The impact of a web-based pre-intubation preparation module on the knowledge, skills and behavior of critical care fellows.

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Abstract

Background: It is a priority to have critical care trainees acquire competency in pre-intubation airway assessment and preparation. We describe the design, implementation, and evaluation of a novel web-based training module on critical care fellows' ability to assess, predict and prepare for tracheal intubation.

Methods: A needs assessment from fellows and from faculty found that structured training on intubation preparation and airway risk assessment was essential. We therefore designed an online module that combines mandatory readings, brief lectures and a case-based virtual activity. In addition to learner satisfaction, the outcome constructs of this module include improvements in fellows' pre-intubation preparation assessment knowledge, skills, safety-oriented behaviors. Paired t-test was used to compare knowledge assessment scores pre and post module. Chi-square test was used to compare pre and post data for the categorical variables in the evaluation of the skill and behavior constructs.

Results: All trainees (N=14) completed the module, and they were satisfied with its contents and structure. The mean score on the knowledge assessment increased significantly (from 79.9% to 90.3%, p =0.02). There was a total of 290 intubations logged by the fellows during the study period. First pass success did not significantly change after the module (88.6% vs 94.3%, p=0.89). There was a significant change in procedural note documentation to include at least one airway risk parameter in the fellow authored notes (65.9% vs 72.9%, P=0.049). All respondents were confident that they will be able to apply what they have learned in the module into clinical practice and that their patients will benefit from their new knowledge.

Conclusion: The implementation of an asynchronous web-based module on airway assessment and intubation preparation was feasible. The module was engaging, enhanced knowledge of our trainees and improved procedural documentation.

Introduction

The most common cause of medical intensive care unit (MICU) admissions is respiratory illness, and mechanical ventilation is needed by 20–40% of MICU patients.[1] These patients require tracheal intubation, and this population is unique in that their physiologic reserve is low. Unlike elective intubations that occur in the operating room, critically ill patients are at risk of hemodynamic collapse and severe hypoxemia during intubation[2,3]. Precision in intubation and difficult airway identification is crucial.[3] The MACOCHA score is an seven-item tool and is currently the only validated tool for predicting intubation procedure difficulty in the critical care setting.[4] The items of the MACOCHA score are what make up its name: **M**allampati III or IV, sleep **A**pnea syndrome, reduced mobility of the **C**ervical spine, limited mouth **O**pening < 3cm, **C**oma, severe **H**ypoxemia, non-**A**nesthesiologist performing the procedure.[4] Each of these items adds one point to the score with the exception of the Mallampati which adds 5 points and sleep apnea which adds 2 points. A total score of more than 2 predicts a difficult airway.[4] International guidelines emphasize the importance of operator training to improve quality of care for

these vulnerable patients.[3] It is therefore a priority to have critical care trainees acquire competency in pre-intubation airway assessment and preparation.

One way to effectively meet this need is by developing a web-based module that engages critical care medicine (CCM) and pulmonary and critical care (PCCM) fellows in their learning. The purpose of developing this learning module is to provide a readily available resource for learning the basic principles of airway pre-assessment and pre-intubation preparation. In a very busy MICU, bedside teaching can be impractical, and didactic lectures are often passive experiences that are difficult to schedule and do not match the need for performance-based learning. An online component to the curriculum allows for flexibility and convenience of access to the educational content, as learners can learn at their own pace and revisit concepts that they have not fully grasped. This use of online distance learning during the coronavirus disease 2019 (COVID-19) pandemic became commonplace as institutions across the globe struggled with needing to maintain social distance while providing impactful, timely and effective educational experiences for medical trainees.[5]

