University of Cape Town

Department of Anaesthesiology & Perioperative Medicine

A Systematic Review and narrative synthesis of the methods used to teach adult airway management skills to novices.

Minor dissertation for Master of Medicine in Anaesthesiology & Perioperative Medicine

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Declaration

I, Kevin Kuno Grunewald, hereby declare the following:

1. this research project is my own independent work performed by myself, aided by the mentioned authors (as acknowledged in this manuscript).
2. neither the whole work, nor any part of it, has been, is being, or is to be submitted for another degree to any other university.
3. this work has not been reported or published prior to registration for the abovementioned degree.

Signed by candidate

Dr. K.K. Grunewald

09/12/2020

Abstract

Background: Airway management is an essential skill for healthcare providers across many disciplines. Inadequate airway management leads to adverse events and deaths. Clear guidance on the use of evidence-based educational methods to train novice airway managers is limited. Best evidence suggests using a “deliberate practice for mastery learning” approach to produce expertise in complex skills.
Objectives: Our primary outcome is a narrative synthesis of the evidence evaluating instructional design elements employed to train novices in airway management. Our secondary outcome is a description of how these techniques employ deliberate practice principles. These data will inform recommendations for future airway training.
Methods: We conducted a systematic review of English language studies published by June 2019. Studies evaluating educational interventions to improve airway management by novices were included. Studies were excluded if they only reported learner reactions to training (Kirkpatrick Level 1 outcomes). Data extraction was performed in duplicate using a standardised form and critical appraisal of the included studies was performed using a tool developed by Hawker, et al. Due to the heterogeneity of the data and in order to best highlight important themes, we performed a narrative synthesis of included studies. Further, we explicitly reviewed the studies using a deliberate practice lens to extract features consistent with this framework.
Results: Our search yielded 506 studies of which 42 were eligible for inclusion. Most studies were rated poor quality and used small convenience samples. Studies included participants from a range of disciplines who were trained using multiple different interventions on part-task trainers, manikins and real patients. Most studies (60%) used overall intubation success rate as the primary outcome measure with only 21% of studies reporting first-pass success rate. Only 10% of studies explicitly mentioned deliberate practice. Important emerging themes include using checklists as scaffolding for progression, using video laryngoscopy to augment teaching, and using different manikins to mimic variations in human anatomy.
Conclusions: Reported studies evaluating airway training are of poor quality. However, available evidence offers usable instructional design elements associated with durable learning and improved expertise. We have made suggestions for incorporating deliberate practice into future airway training. A commitment to evidence-based educational design could improve expertise in this critical skill.
(Prospero registration: CRD42017077843)

Acknowledgements and contributions

Kevin Grunewald contributed to planning, developing and implementing the search strategy, writing of the protocol, screening for eligible articles (including selection of final articles for inclusion), data extraction from all included studies and writing and editing the manuscript.

Clive Schmuck contributed to the screening process as per PRISMA guidelines, including selection of final articles for inclusion.

Prof. Ross Hofmeyr (co-supervisor) contributed to editing the final manuscript and played an important advisory role in keeping the project relevant.

Rowan Duys (supervisor) contributed to planning, developing and implementing the search strategy, writing of the protocol, data extraction from all included studies (as per PRISMA guidelines) and editing of the manuscript.

List of tables

List of figures

Note: as per *Anaesthesia* guidelines for authors (Appendix 3), tables should not be included in the main body of text, but added at the end of the manuscript. They further require figures to be added as separate files and not be included in the manuscript. I have, however, added the figures at the end of the manuscript for ease of reference and to limit the number of files needing upload for this submission process.

Publication-ready manuscript

Journal: *Anaesthesia* (AAGBI)

Systematic Review

Submitting author: Kevin K. Grunewald

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A Systematic Review and narrative synthesis of the methods used to teach adult airway management skills to novices

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Keywords: airway management, training, novices, deliberate practice, simulation

Summary

Background: Airway management is an essential skill for healthcare providers across many disciplines. Inadequate airway management leads to adverse events and deaths. Clear guidance on the use of evidence-based educational methods to train novice airway managers is limited. Best evidence suggests using a "deliberate practice for mastery learning" approach to produce expertise in complex skills.

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Methods: We conducted a systematic review of English language studies published by June 2019. Studies evaluating educational interventions to improve airway management by novices were included. Studies were excluded if they only reported learner reactions to training (Kirkpatrick Level 1 outcomes). Data extraction was performed in duplicate using a standardised form and critical appraisal of the included studies was performed using a tool developed by Hawker, et al. Due to the heterogeneity of the data and in order to best highlight important themes, we performed a narrative synthesis of included studies. Further, we explicitly reviewed the studies using a deliberate practice lens to extract features consistent with this framework.

Results: Our search yielded 506 studies of which 42 were eligible for inclusion. Most studies were rated poor quality and used small convenience samples. Studies included participants from a range of disciplines who were trained using multiple different interventions on part-task trainers, manikins and real patients. Most studies (60%) used overall intubation success rate as the primary outcome measure with only 21% of studies reporting first-pass success rate. Only 10% of studies explicitly mentioned deliberate practice. Important emerging themes include using checklists as scaffolding for progression, using video laryngoscopy to augment teaching, and using different manikins to mimic variations in human anatomy.

Conclusions: Reported studies evaluating airway training are of poor quality. However, available evidence offers usable instructional design elements associated with durable learning and improved expertise. We have made suggestions for incorporating deliberate practice into future airway training. A commitment to evidence-based educational design could improve expertise in this critical skill.

