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Effectiveness of the Introduction to Critical Care in Emergency Medicine Curriculum's Implementation Among Trainees Interested in Intensive Care

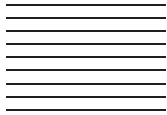
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Education

Effectiveness of the Introduction to Critical Care in Emergency Medicine Curriculum's Implementation Among Trainees Interested in Intensive Care

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Abstract—Background: Emergency physicians and trainees provide the initial care for critically ill patients. In times of emergency department boarding, this care may extend beyond the first few hours. To meet the needs of this population, a standardized novel critical care curriculum targeting third- and fourth-year medical students was developed. **Objectives:** We hypothesized that the institution of such a curriculum is feasible and will provide an increased understanding of the underlying critical care principles within this learner population. **Methods:** We developed a 2-month-long critical care curriculum (February–April) and carried out the course twice from 2022–2023. Our pilot study deployed this curriculum to medical students interested in critical care through the American Academy of Emergency Medicine/Resident and Student Association. The primary outcome included was the overall composite score comparison of the pre- and post-course evaluations, with a higher score indicating that the student improved their comprehension. Secondary outcomes included the individual factors of the pre- and post-course surveys. **Results:** Fifty-one

trainees completed the pilot course, including 11/51 (21.6%) third-year medical students and 40/51 (78.4%) fourth-year medical students. Overall, 39 had “no experience” in critical care and 12 indicated that they had “previous experience.” The students’ baseline pre-course from the pooled 2022 and 2023 Introduction to Critical Care in Emergency Medicine (ICCEM) curriculum data was 3 (interquartile range 4–3) and their post-course score was 9 (interquartile range 9–9), *p*-value 0.015 for the 51/54 students who completed the course. **Conclusions:** The novel curriculum was found to be effective during its implementation in third- and fourth-year medical students. As such, it indicated that a critical care fundamentals course improves confidence in these topics for students with and without prior experience. Further work is necessary to understand the generalizability and knowledge retention of the proposed pilot curriculum. © 2024 The Author(s). Published by Elsevier Inc. This is an open access article under the CC BY-NC license (<http://creativecommons.org/licenses/by-nc/4.0/>)

Keywords—critical care; emergency medicine; medical education; international curriculum

IRB Statement: According to the University of Vermont, this project does not meet the federal regulatory definition of research requiring institutional review board (IRB) review and approval.

Trial Registration: According to the IRB committee, this project does not meet the federal regulatory definition of research requiring IRB review and approval.

Introduction

Medical students dedicate their clerkship education to foundational topics in medicine, such as internal

medicine, surgery, and psychiatry. Although many consider critical care medicine too advanced for an early trainee, the initial critical care, and sometimes extended critical care stabilization in areas with limited intensive care unit bed capacity, is provided in the emergency department (ED) (1,2). Trainees must be prepared to provide this. Whereas prior work has focused on teaching fourth-year medical students critical care management and procedural skills at a basic level, it lacked a foundational and incremental model that coupled theoretical critical care medicine with practical experiences (3,4). Given that these critical care topics are complex, it is unknown if these difficult concepts can be broken down and effectively taught to medical students.

Prior works investigating aspects of the flipped classroom have found that there are benefits to those who participate in the style (5,6). The flipped classroom is an emerging pedagogical method, which employs asynchronous video lectures and active, group-based problem-solving activities (7,8). This instructional model also allows for more fluidity and tailoring according to the material and audience, so incorporating evidence-based practice (EBP) is not limited by this model. Additionally, incorporating EBP into medical students' academic learning is found to have a positive impact on their future patients (9). By integrating educational content in a longitudinal fashion, this format has proven to be an effective means to teach complex topics.

Our study sought to determine if the institution of a critical care curriculum targeting medical students, utilizing a flipped-classroom, incremental model of learning, is feasible. We deployed a 2-month-long "Introduction to Critical Care in Emergency Medicine (ICCEM)" course through the American Academy of Emergency Medicine/Resident and Student Association (AAEM/RSA) to medical students interested in emergency medicine (EM). We hypothesized that instituting such a curriculum would increase their global understanding of critical care principals as measured by pre- and post-course completion examinations and surveys.