First-Pass Success

First-pass success reduces the likelihood of complications from tracheal intubation.[6,7] In a multi-center Japanese study looking at emergency intubations, 2,616 patients requiring emergent intubations were reviewed.[7] There were higher odds of adverse events when patients required more than two attempts at intubation (odds ratio 4.5; 95% confidence interval 3.4 to 6.1).[7] Several factors have been attributed to first-pass intubation success rates and these include both patient and operator factors. Operator experience, operator working department (i.e., emergency medicine versus other department), patient restriction in mouth opening, restriction in neck extension and swollen tongue were identified as independent predictors of first past success in emergency tracheal intubation.[8] Interestingly, there is overlap with these factors and the components of the MACOCHA score.[3,8] These variables formulate 4 of the 7 items in the MACOCHA score calculation worksheet.[3] While these quantitative data are useful in identifying some independent variables to intubation success rates, qualitative data can also unearth nuanced opportunities to increase successful intubation such as pre-intubation preparation. In a Danish qualitative study that explored factors that contribute to unanticipated difficult airways, insufficient airway assessment was identified as a main contributor to adversity.[9] The authors inferred that if the operator had assessed the airway, then they would have anticipated difficulty and consequently prepared for it.[9] Pre-intubation airway assessment is a necessary step in identifying and preparing for the difficult airway, which accounts for its emphasis in standard airway courses.[3,10,11]

Web-based learning

Based on a systematic review and metanalysis, simulation training demonstrated superior educational outcomes to no intervention and non-simulation intervention when teaching advanced airway management.[12] Given that much of airway management focuses on practical skills, unsurprisingly simulation training was found to be best suited to deliver that educational content. However, airway

assessment and pre-intubation preparation does not require the acquisition of haptic skills and most of the learning objectives in this part of airway management are in the cognitive domain and involve visual learning which are amenable to online instruction. There is an opportunity to blend web-based self-directed learning with a broader hands-on simulation-based course, thus potentially saving costs by maximizing in-person instructor time.

Web-based learning has several advantages including flexibility of access, ease of content updating, low cost and appeal to adult learning preferences.[11] In their systematic review looking at the impact of online learning, George et al found that 29% of the studies demonstrated an increase in knowledge and 40% showed greater skills.[13] They reported 67% had no difference in attitudes to e-learning as it compares to traditional methods though 14% of the studies were satisfied more by online learning.[13] The authors concluded that online learning was just as effective, if not more effective than traditional methods, defined as “face–to–face learning that takes place in a classroom environment”.[13] Despite a focus on undergraduate students, this review looked at health science instruction which broadly has similar themes to post-graduate health professional education.[13] In relation to the content-specific application of online learning (i.e. airway management), web based methods of instruction have been demonstrated to increase post-course knowledge scores and satisfaction among anaesthesiology residents.[11,14]

Conversely, online education has a reputation of being boring.[15] This is particularly evident when non-engaging didactics are simply placed on an online learning platform and called e-learning.[15] One way to overcome this barrier is to instruct through problem solving of engaging cases. The principles of case/problem-based learning (PBL) and more broadly those of adult learning theory are acknowledged by Gaupp et al and are commonly accepted and used in the healthcare field.[16] The appeal of PBL in medical education could be due to its mirroring of physicians’ daily problem-solving based practice. Furthermore, PBL is in keeping with adult learning preferences as described by Knowles et al, where the focus is problem-centered and less content-oriented.[17] Online learning has the additional benefit of meeting the adult learning principle of self-direction because learning can be asynchronous and adjusted to the pace of the learner.[17]

There is a paucity of literature around how the topic of airway management is taught in CCM and PCCM fellowship programs since most of the relevant literature centers around Anesthesiology and Emergency Medicine (EM) trainees.[18] The Accreditation Council for Graduate Medical Education (ACGME) specifies that PCCM fellowship programs must have trainees achieve endotracheal intubation and airway management competency, though the methods of acquiring competency are not clearly described.[18–20] We propose launching a web-based module that teaches fellows how to assess airway difficulty and prepare for it using the framework of adult learning. Specifically, the module is designed to be problem-centered and the content is immediately relevant in that it applies to learners’ daily work. This is in keeping with the principles of andragogy as described by Malcolm Knowles.[17]

In this report, we sought to answer the question: a web-based pre-intubation airway assessment module improve the knowledge and attitudes of critical care fellows' identification and preparation for a difficult airway? We hypothesized that a web-based training module will improve fellows' ability to assess, predict, and prepare for a difficult airway. We also hypothesize that their safety-focused behaviors will be reflected by adequately preparing for an airway and documenting this in their procedure notes accordingly. Completion of the web-based pre-intubation airway assessment module is the sole independent variable. The dependent variables are the following: improvement in the fellow's airway assessment skills, and behaviors.