(Prospero registration: CRD42017077843)

Introduction

Airway management is an essential skill for healthcare providers in many disciplines. Consensus from the fourth National Audit Project of the Royal College of Anaesthetists (NAP4) and the Difficult Airway Society (DAS) indicated that although complications from inadequate airway management are fairly rare, they remain underreported, and there is significant room for improvement [1]. While similar evidence is scarce in South Africa, one survey over a 10 year period at a tertiary hospital showed inadequate airway management to be one of the main reasons for anaesthetic adverse events and deaths [2]. This is strengthened by the most recent Saving Mothers Report, where airway related complications were reported as one of the most common causes of maternal death related to anaesthesia [3]. Anaesthetists manage airways more frequently than other disciplines. In general, this should result in a high level of proficiency. Anaesthetists are therefore well placed to train novices in the theory and skills required for airway management. We are thus beholden to ensure that training methods are grounded in the best evidence and are continually evaluated.

Best evidence suggests it is necessary to use "deliberate practice" and a "mastery learning" approach to produce expert performance of skills [4]. The fundamental principles of deliberate practice are:

1. "Highly motivated learners with good concentration…
2. …addressing well-defined learning objectives or tasks…
3. …at an appropriate level of difficulty…
4. …through focused, repetitive practice…
5. …that yield rigorous, reliable measurements…
6. …and provide informative feedback from educational sources (e.g. simulators, teachers)."

This further promotes:

7. "monitoring, error correction and more deliberate practice…
8. …enabling evaluation and performance that may reach a mastery standard where learning time may vary but expected minimal outcomes are identical…
9. …and allows advancement to the next task or unit."

Effective learning is often achieved where simulation-based learning is combined with deliberate practice [5,6]. Deliberate practice requires supervision and can be a resource-heavy curriculum design choice. This may not be sustainable in Africa, where the number of healthcare educators is low compared to the developed world [7,8].

Despite the importance of airway training in our setting, no formal national airway training curriculum exists. Our current national *anaesthesia* curriculum from the College of Anaesthetists of South Africa specifies a wide range of airway competencies that need to be mastered, but provides no guidance on knowledge and skill acquisition [9]. Training remains location-, or programme-specific, and the current training model utilised in our country consists of limited *ad-hoc* training sessions on part-task trainers, unstructured supervised clinical apprenticeships, and very limited access to immersive scenario-based simulations [10]. No practical evaluation of the training programme or competence of participants exists. There is an urgent need to design, implement and evaluate a new airway management curriculum for novice learners that conforms to the current best-practice standards in medical education, with a view to roll-out across our region. To ensure this curriculum is well grounded in evidence-based techniques we planned a systematic review of reported airway training methods and their effectiveness.

Our primary outcome is a synthesis of the evidence evaluating reported techniques and instructional design elements employed to train novices in airway management. Our secondary outcome is a description of how these techniques have been used to adhere to the principles of deliberate practice. These data will inform recommendations for the design of future airway management training for novices which may be integrated into curricula.

Methods

Protocol and registration

This systematic review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [11]. The University of Cape Town Faculty of Health Sciences Human Research Ethics Committee determined that research ethics review and approval was not required (HREC REF NO: R042/2017). The protocol was registered with the PROSPERO registry for systematic reviews (CRD42017077843).

Information sources and search

An electronic search was performed with the assistance of a research librarian between 1 September 2017 and 1 October 2017, and subsequently repeated in June 2019 prior to final data extraction. English language studies in the PubMed/MEDLINE, Web of Science, EMBASE and EBSCOhost databases were searched, with no limit on publication dates. The "population, intervention, comparator/control, outcome" (PICO) framework was used to formulate the final search strategy. Medical subject headings (MeSH) that were used include: health personnel, students, health occupations, airway management, education, cognition, learning and clinical competence (Appendix 1). Reference lists of articles were screened for additional relevant studies, and the authors consulted experts in the field of medical education and airway training for additional literature.

Eligibility criteria

Systematic reviews, editorials, case reports, abstracts and non-full-text articles were excluded.

All studies describing or evaluating educational interventions to improve the management of airways by novice airway trainees were included. Novice airway trainees were defined as anyone requiring basic airway management training. This included undergraduate nurses, paramedics and doctors, as well as junior clinicians. Any senior clinicians that required novice-level airway training, such as specialists from fields not familiar with airway management, were also regarded as novices.

Studies were included if they described and implemented training programmes with structured learning objectives. These included: bag-valve-mask ventilation, supraglottic airway device and endotracheal tube insertion, and emergency surgical airway training in adults. Exclusion criteria included studies of paediatric airway management training, and those involving training of experienced airway providers in advanced airway techniques such as awake fibre-optic intubations, or studies where the manikin or patient being intubated had a known, reported difficult airway. Studies evaluating training programmes that covered both basic airway management techniques, including airway rescue techniques, and advanced airway management techniques were included.

Studies comparing specific airway devices to establish which ones were easier to use or insert were excluded. However, studies that evaluated devices as training tools (in other words, a training intervention occurred and was described) were included.

Studies were included according to the type of outcomes data reported using Kirkpatrick's four-level training evaluation program as a framework [12]. We included studies that reported improvement in learner knowledge and skills (Kirkpatrick 2), change of behaviour in the clinical environment (Kirkpatrick 3) or improved patient outcomes (Kirkpatrick 4) and excluded studies that exclusively reported reactions or self-evaluation of the usefulness of the training (Kirkpatrick Level 1).

Study selection

Duplicate studies were removed using Endnote. Screening for eligible studies was performed independently by two reviewers (KKG and CS), initially using the title and abstract, and then with subsequent review of full text. Any discrepancies were resolved by third reviewer consensus (RD).