Materials and Methods

Program Development

We designed a 2-month-long curriculum, the ICCEM course, which exposed third- and fourth-year medical students to foundational critical care topics. The initial curricular material was developed and pretested over 2 years on second-year medical students interested in EM and critical care. None of the second-year medical students involved in the pretesting period were involved in the studied course. It was determined that completion of

the basic sciences was a necessary prerequisite for the curriculum in order for students to comprehend the vast and complex topics presented in the course, and hence the primary target population was third- and fourth-year medical students.

Study Population and Participants

The AAEM is an organization that focuses on improving and advocating for the specialty of EM, as well as a separate constituent composed of residents and students nationally and internationally, the AAEM/RSA. The AAEM/RSA supported the ICCEM curriculum by providing an online platform for the course, the student population, advertising, and marketing efforts. According to the institutional review board (IRB) committee, this project does not meet the federal regulatory definition of research requiring IRB review and approval.

The organization also assisted in recruiting the participants, primarily third- and fourth-year medical students interested in the ICCEM curriculum. The inclusion criteria included medical students who completed at least 2 years of medical school. The AAEM/RSA marketed the course toward this audience through a list serve, targeted e-mails, announcements, and promotional material. The interested participants were asked to complete a registration application, indicating the current year of medical school to ensure that qualifications were met. Additionally, we asked if the participant had completed the requisite 2 years of medical school, and if they indicated "no," they were asked to wait for future iterations of the course.

Objective and Design

The primary objective of the ICCEM program was to identify third- and fourth-year medical students who were interested in critical care and provide them with an early opportunity to enhance their theoretical and practical skills in intensive care medicine. At the conclusion of the course, all participants were expected to be proficient in a broad array of critical care objectives (Table 1).

Course Curriculum and Academic Strategies

Didactics

Flipped classroom lectures and discussions

The didactics section was delivered in a pre-recorded lecture-based format. The discussion sessions were led by the course directors with an EM intensivist who supervised the conversation. Multiple-choice and open-ended questions were integrated to prompt critical thinking and a deeper understanding of the material (10).

Table 1. Objectives of the Introduction to Critical Care in Emergency Medicine Curriculum

1. Identify third- and fourth-year medical students with an interest in critical care
2. Provide students of the program with the opportunity to enhance their critical care skills and knowledge
3. Improve a student's understanding of evidence-based medicine through up-to-date medical concepts in critical care
4. Develop a student's theoretical critical care knowledge through a flipped-classroom based approach to learning
5. Enhance a student's practical critical care skills through hands-on experiences
6. Test both the theoretical and practical skills obtained through case-based scenarios
7. Demonstrate competence in critical care concepts
 - Critical care pharmacology
 - Arterial blood gas interpretation
 - Oxygen therapy and ventilation
 - Intra-aortic balloon pump, extracorporeal membrane oxygenation (ECMO) and central line insertion
 - Pediatric and neonatal critical care
 - Hemodynamic and intracranial pressure monitoring
 - Cardiac pacing and implantable cardiac devices
 - Fluid therapy and massive transfusion
 - Point-of-care ultrasound
8. Demonstrate competence in critical care procedures
 - Advanced airway management and rapid sequence intubation
 - Mechanical ventilation and knobology
 - Point-of-care ultrasound

Scenario-based quizzes

Students were asked to complete a short quiz pertaining to that week's topic. The primary intent of the quizzes was to extrapolate a student's understanding of that week's content and further solidify difficult material if lower examination scores were found.

Practical In-Person Session

The practical portion of the course took place during the pre-conference section of AAEM's Scientific Assembly in 2022 and 2023. All students were required to attend this session for course completion. The session had a duration of 4 h and included advanced airway management and mechanical ventilator utilization, as well as point-of-care ultrasound (POCUS). With completion of a post-course survey, they also received a certificate of completion.