Methods

Study population and Setting

We included all our enrolled critical care (N = 8) and pulmonary and critical care (N = 6) fellows for the academic year 2021–2022. Fellow participation in this educational initiative was made mandatory by their respective program directors since competency in the content of this module is required by the ACGME.[19] However, participation in the post-module survey was optional.

The study was conducted at Baystate Medical Center in Springfield, MA which is a regional campus for the University of Massachusetts Medical School. There is a 25 + MICU staffed by two teaching teams. The PCCM division includes a 3-year PCCM fellowship and a 2-year CCM fellowship with a total of 14 fellows who have overlapping responsibilities and training. Most of the MICU intubations are performed by the ICU fellow or attending with some performed by anesthesiology residents or staff.

Module development

A targeted needs assessment was conducted by informally interviewing the fellows from the previous academic year (N = 14) and MICU faculty (N = 15) to identify gaps in skill and knowledge of fellows. Over the course of a week in the middle of the academic year, the first author asked all fellows, "what skill or area would you like to see improved in your fellowship training?" during brief staggered discussions. Their responses were recorded and compared with faculty responses to the same question. Fellows in various stages of training stated that training in airway preparation varied throughout their training and was identified as an area of need for improved training. Some fellows identified that the heterogeneity in their intubation experience is due to several factors including the supervising intensivist's comfort level with supervising intubations, patient acuity and competition with other trainees. These findings were concordant with other programs across the United States.[18] Faculty's response to the question was recorded in an email communication. Specifically, the program directors (ED and MT) agreed that fellow's preparation for tracheal intubation was an area to improve. We used informal discussions to allow candid responses, avoid survey fatigue. and to obtain a high response rate from the stakeholders. Fellows get their initial exposure to tracheal intubation early in their training while rotating in the operating room with anesthesiologists. These intubations are electively scheduled in anticipation of a

procedure and are largely performed on patients being non-critically ill patients. All fellows were familiar with some airway assessment tool though they were less familiar with the MACOCHA score which is better suited for the patient population they will be caring for in their subspecialty. Faculty all agreed that assessment of an airway and systematic preparation for intubation is core critical care knowledge and that our fellows should be comfortable in independently doing this before they graduate.

We designed a short web-based module that was published in July 2021 and fellows were expected to complete it before the end of August 2021. Faculty with expertise in adult CCM (FA, MT, ED) developed the educational content. We used Canvas, an available learning management system (LMS), to deliver the content. The work was self-directed and asynchronous. An e-mail invitation was sent to each fellow and they were expected to register on the website to access the module. There were required readings, optional readings, multimedia presentations and case-based activities within the module (Table 1). We aimed to implement a rich resource of information that was developed from real ICU-life tasks which were problem-centered in keeping with Knowles' principles of Andragogy. Faculty verified via the LMS that the modules were completed. Reminders were sent by email to the fellows to ensure timely registration and completion of the learning module. Faculty were available to answer questions regarding the material. The learning objectives for the module are listed below.

Table 1

Module steps	Description
1. Introduction	Lists the module objectives and inform learners what to expect of the course including the reason for needing to complete the course.
2. The history and physical Exam	Discusses the features in a patient's history and physical exam that are salient in stratifying their intubation difficulty.
3. Prepare the patient	Describes a practical strategy to position the patient ideally to facilitate intubation.
4. Prepare the Equipment	Compares the various available tools and drugs needed for intubation.
5. Prepare the team	Highlights the importance of interprofessional team communication and role clarity.
6. Prepare for difficulty	Defines the difficult airway, covers back up procedures and institutional support for an airway emergency.
7. Go through a case	Learners practice the application of the content covered in the module and applies them to a hypothetical scenario that gets more complex as the trainee goes through it.

By the end of this module learner's will be able:

1. To list common complications observed with difficult tracheal intubations
2. To apply the MACOCHA score in the pre-intubation assessment of difficult airways.

3. To list commonly used pre-intubation medications, their onset of action, half-life and main adverse effects.
4. To identify patients who require post intubation resuscitation medications
5. To distinguish between patients who require rapid sequence intubation, delayed sequence intubation and those who would benefit from awake intubation.
6. Demonstrate a safety focused attitude by using best practice checklists when performing tracheal intubation.