Data collection process and data items

Included studies were reviewed in duplicate (KKG, RD) and data extracted using a standardised form (Appendix 2) into a Microsoft Excel spreadsheet (v16, Microsoft Corporation, Redmond, Virginia). Disagreements were resolved through consensus. Extracted information included study design/methodology, study setting, study population (including participant demographics and baseline characteristics), data collection methods, details of the intervention and control conditions, impact of the intervention (using Kirkpatrick's framework), expected learning outcomes, stated aim of the study, recruitment and study completion rates, outcomes and times of measurement, adherence to deliberate practice principles, documented improvement in learning/performance, and subjective reviewer opinions on the strengths and weaknesses of the articles. We explicitly interrogated the methods section of each study to make a subjective judgement on whether the proposed educational intervention was sufficiently described to allow reproduction.

Risk of bias assessment

Due to the heterogeneity of the study designs, risk of bias assessment was not done. However, in order to provide an objective measure of the quality of the studies included, we used the critical appraisal tool developed by Hawker, Payne, Kerr, Hardey and Powel (2002) to overcome the problems encountered with critical assessment of heterogenous data from disparate paradigms. They found that '*the traditional method of systematic review had to be modified and appropriate assessment criteria needed to be developed to encompass all the different types of material while remaining explicit and demonstrating reliability*' [13]. They designed a review process to ascertain the level to which the aims, methods, sampling, data analysis, and reporting of results in the studies included in the review were transparent and rigorous. These indicators allow judgements and grading of the quality of the research under review, leading to a summated score (from 9 - very poor to 36 - good) for each study.

Synthesis of results

Due to the heterogeneity of the included study designs, the limited descriptions of the educational interventions, and the wide range of assessment instruments used, a traditional meta-analysis was not possible. In order to accommodate the diverse nature of the data, and to highlight why important instructional design and outcomes measure elements proved successful or not, we performed a narrative review of included studies. Further, we explicitly reviewed the studies using a deliberate practice framework to extract features consistent with this instructional design and to highlight the contexts in which these elements were employed.

While this approach contrasts with traditional meta-analytical techniques, precedent in the education literature is well established [14], and it was a necessary pragmatic choice to create usable data to inform future educational design. Moreover, a deliberate attempt to describe how and why instructional design elements were successful or not, offers a richer and more useful interpretation of the data than a quantitative synthesis would have provided [15].

Results

Numbers

Our search yielded 506 studies (446 database results and 60 from manual search of references) after removal of duplicates. Title and abstract screening reduced this to 76 studies. The full texts thereof were examined for eligibility, leaving a total of 42 studies included in our data analysis (Figure 1). The most common reason for exclusion was evaluation of a non-educational intervention, such as those studies comparing different airway devices for ease of insertion.

Scope of studies

Studies from high-income countries comprised 40 of 42 publications (95%). No studies originated from Africa. Most studies (70%) were published before 2010, with only four studies (10%) published in the last 3 years (Table 1).

Most studies (48%) were published in emergency medicine journals, followed by journals in anaesthesia (21%), education/simulation (14%), medicine (14%) and surgery (2%).

Population

Only 11 studies (26%) performed a sample size calculation and the rest used convenience sampling. Twenty-one (50%) studies enrolled less than 50 participants, 13 (31%) included 51-100 participants, and only eight (19%) included more than 100 participants.

Participants from multiple disciplines were enrolled in seven (17%) studies (Figure 2). Of the 12 studies including multiple disciplines or levels of experience, only six (50%) reported the reason for choosing this design. The predominant reason was because they were part of a larger group needing airway training (convenience sample). Limited demographic information about participants was reported. Undergraduate students were participants in 60% of the studies, with 64% of these being medical students. Importantly, all participants were reported to have had either no airway management experience (45% of participants) or extremely limited airway management experience (55% of participants).

Intervention

A wide range of training interventions were described, with hands-on practical training using skill stations and part-task trainers featuring in 71% of studies (Figure 3). Nine (21%) studies repeated training at least once after the initial event in an attempt to investigate knowledge and skill retention. We judged that only half the studies described their training intervention in sufficient detail to allow replication of their training program.

Control

Twenty-one studies (50%) reported a control arm. A new or ‘step-up’ educational package was compared to the existing institutional education package in nine (43%) of these studies. The 21 studies without a control arm aimed to evaluate the adequacy or safety of a specific training intervention through measurement of participant performance against a benchmark success rate (Table 2).

Outcome

The primary aims of the included studies were to evaluate a training programme for its effectiveness (60%), or to evaluate a specific device, used in a training intervention, for its effect on learning and success rates (40%). Several outcome measures were employed to evaluate the impact of the training (Table 3). The majority (60%) reported on overall success rate. This was most commonly the percentage of participants that were able to achieve successful insertion of an endotracheal tube (ETT) or laryngeal mask airway (LMA) within a time limit or pre-defined number of attempts. Time to successful intubation or ventilation was the next most frequently measured outcome (40%), followed by the number of attempts required to achieve success (36%). First pass success rate was reported in 21% of studies.

Complications recorded during intubation attempts, including trauma to orofacial structures, arrhythmias, patient desaturation, manikin measures of trauma such as teeth clicking, and failure rates, were reported in 26% of studies.

Ten studies attempted to demonstrate either that participants had achieved an adequate success rate, or an adequate level of competence for safe practice. In six of these studies, all participants achieved adequate success rates, while four reported unacceptably low performance rates in participants after the training intervention. The benchmark success rate used to denote ‘acceptability’ or ‘adequacy’ varied from 80% to 95% between studies.