Airway management

This section of the in-person session taught students the practical components of rapid sequence intubation (RSI) and introduced the "7 Ps" of airway stabilization (11).

Ventilator knobology

The practical aspects of mechanical ventilation covered ventilator knobology and scenario-based discussions (12).

POCUS

The final practical session included introductory ultrasonography skills utilizing the extended focused assessment with sonography in trauma examination as the basis for instruction (13).

A full breakdown of the ICCEM course, including the didactic and practical in-person sessions, can be found within Appendix 1.

Course Cost

The cost of the course varies based on the location of its implementation; however, the hybrid approach reduced the cost. Students were charged \$40.00 USD to cover the cost of equipment for the in-person session, support systems, website, Zoom sessions, and further organizational work. Additional costs included the rate of the conference room, with tables, chairs, and audiovisual support. However, AAEM's Critical Care Medicine Section provided section members full scholastic support. The course directors, instructors, Critical Care Medicine Section faculty, and administration staff did not receive monetary compensation, and their volunteer time is included (Table 2). Most of the in-person session equipment came from local fire/rescue and critical care transport agencies, with the remainder of the necessary items being provided by vendors such as STORZ® (KARL STORZ Endoscopy-

Table 2. A Summary of the Course Components Requiring Volunteer Faculty and Required Hours

Group	Requirement	Volunteer needs	Hours
Didactics/online lectures	Yearly critique of lectures	Course director, instructor/s and CCMS faculty	5 sessions (2 h each) = 10 h total
	Lecture recording	Course director and instructor/s	9 sessions (3 h each) = 27 h total
	Weekly zoom sessions (n = 9)	Instructor/s, administrative staff and CCMS faculty	9 sessions (1 hour each) = 9 h total
	Creation of quizzes and marking (n = 9)	Course director	9 quizzes (1 hour each) = 9 h total
In-person practical session	Advanced airway management and rapid sequence intubation	Course director, instructor/s administrative staff and CCMS faculty	1 session (2 h) = 2 h total
	Mechanical ventilation and knobology	Course director, instructor/s administrative staff and CCMS faculty	1 session (2 h) = 2 h total
	Pre-session administrative work (organizing both practical sessions and equipment acquisition)	Course director, instructor/s, and administrative staff	2 sessions (2 h each) = 4 h total
Total volunteer hours			54 h per year for course director 54 h per year for instructor/s 17 h per year for administrative staff 23 h per year for CCMS faculty

CCMS = Critical Care Medicine Section.

America, Inc., El Segundo, California), Glidescope® (Verathon, Bothell, Washington), and Hamilton Medical® (Bonaduz, Switzerland). The borrowed equipment was returned, leaving no additional cost for the materials. In total, the course cost was \$950.00.

Analytical Variables and Definitions

Graduates of the course were asked to anonymously complete a longitudinal pre-course and post-course survey (Supplementary Figures 1 and 2, available online), linking them through SurveyMonkey and assigning each participant a number undiscoverable by the research team and

course faculty. A 3-point adjectival scale identified their perceived value of the course and comfort level with critical care topics. The adjectival scales split students into those with either 'no', 'previous', or 'extensive previous' experience in critical care prior to the start of the course. From there, they were then asked about their comfort level with critical care topics after completing the course, ranging from 'much more post-course', 'more post-course', and 'about the same post-course' (Figure 1). We solicited comments for each course component based on their perceived value of online didactics, course constituents, and the in-person practical sessions. Finally, a 10-question pre- and post-course quiz determined the course's effect on a student's understanding of critical care topics and