Data Collection

Data collection started when the fellows commenced the module. Data in the form of quantitative surveys and pre/post module quizzes were collected and analyzed. The same surveys had open response questions which separately contributed to the qualitative analysis.

To measure behavior change, we manually reviewed the procedural documentation of every intubation performed by our fellows 3 months pre (3/1/2021-6/30/2021) and 3 months post (9/1/2021-12/31/2022) implementation of this module. Operators are required to document the number of attempts it took them to achieve success at intubation. We did not include data from July and August as this was used as the run-in period when fellows could take the module. We allowed two months to complete the module to account for variation in fellows' schedules in keeping with Knowles' concept of self-directed learning. Since the timing of this study coincided with July 1st, when fellows turn over at our hospital, data from graduated fellows was excluded. We analyzed intubation documentation pre and post intervention and compared the percentage of instances of specific documentation of pre-intubation assessment and preparation in the fellow's notes before and after the intervention. We identified the fellow performed intubations by reviewing each fellow's procedure log available on New Innovations. The fellow was given credit for first pass success at intubation based on their chart documentation of number of attempts (1 vs more than 1). We reviewed the same notes for documentation of intubation risk of the individual patients. If the fellows included any of the 7 components of the MACOCHA score in their note, then they were credited with having documented intubation risk. To ensure accuracy of data collection, two additional reviewers audited the data by selecting 5 random procedure documentation notes for agreement. There was 100% agreement in the data collection among reviewers and the primary data collector.

Data Analysis

There were four main constructs that were analyzed: learner satisfaction (reaction), improvement in learner knowledge, improvement in intubation skill, and change in behavior. We used IBM SPSS software for our data analysis of the quantitative data.

The first construct was learner satisfaction. At the end of the module, learners were surveyed for their satisfaction and reaction to the module by using an adaptation of select questions from the short Demand-Driven Learning Model (DDLM) survey which combines quantitative and qualitative items.[21] We

adapted the survey tool to meet our content-specific terminology. The inventory asks participants to rate their responses on a 1–5 Likert scale. This evaluation tool was selected because it aligns with the web-based framework and because of its wide applicability. The measure provides rapid feedback to module developers to allow for timely intervention.[21] In our analysis, we used descriptive statistics to report on the Likert scale post course module surveys results.

The second construct is fellows' *improvement in the knowledge of the delivered module content.* Knowledge improvement is defined as an increase in post module multiple choice testing. We compared overall scores of the participants pre-module test with post-module using a paired t-test and considered P-values < 0.05 to be statistically significant. The multiple-choice questions (MCQs)were constructed by a specialist in critical care medicine and were vetted and approved by a group of practicing intensivists until consensus was reached. This provided evidence of content validity for the MCQ quiz. Both pre and post quizzes contained eleven MCQs and were scored as a percentage. Each item included 3 distractors and 1 correct answer. Their content was focused on demonstrating knowledge of the learning outcome concepts. We used a two-tailed test to compare pre and post knowledge acquisition.

The third construct is fellows' *improvement in skills to intubate*. Skills improvement is defined as the incidence of first-pass success at intubation by the fellow. Content validity for the use of first pass success as a metric for intubation skill is supported by the critical care medicine literature.[6,7] We compared the aggregate percentage of 1st pass success three months before the module with the proportions three months after. We coded for 1 attempt versus more than 1 attempt at intubation then we used the Fischer exact test since there were fewer than 5 counts in the crosstabulation contingency table. This test was used to analyze the difference between proportions pre and post module.

The fourth construct is *fellows' enhancement of safety focused behaviors*. Change in behavior was analyzed by two modalities. The first was reported as a proportion using data from the post module survey to the question: "How likely will you change what you document in your procedural notes to reflect what your learned?". The second is record of airway risk stratification in procedural notes. In order to obtain evidence of validity and consequences of testing (i.e. congruency in action and self-report) we reported on the proportion of procedural notes (recorded in patient charts and authored by our learners) that accurately comment on airway risk stratification three months before and three months after the module. This is not described in the literature as a metric for measurement of attitudinal change. However, upon discussion with experts in the field this was an agreed upon surrogate for behavior and safety-based action. We used Chi-square test to compare the difference in proportions.