A variety of methods were employed to evaluate whether participants had achieved the proposed learning outcomes, or to evaluate participant performance during the training process (Table 4). Assessment using manikins or patient simulators was most frequent (74%), with 32% of these studies also assessing participants *in vivo* in operating rooms, hospital wards or in the pre-hospital setting. Ten studies (24%) exclusively assessed participants on patients. Ten studies (24%) tested participants’ knowledge with a written exam, but this was never the only means of assessment.

Risk of bias and quality of studies

Only two studies (5%) achieved a perfect score on the Hawker, et al. quality assessment, with 14 (33%) achieving good scores of 32/36 and above. Fifteen studies (36%) scored very poorly, with less than 27/36. The most common areas of weakness were sample size (small convenience samples) and poor description of the sample demographics. Fifteen studies (36%) scored poorly in the methods sections, with inadequate descriptions of the training programmes implemented.

Narrative data synthesis

We used a framework that describes the nine features of deliberate practice for mastery learning [4] as a lens with which to examine the training interventions in the included studies. This enabled extraction of features consistent with deliberate practice.

Some features of deliberate practice methodology were present in all studies. However, deliberate practice was explicitly mentioned in only four studies (10%). Of these, two reported all nine features as part of their training interventions [16,17] and the remaining two studies [18,19] mentioned five and one feature respectively.

Two additional studies that did not mention deliberate practice explicitly, incorporated all nine features into their training [20,21]. Both studies were published before the concept of deliberate practice had become universally used in educational literature.

We report specific aspects of the training interventions in included studies that are consistent with the deliberate practice for mastery learning framework. We also suggest instructional design features for an airway management curriculum that would promote deliberate practice (Table 5).

Other important themes

Several other important themes were identified during the narrative synthesis process. They describe the application of educational techniques or novel devices in training interventions. We report the themes the authors believe to be relevant because of their relation to current educational or airway device trends.

Blended learning

Blended learning approaches, where learners are instructed to complete online learning tasks before contact-time with instructors, were employed in two studies [16,22]. Blended learning was associated with equivalent airway management knowledge and performance on manikins compared to face-to-face learning, with the advantage of freeing up instructors for other clinical tasks [22]. Combining a blended learning curriculum with deliberate practice was associated with improved airway management skills in the clinical environment [16]. This would be particularly beneficial in resource-limited settings.

Guided vs experiential learning

Two studies [17,21] describe the use of self-directed experiential learning. Learners were given limited instruction before being tasked with learning the skills of intubation on a part-task trainer by themselves. The training programmes were designed to create a period of 'floundering' and 'discovery', before instructors re-joined learners to assist with completing the learning outcomes. Learners in the 'experiential' learning groups performed acceptably [21] or better than controls [17].

Video versus direct laryngoscopy

The use of video laryngoscopy (VL) as part of a training programme was evaluated in several ways. Three studies described learners using VL with a standard Macintosh blade shape for direct laryngoscopy (DL) while instructors and other learners in the group watched the video screen [23–25]. This enabled improved real-time feedback from instructors, shortened learning curves, improved engagement and learning for a larger group of observers and was associated with improved overall success rates and reduced complications in manikins and patients. In one of these studies [25], the researchers observed no difference in intubation success rates between participants who received instruction with DL first compared to VL first. A separate study [26] comparing the teaching order of DL vs VL using a hyper-angulated blade, found that learners that used DL first achieved superior success rates.

Part-task trainers and patient simulators versus real patients

Training learners on part-task trainers or in simulated learning environments produced equivalent results to training in real patient environments in one study [27], or acceptable success rates in two studies without controls [16,21]. However, using part-task trainers and simulation-based pedagogy afforded the learners several advantages. Students reported feeling more comfortable using these techniques. Further, it allowed for more feedback, more practice, and promoted transfer of skills to long-term memory because there was a much shorter time between attempts than in an operating theatre. It allowed ‘chunking’ of complex tasks into simple achievable tasks. Patients were protected from complete airway novices leading to fewer adverse events in clinical scenarios. It enabled guided discovery (learning by figuring it out on your own) which is inappropriate on human patients [20,21]. Lastly, a deterioration in learner success rates associated with exposure to manikins with different airway ‘anatomy’, suggests it is possible to mimic the normal variations in human anatomy, using different manikins [21].

Supraglottic airway devices

Several studies demonstrated short learning curves and acceptable success rates in supraglottic airway device insertion with a variety of instructional designs [28–34], including only a very brief instructional video [29] or five minutes of manikin-based training [33]. These studies demonstrate that mastery of this important technique can be achieved by novices with limited time on task or instruction.

Discussion

Our systematic review of the literature describing airway management training interventions aimed at novice learners found heterogenous studies of generally poor quality. Few studies were contemporary, none were from Africa, and none from low income countries. The use of features consistent with a deliberate practice model was associated with improved learner performance, but few studies explicitly incorporated deliberate practice into instructional design. In general, the interventions evaluated were not described in sufficient detail to allow replication.

The included studies commonly used intubation success rate as the primary outcome measure, but ‘first pass success rate’ may be more suitable because it implies a lower risk of airway trauma and complications [35]. There was limited reporting on complication rates, and often only self-reported complications were described.

