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Review Article

Critical Appraisal of Anesthesiology Educational Research for 2020

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Introduction

The purpose of a critical appraisal is to systematically assess the rigor and trustworthiness of study findings.[1] Whether it is for medical practice or education, journals use this process as a basis for accepting or rejecting manuscripts, and readers use these skills to determine what evidence is strong enough to compel changes in practice. A regular systematic review of the published literature in a field can provide an overview of the topics scholars in the field are examining at a point in time. Additionally, it can highlight topics and interventions that practitioners may want to implement and spark conversations about important areas in the field.

This study reviews and appraises peer-reviewed journal articles about anesthesiology education published in 2020. In this fourth iteration of our critical appraisal in anesthesiology education series,[2–4] we seek to highlight articles with rigorous designs and high-quality evidence as well as showcase articles that present innovative ideas relevant to the anesthesiology education community. We hope that anesthesiology educators will be able to use each study from the series to help inform their educational research and implement best practices.

Materials and Methods

Article Identification

The methods we used for this appraisal closely follow the methods for the *Critical Appraisal of Anesthesiology Educational Research for 2019*.[3] For the 2019 iteration, we modified the methodology to highlight articles that were especially innovative and relevant to educators, not just the articles with the most rigorous study design and implementation. Much of the description of the methodology for this study is added here verbatim from that article with some additional modifications.

To identify all articles in anesthesiology education published during the timeframe examined for this project, a medical librarian (M.P.M.) searched 3 Ovid MEDLINE databases (MEDLINE, In-Process & Other Non-Indexed Citations, and Epub Ahead of Print), Embase.com, ERIC (via FirstSearch), PsycINFO (via EBSCOhost), and PubMed. These databases were selected to cast a suitable net over the health sciences, education, and psychology literature. Each search consisted of a set of anesthesiology and education terms. Appropriate controlled terms were used in MEDLINE, Embase, PubMed, and ERIC and were supplemented with a search of article title and abstract keywords. The PsycINFO search relied entirely on article title and abstract. A secondary approach to capture relevant studies involved searches of PubMed that targeted (1) education papers published in anesthesiology journals and (2) anesthesiology-related papers published in medical education journals. All searches were initially run on May 5, 2021, to allow time for studies published in 2020 to be indexed. Animal and non-English studies were excluded from the search results, and all searches were limited to publication year 2020 with 2021 publications preprinted in 2020 excluded. The Ovid MEDLINE search is available in Table 1. All reproducible searches are included in Appendix A. Endnote X20 (Clarivate Analytics) was used to remove duplicates.

In addition, we conducted a manual review of the highest impact factor journals in both the fields of anesthesiology and medical education, as identified in Journal Citation Reports (Clarivate Analytics) and accessed through PubMed, to ensure that our searches did not exclude relevant articles. Medical education journals included *Academic Medicine*, *Medical Education*, *Advances in Health Sciences Education*, *Medical Teacher*, and *Simulation in Healthcare*. For anesthesiology, the list included *Anesthesiology*, *Anesthesia & Analgesia*, the *British Journal of Anaesthesia*, and the *Journal of Clinical Anesthesia*. We also included the *Journal of Education in Perioperative Medicine* due to its focus on medical education in anesthesiology.

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Inclusion and Exclusion Criteria

We followed the same inclusion and exclusion criteria used by Heitz et al in the critical appraisal of research in education in emergency medicine and in previous years' critical appraisals of research in anesthesiology education.[2–5] We included all levels of learners (students, residents/fellows, and practicing clinicians) and articles applicable to physicians, nurses, and other providers in the field of anesthesiology. Studies were defined as hypothesis-testing investigations, evaluations of education interventions, or explorations of educational problems.[5] Publications were excluded if they were (1) not studies (editorials and commentaries), (2) short reports that lacked enough information to be evaluated, (3) not relevant to anesthesiology learners, (4) single-site survey studies, or (5) studies that examined outcomes limited to an expected learning effect without a comparison group.[5]

Data Collection

To create the list of articles to be included in the critical appraisal, 2 authors (L.Z. and F.G.-R.A.) reviewed all abstracts and applied the inclusion and exclusion criteria. Abstracts unrelated to education or anesthesiology were excluded without further review. This included abstracts focused on clinical topics such as patient education and clinical research. All other abstracts were also divided into 2 separate lists. Two additional authors (F.C. and R.M.) were each assigned 1 list and independently applied the inclusion and exclusion criteria to their assigned abstracts. If the initial reviewers (L.Z. or F.G.-R.A.) and the second reviewer (R.M. or F.C.) agreed that the article should be excluded, the article was excluded. Differences of opinion were reconciled by a third reviewer (L.Z., F.G.-R.A., F.C., or R.M.) who was not initially assigned the abstract. The list of articles and abstracts was maintained in a Microsoft Excel database.