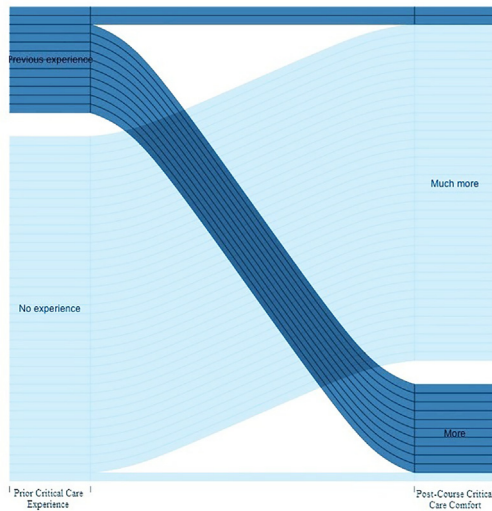


Figure 1. Pre- and post-course survey responses regarding comfort with critical care prior to and after the curriculum.

overall retention of the material at its conclusion (Appendix 2, available online). A washout period of 2 months was used to allow researchers to replicate the pre- and post-course quizzes for comparison.

Outcomes Measures

The primary outcome included the composite score of the pre- and post-course examinations. Secondary outcomes included the individual factors of the pre- and post-course surveys.

Statistical Analysis

We reported medians and interquartile ranges (IQR) utilizing the Wilcoxon signed-rank test. Statistical significance was set at $p \leq 0.05$. All analyses were performed using Stata 16.0 (College Station, Texas). As a longitudinal analysis, loss to follow-up was not a concern during the initial stages of this study, with a 100% response rate for those who completed the curriculum on the post-course survey and quiz at 2 months, administered immediately after the in-person practical portion of the ICCEM curriculum. During subsequent analyses of the course, we are preparing for a $< 5\%$ loss by implementing initial contact via e-mail and subsequently contacting their respective medical school or residency program if we are unable to locate them.

Results

A total of 51/54 students completed the ICCEM course, of which 11/51 (21.6%) were third-year medical students

and 40/51 (78.4%) were fourth-year medical students. Prior to the start date, 76.5% ($n = 39$) of the students had no prior experience with critical care, and 23.5% ($n = 12$) had previous experience as either a nurse or paramedic. Upon course completion, 100% of students reported further confidence in foundational topics of critical care. The attrition rate of three students was attributed to difficulty balancing medical school demands and the requirements for the ICCEM course. This was confirmed on follow-up with the students who had dropped out. All three students withdrew from the course prior to completion of the second lecture, or prior to fulfilling one-quarter of the curriculum, and they were excluded from our analysis.

All graduates provided feedback on the course (Table 3). Those not in agreement with recommending the course to trainees without critical care experience (2/51) indicated that the curriculum may have been too detailed, with certain aspects of the course being more complex than others, including intricacies of mechanical ventilation and the physics of extracorporeal membrane oxygenation and ultrasonography. The completion time for the course was also critiqued ($n = 1$), suggesting that the curriculum be extended to allow for further comprehension of the material.

For course graduates, recommendations for future iterations were also encouraged. The primary feedback centered around further practical involvement during the in-person session, including arterial and central line insertion. Inclusion of a lecture on rounding in the intensive care unit (ICU) was also mentioned.

The students' baseline pre-course test score for the 2022 ICCEM curriculum was 4 (IQR 5–3) and their post-course score was 9 (IQR 10–9), p -value 0.033. The students' baseline pre-course test score for the 2023 ICCEM curriculum was 3 (IQR 4–2) and their post-course score was 9 (IQR 10–9), p -value 0.044. The pooled data from both the 2022 and 2023 ICCEM courses showed a pre-course score of 3 (IQR 4–3) and a post-course score of 9 (IQR 9–9), p -value 0.015. An example comparison of the 2022 and 2023 ICCEM pre-course and post-course score averages categorized by prior critical care experience (Figure 2) and medical school year (Figure 3) are included.