No studies included approaches to failed or unexpectedly difficult intubations such as the DAS guidelines. Further, no studies included other critical elements to avoid preventable harm in airway management such as human factors and teamwork training, front-of-neck airway rescue techniques, algorithmic approaches or decision-making skills. While debate exists around whether novices should learn emergency rescue techniques and whether this will promote unnecessary front of neck access in “can’t intubate, can’t oxygenate” situations, current consensus suggests it should be included [36–40]. In the low-middle income country (LMIC) context, where inexperienced practitioners are forced to manage airways without assistance from ‘experts’, we believe rescue techniques to be an essential feature of novice airway training.

Deliberate practice is necessary to achieve expert performance, and various programmes have employed deliberate practice for mastery learning with successful outcomes in medical education [5,41,42]. Since acquiring expertise in airway management is fundamental to so many fields within healthcare, there may be value in explicitly designing and evaluating education programmes to incorporate this approach. Previous reviews have described what educational techniques are available to would-be learners and trainers [43] and what the important curricula aims should include [36]. However, there is a dearth of scholarly articles that have applied a medical education framework to understanding the process of teaching and learning airway management skills [44].

It is possible to use a deliberate practice for mastery learning framework to systematically design a training curriculum that uses tools and techniques such as simulation, part-task trainers, and VL to encourage deliberate practice of manual skills, but also decision-making and human factor skills necessary to become a safe airway practitioner.

Limitations

We excluded studies that examined only Kirkpatrick Level 1 outcomes. While learner satisfaction does not necessarily translate to improved knowledge, behaviour or outcomes, we may have missed studies that provide examples of engaging and enjoyable training programmes. The included studies were heterogenous, and thus we did not attempt a systematic assessment of risk of bias or quantitative synthesis of data. Instead, we have attempted to provide a narrative review of the techniques available to programme designers, through the deliberate practice lens, with a critique of what is afforded to the learner and trainer using various instructional design elements.

Conclusion

Airway skills training is important to clinicians across a range of disciplines and working environments. In the LMIC context, the need for airway management proficiency often extends beyond the traditional acute and critical care teams. But scholarly evaluation of the impact and design of existing training programmes is not well reported in the literature.

Critical learning objectives encompassing the cognitive, decision-making and communication skills required to avoid adverse events during airway management appear absent despite consensus that it is important to include these elements in novice programmes.

Deliberate practice offers a model for programme design that is embedded in the theory of acquisition of excellence, but few reported programmes seek to include this framework explicitly.

We have made suggestions for achievable instructional design elements that incorporate deliberate practice. Airway management instructors are encouraged to test our ideas, and their own programmes, not only to answer the question of ‘does it work’, but to explore ‘how, in whom, why, and in what context’ do their programmes work, and to report these data systematically, to help inform future airway programme design and prevent avoidable patient harm.

Competing interests

No external funding and no competing interests declared.

Appendices

Appendix 1: Screenshot of search strategy

#36	Add	Search **((((("Cognition"[Mesh]) OR "Learning"[Mesh]) OR "Clinical Competence"[Mesh]))) AND ((("Airway Management"[Mesh]) AND "Education"[Mesh]))) AND ((((Health Personnel[MeSH Terms]) OR Students, Health Occupations[MeSH Terms]))) Sort by: **PublicationDate**	420	10:31:42
#35	Add	Search **((("Cognition"[Mesh]) OR "Learning"[Mesh]) OR "Clinical Competence"[Mesh])** Sort by: **PublicationDate**	502956	10:31:31
#34	Add	Search **(("Airway Management"[Mesh]) AND "Education"[Mesh])** Sort by: **PublicationDate**	2510	10:31:17
#33	Add	Search **(((Health Personnel[MeSH Terms]) OR Students, Health Occupations[MeSH Terms]))** Sort by: **PublicationDate**	487928	10:30:50

Appendix 2: Data extraction sheet

Data extraction sheet

Administrative: (Hawker scoring 1)

Reviewer name: _________________________________ Date: _____/______/___________

Citation information:

Author/s:

____

Title:

____

Publication: _______________________________ Vol;Issue;Pages: ___________________

Search Method:

☐ Electronic search ☐ Hand search ☐ Grey literature ☐ Recommendation

Study design: *(tick all that apply)*

☐ Cross-sectional ☐ Quantitative

☐ Case control ☐ Qualitative

☐ Cohort

- ☐ Prospective
- ☐ Retrospective

☐ Single group (before and after) study

☐ Trial

- ☐ Non-randomised

☐ Randomised

Aim of study: (Hawker scoring 2)

____
____
____
____
____

Research Question/Hypothesis: (Hawker scoring 2)

____
____
____
____
____

Study setting: (Hawker scoring 3)

Proposed training *(tick all that apply)*

☐ Clinical (patients)

☐ Computer-based (electronic)

☐ Simulation (manikins)

☐ Lectures (didactic)

☐ Deliberate Practice

☐ Other ____

Physical setting *(tick all that apply)*

☐ Classroom

☐ Skills laboratory

☐ Training centre

☐ Clinical environment

☐ Other ____

How was the data collected? *(tick all that apply)* (Hawker scoring 3)

☐ Interview

☐ Questionnaire

☐ Written exam

☐ Observation

☐ Simulation

☐ Actual patients

☐ Other (please specify)
____

Level of Impact (Kirkpatrick)

1 (reaction)
____

2 (learning)
____

3 (behaviour)
____

4 (results)
____

Population: (Hawker scoring 4)

Participant demographics and baseline characteristics

Number of participants ________________

Country __________________________________

Level of experience *(tick all that apply)*

☐ Students / undergraduates

☐ Junior doctors (Interns/Cosmo/MO)

☐ Registrars / Residents

☐ Specialists

☐ Other ____

Profession: *(tick all that apply)*

☐ Medical

☐ Anaesthesia ☐ Surgery ☐ ICU ☐ Emergency medicine

☐ Other ____

☐ Nursing

☐ Paramedic

☐ Other ____

Intervention:

Type

____

______

Duration _____________ (hours) and frequency ___________________ (times) of exposure

Comments

____

Comparison/control:

What were they comparing the intervention to and why?