Another indirect measure of behavior is learner self-efficacy in intubation. Based on the work of Bandura, this is defined as how confident a learner perceives their ability to perform a specific task. Self-efficacy is a motivational construct that is linked to behaviour and persistence with a challenging task.[22,23] This was measured by self-report in the post-module survey and reported with descriptive statistics as it relates to the four previously described constructs.

Results

All fourteen fellows participated in the module but 11 completed the post module survey (78.6% response rate). The majority of the fellows are graduates of Internal Medicine residency (79%) while the rest are Emergency Medicine trained. Other characteristics of our learners are summarized in Table 2. Module participation was confirmed by reviewing the activity page on the LMS and we noted that it took learners a median time of 64.5 (SD51.5) minutes to complete the module. Analysis of the survey demonstrated that all respondents were either very satisfied (64%) or somewhat satisfied (36%) that the module contributed to their learning. All were satisfied with the organization of the module and most (91%) were satisfied with the learning management system that was used (Table 3). They were also all satisfied with the resources provided (Table 3).

Table 2
Characteristics of the learners

	N (%) Total 14
Male Gender	9 (64)
Pre-fellowship Internal Medicine Residency	11 (79)
Pre-fellowship Emergency Medicine Residency	3 (21)
Critical Care	8 (57)
Pulmonary and Critical Care	6 (43)
PGY 4	6 (43)
PGY 5	6 (43)
PGY 6	2 (14)

Table 3

Post-Module Survey Evaluation by Students				
N = 11	Minimum	Maximum	Mean	Std. Deviation
How often was the content appropriate in depth?	4	5	4.55	.522
How often was the content relevant to your professional needs?	4	5	4.82	.405
How often were the learning objectives clear to you?	4	5	4.73	.467
How satisfied were you that your instructor(s) were knowledgeable about the topic?	4	5	4.91	.302
How satisfied were you that your learning activities contributed to achieving the learning objectives?	4	5	4.64	.505
How satisfied were you with the learning management system (ie. Canvas- the web learning platform)?	3	5	4.55	.688
How satisfied were you with the instructor(s) responsiveness to your learning needs?	3	5	4.45	.688
How satisfied were you with the additional resources provided?	4	5	4.91	.302
How satisfied were you with the organization and structure of the online learning module?	4	5	4.91	.302
How satisfied were you that the module addressed your individual learning style and preferences?	3	5	4.64	.674
How confident were you with your overall knowledge on pre-intubation preparation before taking this module?	3	5	3.82	.603
How confident would you rate your overall knowledge on the presented content after taking this module?	3	5	4.18	.751
How confident are you that you will be able to successfully intubate at the first attempt after this course?	3	5	4.18	.751
How confident are you that you will be able to apply what you've learned from this module into clinical practice?	3	5	4.36	.674

The mean pre-module quiz score was 79.9% and that increased to 90.3% in the post module quiz ($p = 0.02$). Participants unanimously agreed that they would use what they learned into clinical practice and they all indicated that it is very likely that their patients will benefit from their new knowledge (Table 3). Self-reported confidence in pre-intubation preparation knowledge increased among learners. The mean

confidence rating on a 5-point Likert self-report scale was 3.82, SD 0.57 and 4.18, SD 0.72. All fellows indicated that they were confident that they will be able to apply what they have learned in the module into clinical practice.

Learners self-reported high confidence in successfully being able to intubate at the first attempt after taking the module (Mean 4.18, SD 0.72, of a maximum 5 in a Likert scale). To measure the first-pass success rate of fellows taking the module, a total of 290 intubation were logged by the fellows in the 6-month study period. We excluded 176 procedures due to missing data and included 114 valid procedures (44 pre and 70 procedures post module). First pass success did not significantly increase (88.6% vs 94.3%, $p = 0.89$).