Discussion

In this pilot critical care curriculum, we sought to understand if complex critical care principles can be broken down to learners and ultimately enhance their understanding of ICU-bound patients. This could lead to improved patient care during ED boarding times, thereby making this a clinically effective educational program. After the implementation of an intensive care curriculum as demon-

Table 3. Graduate Feedback on Various Aspects of the Introduction to Critical Care in Emergency Medicine Curriculum

	% (n)
I highly recommend this curriculum to those without critical care experience	92.6 (25)
The primary reason I applied for this course was achieved	100 (27)
The course was completed in an adequate amount of time	96.3 (26)
Having EM-CCM faculty present during the online sessions was beneficial	100 (27)
The quizzes and cases were a beneficial component of the course	100 (27)

EM-CCM = Emergency Medicine – Critical Care Medicine; n = number of graduates in agreement.

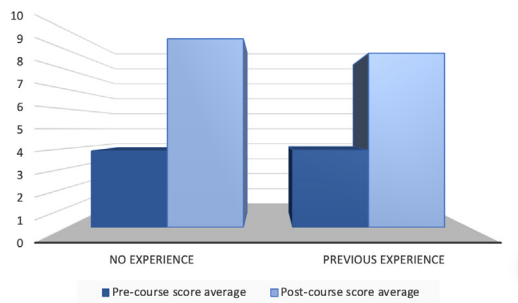


Figure 2. Pre- and post-2022 Introduction to Critical Care in Emergency Medicine (ICCEM) and 2023 course scores based on prior or no prior experience in critical care.

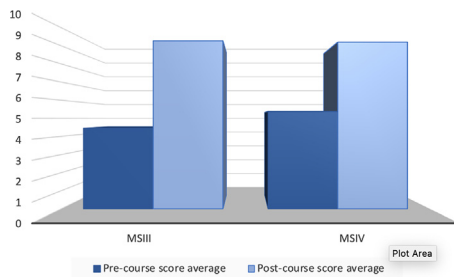


Figure 3. Pre- and post-2022 and 2023 ICCEM course scores based on year of medical school, third-year medical student (MS3) vs. fourth-year medical student (MS4).

strated, a student’s self-perceived confidence in critically ill patient management and medical knowledge can be enhanced (14). Overall, we found that all our medical student participants agreed that the curriculum was beneficial and improved their critical care knowledge, which held true for those with previous critical care experience as paramedics or nurses.

Formal medical school critical care curricula, meant to educate students prior to an ICU rotation, is mostly absent or deficient in standard teachings. Additionally, professional organizations offer critical care educational opportunities at a costly price, with most being too advanced for medical student comprehension and often too specialized, focusing on a single aspect of critical care. Examples of these programs include the Fundamental

Critical Care Support curriculum through the Society for Critical Care Medicine, the American College of Chest Physicians’ Critical Care Ultrasonography program, and the European Society of Intensive Care Medicine’s Intensive Care Fundamentals course. With the increase in ICU boarding in the ED, it becomes imperative that an introductory, cost-effective course be created for trainees to solidify their basic framework of critical care while building toward more advanced topics. In that vein, we felt that an overall flipped-classroom online learning structure coupled with an in-person practical component was the appropriate avenue for knowledge dissemination, with most ICCEM graduates concurring.

We chose several skills integral to EM and critical care, coupling both the flipped-classroom online didactics and in-person practical components, including endotracheal intubation, mechanical ventilation, and POCUS. It wasn’t until students completed the flipped-classroom online component of the ICCEM curriculum that they were then able to learn the practically relevant clinical skills. Additionally, some studies have found that certain critical care procedures are influential when the acquisition of the skill occurs early, and curricula that allow medical students to incorporate theoretical concepts into practice have further enhanced understanding of the material (15–18). Common knowledge gaps found during the practical portion of the course revolved around preparing for intubations in a systematic approach, knowledge of pharmacology and order of medication administration during RSI, various mechanical ventilatory settings focused on a patient’s unique pathophysiology, and identification of anatomical structures during ultrasonography. Although we reinforced the same underlying principles in both the didactic and practical components of the course, we found students more often struggled with translating their theoretical knowledge into treatment-based care for different pathologies. We overcame these clinical implementation barriers through exposure, repetition, and meticulously focusing on the methodologies and standards of care with the integration of scenario-based approaches.