____
____
____
____
____

Outcomes:

What were the learning outcomes?

____
____
____
____

When were the outcomes measured? *(tick all that apply)*

☐ Immediately ☐ 0-3 months ☐ 3-6 months ☐ 6-12 months

☐ > 12 months ☐ Other ____

Findings: (Hawker scoring 7)

What were the findings?

____
____
____

____
____

Documented improvement in learning/performance?

If the article provided documentation for improvement in learning / performance, tick those applicable

☐ Learning / cognition

☐ Skills ☐ Real clinical environment

☐ Simulation

☐ Hands-on psychomotor skills

☐ Decision-making skills

☐ Attitude

Deliberate Practice?

Specifically stated in study? ☐ Yes ☐ No

Features of deliberate practice *(tick all that apply)*

☐ Highly motivated learners

☐ Well-defined learning objectives or tasks

☐ Appropriate level of difficulty

☐ Focused, repetitive practice

☐ Yielding rigorous, reliable measurements

☐ Informative feedback

☐ Promoting monitoring and error correction

☐ Enables evaluation and performance that reaches mastery standard

☐ Allows advancement to the next task or unit

Overall impression: (Hawker scoring 9)

Additional comments regarding overall strengths and weaknesses of the article

____
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____
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____
____

Appendix 3: Instructions for authors for submission to *Anaesthesia*

Author guidelines available at the following link:

https://associationofanaesthetists-publications.onlinelibrary.wiley.com/hub/journal/13652044/homepage/forauthors.html

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Tables

Table 1: Country, decade of origin and design of included studies

Category	Results
Region	**n (%)**
USA	20 (49)
Canada	6 (15)
UK	4 (10)
Australia	3 (7)
Germany	3 (7)
China *	1 (2)
Finland	1 (2)
Israel	1 (2)
Japan	1 (2)
Malaysia *	1 (2)
Singapore	1 (2)
Publication dates	
Before 1990	2 (5)
1990 - 1999	7 (17)
2000 - 2009	20 (48)
2010 - 2019	13 (31)
Study design	
Randomised controlled trial	19 (45)
Non-randomised controlled trial	2 (5)
Quasi-experimental	8 (19)
Observational	13 (31)

* Upper-middle income countries

Table 2: Description of Comparator and Intervention arms in relevant studies

Intervention	Control/comparator	n (%)
Step-up package	Current educational package	9 (43%)
Video laryngoscopy as educational tool	Direct laryngoscopy	5 (24%)
Repeat training, practice and feedback	Once-off training intervention	2 (10%)
Manikin-only training	Practice on patients in operating room	1 (5%)
Teaching done by house-staff team (residents)	Teaching done by experienced attending	1 (5%)
Success rates after training basic emergency medical technicians	Success rates after training paramedics	1 (5%)
Ego-oriented, quantitative feedback	Task-oriented, qualitative feedback	1 (5%)
Lectures, followed by immediate or delayed simulation training	Lectures only	1 (5%)

Table 3: Outcome measures used in included studies

Learning outcomes	**n (%)**
ETT or LMA insertion success rate	25 (60%)
Time to successful intubation/ventilation	17 (40%)
Number of attempts	15 (36%)
Quantitative rating of skills based on checklist	12 (29%)
Complications	11 (26%)
First-pass success rate	9 (21%)
Qualitative rating of attempt	6 (14%)
Questionnaire rating confidence and testing knowledge	2 (5%)
Written exam	2 (5%)
Non-specific theoretical and practical assessment	1 (2%)
Number of hand movements during attempt	1 (2%)

Table 4: Evaluation methods and timings of assessment

Type of assessment	**n (%)**
Manikin/simulator	31 (74%)
Clinical environment	20 (48%)
Written exam	10 (24%)
Self-reported success rates	7 (17%)
Timing of assessment	**n (%)**
Immediately after training	31 (74%)
Multiple times after training	24 (57%)
During/integrated into training	13 (31%)
Before and after training	10 (24%)

Table 5: Features of Deliberate Practice, examples from included studies, and proposals for future airway curriculum design