Nearly all (91%) of learners indicated that they would likely change what they document in their procedural notes based on what they have learned in the module. This behavior change was also observed in procedural note documentation of the 114 valid intubation notes that were reviewed. The percentage of procedure notes that included at least 1 mention of a component of the MACOCHA score did significantly increase from 65.9–72.9% ($P = 0.049$). One learner adds in the open response part of the post-survey, “I am incorporating more objective data into [my] documentation.” They reported starting to use several tools such as the MACOCHA score and Cormack-Lehane grading in their documentation to “help the next person come and intubate.”

The post-course survey also included other open-response questions. A selection of participant responses to the question (what was the most valuable aspect of the module) include:

- “Learning the different tools and medications”
- “[There were a] variety of modalities to keep [the] information engaging. I learn best from questions and videos, so this was great!”
- “[It was] presented in a very straight forward fashion”
- “The resources were great, the videos were full of knowledge yet concise”
- “It was really helpful to understand what resources are available for me at this facility. In addition to that, what are specific things I should be calling the DART [Difficult Airway Response Team] for instead of trying to intubate the patient myself”

When asked how can the module be improved, some learners wrote that spaced learning approaches would have been helpful. One area or improvement learners pointed out is including more information on advanced techniques and difficult airway management. They also indicated more hands on training (eg. simulation) would have augmented their learning.

Discussion

While intubation remains an essential skill in critical care training, there are few educational studies that have been published concerning our learner population. Most of the literature on this topic is related to

trainees in anaesthesiology and emergency medicine. We successfully implemented an asynchronous module that teaches CCM and PCCM fellows how to accurately assess the difficulty of an airway and to prepare for an intubation procedure. The high response rate on our survey allows for a satisfactory representation of learner reaction and self-assessment of skills.

Participant reaction to the module was overwhelmingly positive. This is supported by feedback from the learners who pointed out that the ease and convenience of technology use, its concise nature and clear organization were strengths. While learner satisfaction is critical to the quality of learner-centered curricula, learner satisfaction remains subjective and does not necessarily represent improvement in knowledge and skill.[24] We therefore supplemented this finding with data on other learning and behavior constructs in keeping with the Kirkpatrick training evaluation model.[25]

Our form of online instruction is independent and requires motivation and self-efficacy. Self-efficacy can impact learner behavior.[26,27] For example, greater self-efficacy has been correlated to persistence in learning and other domains.[26,28] The positive response on confidence as reported by our learners could explain improvement in knowledge, practice behavior and skills of fellows.

Baseline knowledge of the content matter was high (80%) but these results are likely skewed by the inclusion of senior fellows (2nd and 3rd year) in the analysis. The mean pre-module quiz score for first year was 76%. The overall mean score increased by 13% which supports the module's effectiveness in knowledge transfer.

We note that first pass success rates by fellows were 88.6% which is somewhat higher than what is reported in the literature for trainees.[10] This is likely due to the inclusion of pre-fellowship emergency medicine trained participants whose prior experience emphasized intubation skills. Additionally the heterogeneity of post-graduate year training amongst the group likely contributed to this high first pass success rate. Despite that, the improvement in first pass success post module was not statistically significant. It is likely that the intubation data underrepresented the fellows since the data collection overlapped with a change in academic year where graduating fellow data was eliminated since they would not be completing the module. Another reason for underrepresentation, is the fellows schedule. For example, it would be unlikely for a fellow assigned to a non-ICU block to be intubating and if that happened to overlap with the study period then their skills would not be captured.

Self-reporting of practice change can represent actual behaviour change in the context of measuring outcomes related to medical training programs. [29] The majority of learners indicated that they would change how they document airway risk in their procedural notes and this was in fact observed in the procedural notes we reviewed. All fellows use templates for intubation procedural documentation, though these do not require the inclusion of the components of the MACOCHA. Improving the template could have the potential of conditioning the fellows into needing to think of assessment risk in a more systematic way though this would require institutional and inter-departmental buy-in.

When evaluating the 'Prepare to Intubate' module, the authors sought to determine how the content was applied to daily clinical practice and what barriers exist in implementing best practices that were taught in this module. Some potential barriers included patient differences such as the variations in patient population. An intubation plan must be individualized and one cannot teach every nuanced scenario that may arise. Different disease processes may need different airway preparation including allowing airway experts to take over. This was echoed by one of the participants who pointed out that there are circumstances where airway intubation simply should be attempted by the DART team. Another barrier to implementation was simply remembering the content and a suggested solution by one of the participants for this was, "a one-page cheat sheet would be helpful as a quick guide." Visual aids to help remember technical concepts such as ramping could also assist as a solution for this.