Multiple graduates denoted that the ICCEM course integrated EBP into the curriculum, which has the potential to improve their practice environment and patient outcomes. Although the primary aim of the ICCEM course consisted of educating the next generation of emergency physicians here in the United States, we also believe this model can be incorporated internationally. Due to its low financial cost, the ICCEM course could easily be established at any medical school or residency with simulation availability and faculty interest, with the potential to have a positive impact on future physicians and their critically ill patients.

Next Steps

Throughout the ICCEM course, multiple pathologies and interventions were presented in a variety of circumstances, which was crucial to pattern recognition and hypothetico-deductive methods, and they are some of the most common techniques applied by emergency physicians in evaluating critically ill patients (19). For future iterations, we plan to expand to specific medical schools or residencies whose students or residents exhibit a strong interest in critical care. Lastly, to prove the assumption that graduates of the ICCEM curriculum are more comfortable managing critically ill patients in the ED, a prospective analysis studying ICCEM graduates vs. non-ICCEM graduates would be necessary. This will be a future direction of the study once further iterations of the course are completed. Additional future recruitment of EM interns into the ICCEM curriculum may also be considered.

Limitations

The study of the course was limited by its preliminary data. The course directors regulated the curriculum to 30 students due to time and equipment constraints, with a strong belief that the benefits of the program would be diluted if additional students were included, thereby restricting our sample size. However, with increased resources and faculty, the curriculum will likely accept additional students in the future based solely on initial interest. Along this line, faculty volunteer time and variation in teaching style is an unknown factor in training course participants, possibly requiring standardization of the teaching method and guidelines for the course. Second, all students going into EM who graduated from the ICCEM course were also members of the AAEM/RSA, thus representing a motivated cohort of individuals. To create a course directed toward EM-bound students interested in critical care, the integration of this curriculum into an EM-specific professional organization was purposeful

to capture individuals interested in a curriculum of this nature.

Conclusions

Critical care is a specialized field encompassing fundamental concepts that apply to every avenue of medicine. Many medical schools forgo implementing critical care into their curriculums due to the underlying complexity of the field. However, it was demonstrated that we could effectively implement the ICCEM curriculum among the medical student population by utilizing a combined theoretical and practical incremental model of learning that is cost effective. Future work is necessary to determine how to best extend this curriculum to a more widespread audience.

Declaration of competing interest

None.

CRedit authorship contribution statement

Matthew M.T. Carvey: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ava A. Omidvar:** Writing – review & editing, Writing – original draft, Visualization, Investigation, Data curation, Conceptualization. **Elias E. Wan:** Writing – review & editing, Writing – original draft, Conceptualization. **Allyson M. Hynes:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Investigation, Formal analysis, Data curation, Conceptualization. **Skylar A. Lentz:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation, Data curation, Conceptualization.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.jemermed.2024.03.012](https://doi.org/10.1016/j.jemermed.2024.03.012).

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Article Summary

1. Why is this topic important?

Emergency physicians and trainees provide the initial care for critically ill patients. To meet this population's needs, a standardized novel critical care curriculum targeting both third- and fourth-year medical students was developed to ensure adequate critical patient care in the emergency department (ED).

2. What does this study attempt to show?

We hypothesized that the institution of an introductory critical care curriculum is feasible and will provide an increased understanding of the underlying critical care principles within the medical student population.

3. What are the key findings?

Based on pre- and post-course completion examinations and surveys, we concluded that instituting such a curriculum will increase a medical students global understanding of critical care principals. From the pooled data of the 2022 and 2023 Introduction to Critical Care in Emergency Medicine (ICCEM) courses, the students' baseline pre-course score was 3/10 (interquartile range 4–3) and their post-course score was 9/10 (interquartile range 9–9), *p*-value 0.015.

4. How is patient care impacted?

A standardized novel critical care curriculum targeting both third- and fourth-year medical students was developed to ensure adequate critical patient care in the ED.