Feature of Deliberate Practice	Summary of findings	Example from included studies	Proposed instructional design feature
Highly motivated learners with good concentration	Motivated learners achieved acceptable success rates, while demotivated learners did not	Motivated learners achieved 90% success rates [45] Volunteers complied with required independent practice [20] Unsupervised learners did not perform independent practice [18]	Address learner motivation explicitly e.g.: regular supervision and feedback, gamification, progression to next level
Addressing well-defined learning objectives	Checklists of learning objectives were used as scaffolding for learning.	Checklists made available during training and subsequent independent practice [16]	Provide scaffolding for learning by presenting protocol checklist as a training aid
Appropriate level of difficulty	Independent 'grappling' with new complexity was associated with skill retention Different manikins mimicked variable 'anatomy' Unexpectedly difficult airways not included in curricula	Difficulty level pitched beyond learners to encourage 'struggling' before 'rescue' by faculty [17] Different manikins mimicked anatomical variations [21]	Pitch learning objectives appropriately but use challenging tasks to create effortful learning Use different manikins to create variety Include management of unexpectedly difficult airways (DAS guidelines)
Focused, repetitive practice	Learners participated in repetitive practice where a strategy to promote focus was used	Participants given access to learning material and the assessment checklist to guide practice [16,21]	Promote focus in self-directed practice with checklist-guided peer-to-peer feedback
Yielding rigorous, reliable measurements	Checklists improved measurement rigour but few studies measured complication rates	Checklists to evaluate the quality of intubation process [16,17] Interactive video system provided objective measurement [20]	Use checklists to facilitate measurement. Use 1st pass success rate as primary outcome. Include complication rates in measurement
Providing informative feedback from educational sources	Learners appreciated in-person feedback. Real-time feedback facilitated focused practice	In-person supervision preferred to tele-present supervision [22,46] VL enabled real-time feedback from instructors [23–25]	Use VL with Macintosh-shaped blades to enable real-time feedback
Promoting monitoring, error correction and more deliberate practice	Well defined stepwise protocols enabled identification of common errors	Feedback identified errors, allowed time to correct and repeat practice [21]	Highlight common errors, e.g. levering on teeth, to promote correction and deliberate practice Record common learner errors to inform continual instructional design improvement
Enabling performance that reaches a mastery standard (learning time may vary)	"Number of attempts" was an inconsistent predictor of a plateau in learning	Variability in the amount of repetitive practice required to achieve acceptable success rates [46–48]	Define targets for minimum 1st pass success rates on multiple different manikins, before allowing progression to human patients
Advancement to the next task or unit	Breaking complex tasks into simpler "chunks" enabled mastery before progression.	Complex airway tasks divided into achievable developmental "chunks" to enable stepwise progression [21,49,50]	Include a progression in complexity e.g.: part-task trainer, to simulated scenario. to clinical environment to 'rescue techniques'

Figures

Figure 1: CONSORT diagram of study recruitment process

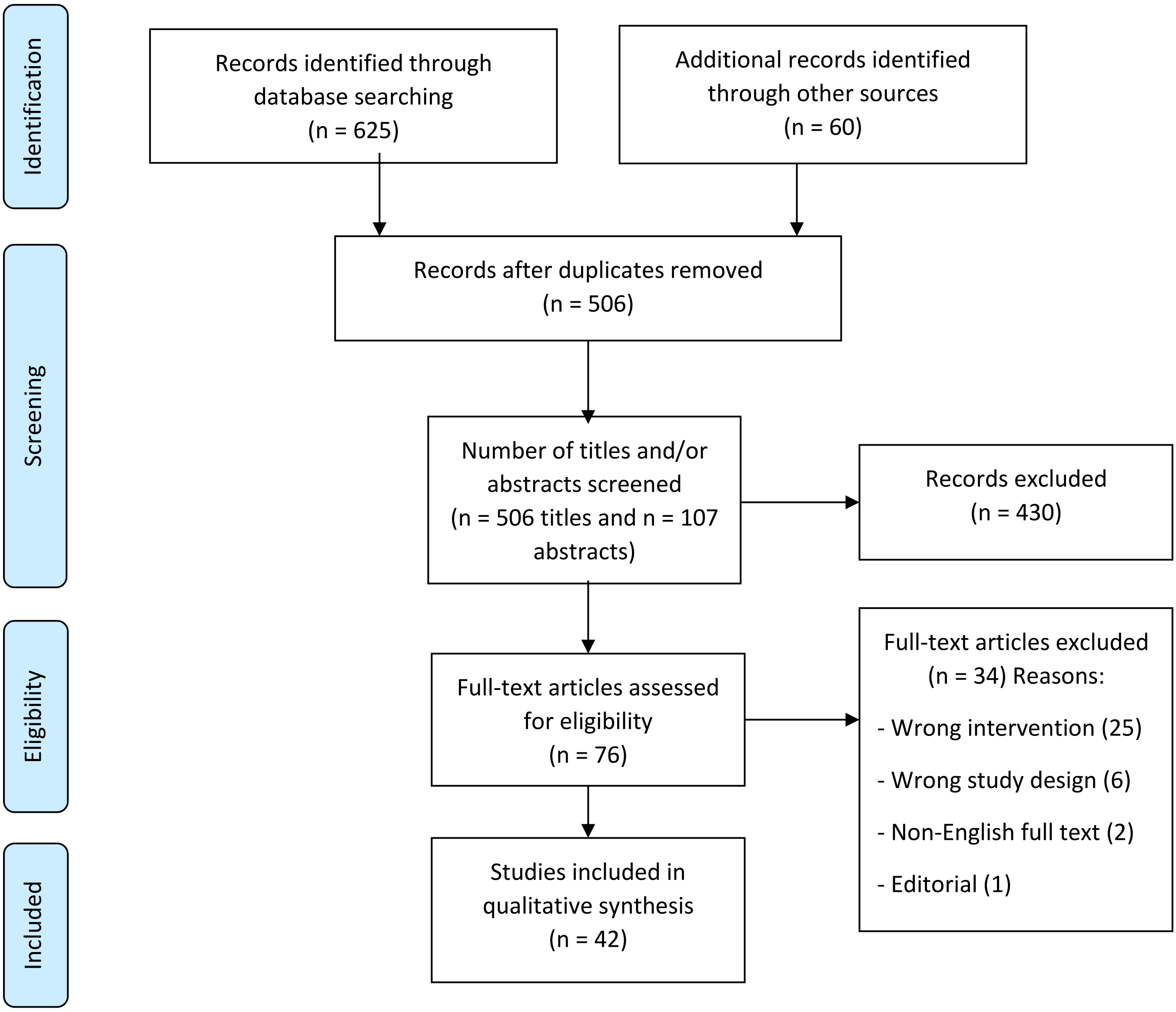


Figure 2: Demographics of study populations including the medical fields and level of experience.