Limitations

Using an experimental design for this study would not have been appropriate in part because our convenience sample of participants was small. A large multicentred experimental design would have protected against threats to internal validity. However, since there was a potential to improve patient care by improving learner behavior and knowledge, we did not want to withhold the educational content from a potential control group.

There are some factors that were identified as potential confounders which may limit the ability to measure the attributable efficacy of the module and its generalizability. The factors include experience in the procedure as reflected by post-graduate year (higher year = more experience) and prior residency training (EM versus Internal Medicine) since EM residents will have more intubation experience than their internal medicine counterparts. Post graduate year (PGY) and prior training were singled out as operator-related variables that could impact first pass success at intubation in the Jung and Kim study thus justifying our need to take this into account when interpreting our results.[8] Contrarily, in their retrospective study, Sakles and colleagues found that PGY was not a predictor of adverse events when intubating.[6] Though, selection bias may account for this finding since junior EM residents are more likely to intubate the less complicated patients compared to their senior peers.[6] Both studies were limited by their observational design but a metanalysis by Crewdson et al supports Jung and Kim's findings that intubation success is attributed to personnel experience. [6,8, 30]

Another limitation to this study was our assumption of attributable educational efficacy. This is difficult to study because while we assume that all fellows completed the online module and learned from it we cannot control for what is learned independently. A more robust way to achieve evidence for response process validity for the knowledge quiz would be to use the 'think-aloud' approach by having learners write out their reasoning for selecting an answer on the quiz. Increasing the item numbers would also help reduce the threat of construct-underrepresentation.[31] Additionally, submitting a formal external expert content review of the test would have helped in reducing the impact of construct irrelevant variance.[31]

Basing the skills evaluation on procedural documentation is appropriate to assess for the first pass success construct though it lends itself to social desirability and reporting bias. It may be that the fellows only submit procedure notes and new innovations logs where they were successful in completing the procedure. One way to improve this is by corroborating this with an observer checklist grading of the fellows' performance, though this is resource exhaustive.

Since the assessment and surveys were completed shortly after the completion of the module, this may only assess their immediate recall which might result in recall bias. This study would have been strengthened by reassessing fellows knowledge and skills at the end of the academic year. Since participants would likely be susceptible to knowledge decay, repeat assessment would be necessary to ensure continued competency.

Conclusion

Following completion of the course our learners expressed a clear realization about the importance of structured steps and preparation before intubation. This has been reflected in their declarations of change in the way they document. Learning about the patient population that is unique to the intensive care unit, their needs, special considerations and resources available was also helpful in driving a safety focused culture at our institution.

The fellows outline some important considerations such as the inclusion of spaced learning throughout the academic year. They also expressed wanting to learn more advanced techniques in intubation. The active learning problem-based aspects of the module seemed to be well received and likely encouraged further reading. They proposed the addition of a practical component (ie. simulation) to the module which would help complement its theoretical framework. Further multicentred studies looking at methods of acquiring competency in intubation skills in ICU airway management are needed.

Declarations

Ethics approval and consent to participate

The curriculum proposal and its planned evaluation were submitted to the Institutional Review Board (IRB) at both Johns Hopkins and Baystate Medical Center IRBs. Both the Baystate IRB (BH-21-169) and Johns Hopkins Homewood IRB (HIRB00013374) acknowledged the project and determined the study was exempt. All methods were carried out in accordance with relevant guidelines and regulations. Informed consent was obtained, fellows could opt out of participation in the post-course survey. All participants were adults above the age of 18.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analysed during the current study available from the corresponding author on request.

Competing interests

The authors declare that there are no competing interests

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None

Authors' contributions

FA is the principal designer of the module. He created, designed and implemented the module and its content in consultation with the listed co-authors. ED and MT co-authored the module content and were responsible for interpreting and analyzing the course evaluation and co-authoring this report. RB and JS critically revised the manuscript for important intellectual content. All authors are responsible for the accuracy and integrity of the work and approved the final version of this manuscript.

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