analysis, and the initial draft. Dr Martin Tweeddale is the guarantor of the paper

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