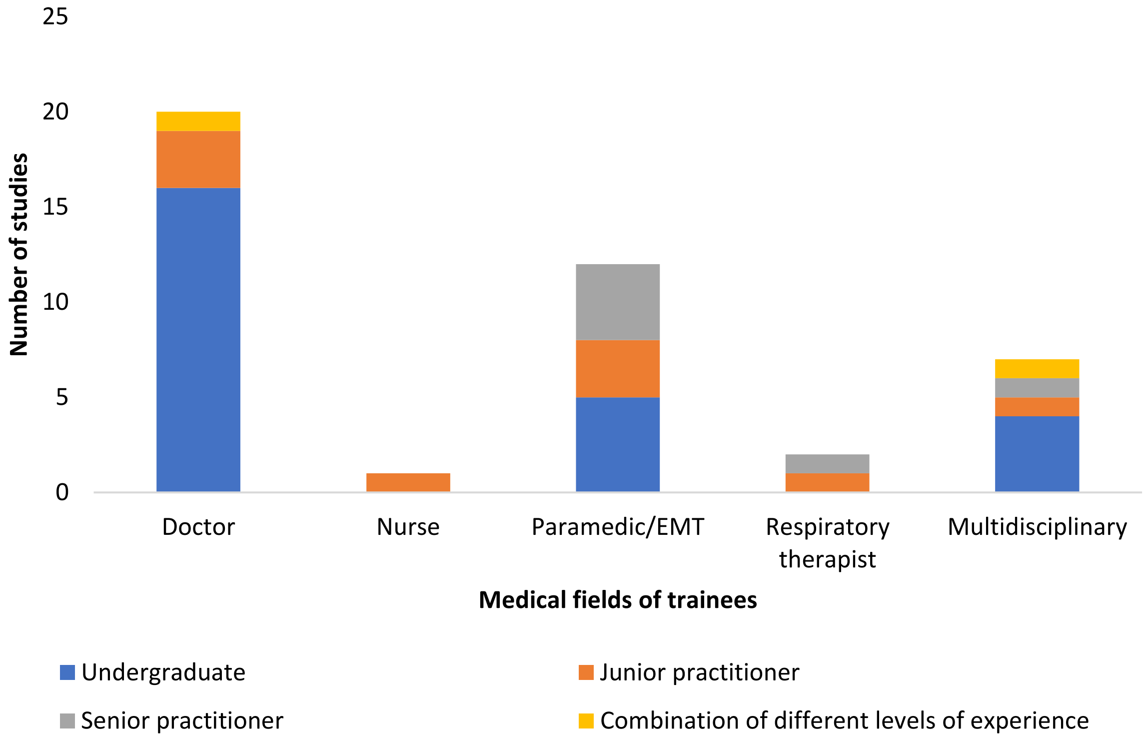
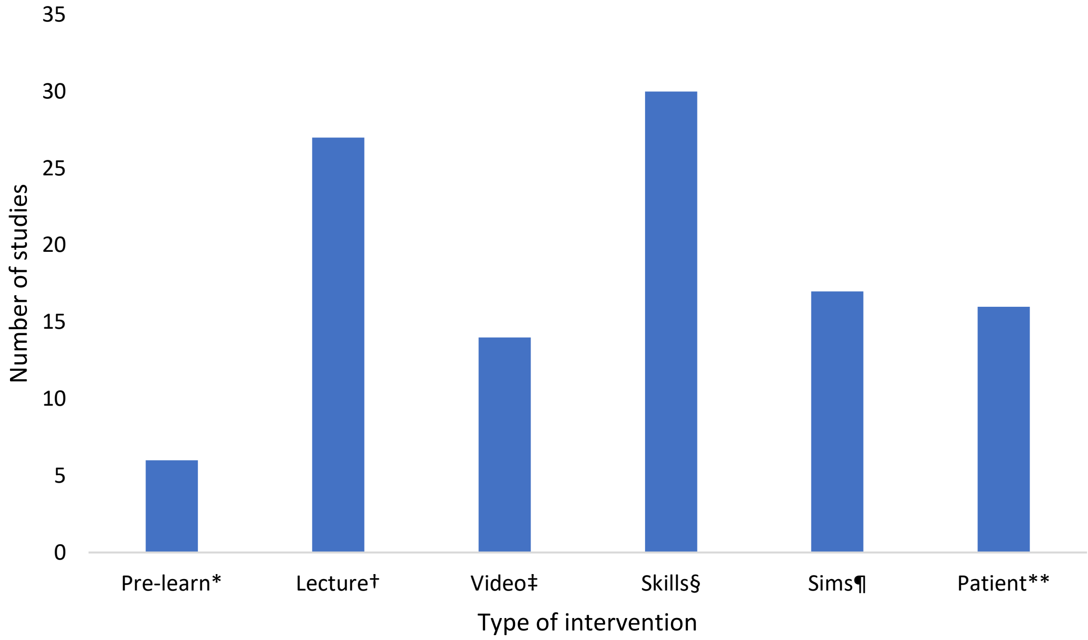


Figure 3: Types of training interventions used among all the studies



* Pre-learning material given to participants before training, † Didactic lectures given by instructors, ‡ Instructional videos watched during training, § Skill stations with part-task trainers, ¶ Immersive simulation using patient simulators, ** Supervised patient episode (in theatre, wards, or in the pre-hospital setting).