Scoring

The quantitative and qualitative scoring rubrics developed by Heitz et al were used to score each article with the addition of a question that asked about the reviewers' overall impressions of the articles. Because there were new reviewers for this iteration, the lead author (L.Z.) met with the reviewers individually to provide training. In addition, 3 authors (F.C., R.M., and L.Z.) were each assigned a list of articles to document funding, setting, study topic, study purpose, and learner group. The categories and the options under each category were selected based on the initial study by Heitz et al, a review of the top-cited articles in anesthesiology education, and data collected from previous years' critical appraisal articles.[2,4–6] These additional questions and the questions for coding can be found in Appendix B. Two authors (R.M. and L.Z.), who have expertise in qualitative research methods, scored all qualitative articles. The 2 authors (R.M. and L.Z.) agreed on all scoring. Tables 2 and 3 show the scoring rubrics used for the quantitative and qualitative articles, respectively. Both rubrics allowed for scores ranging from 1 to 25, with a highest possible score set to 25 to make the scores comparable despite the difference in study type. In addition, a final question asked reviewers to rate each article on a scale from 1 to 10. This is an open scale that was meant to capture the reviewers' overall impression of the article based on their professional opinion. Each reviewer was asked to ignore the rubric for this overall impression and focus on articles that they think educators would want to read.

In keeping with the process established in 2019, the top articles were determined based on the full scoring rubric and the reviewers' overall impression score. This allowed for a balance between articles that have rigorous research methods and the articles that our authors, all experts in anesthesiology education, found to be important contributions to the literature despite less rigorous design.

For the quantitative articles that met inclusion criteria, each article was randomly assigned to 3 reviewers. Each reviewer independently scored, on average, 26 to 27 articles. Qualtrics (version 2021, Provo, UT) was used to capture all scoring data, which then was exported into Microsoft Excel for Microsoft 365 for analysis. Mean scores were calculated through Excel, and the articles with the top mean scores were selected. In addition, z scores were calculated and compared with the mean scores. Interrater reliability was assessed with intraclass correlation coefficient using a two-way random effect model in R (R Core Team, 2021). Because this study did not involve human subjects, institutional review board approval was not sought.

Results

The initial search criteria identified a total of 1,124 citations, and an additional 1,367 citations were identified using the manual search. Fifty-seven articles were included in the quantitative review, and 4 articles were included in the qualitative review. See Appendix C for the full list of articles. Analysis for interrater reliability found an average measure of absolute agreement intraclass correlation coefficient of 0.79 (95% confidence interval of 0.67 to 0.87) for the rubric score and an intraclass correlation coefficient of 0.67 (95% confidence interval of 0.49 to 0.80) for the overall score. Table 4 summarizes the characteristics of these 61 papers. Table 5 summarizes the scores of the quantitative and qualitative articles.

To facilitate easy access to the top-rated articles, an annotated bibliography of the top 12 quantitative papers based on the sum of the scores from the rubric and the overall score is included below.

Berger-Estilita JM, Greif R, Berendonk C, et al. Simulated patient-based teaching of medical students improves pre-anaesthetic assessment: a rater-blinded randomised controlled trial. *Eur J Anaesthesiol*. 2020;37(5):387-93.[7]

Description: This study examined the effect of teaching sessions led by simulated patients in performing preanesthetic assessments compared with standard clinician-supervised learning. The assessment took place during actual patient encounters with trained faculty and showed higher scores in history taking, physical exam, communication of perioperative management, assessment and American Society of Anesthesiologists classification, organization and efficiency, and professional behavior than observed in the control group.

Significance: This study is notable because it uses nonphysicians as teachers, which enables more structured learning without additional burden on physicians. In

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addition, the higher scores in performance were based on observations of actual patient interactions as opposed to simulated experiences. This better demonstrates the effectiveness of the intervention.

Buhl LK, Nozari A. More even distribution of ACGME-mandated cases improves residents' perceptions of fairness and balance. *J Educ Perioper Med*. 2020;22(4):E649.[8]

Description: This study implemented a scheduling system on a neuroanesthesia rotation that emphasized pairing residents with cases based on Accreditation Council for Graduate Medical Education-mandated case numbers and case complexity. The new scheduling system improved residents' sense of fairness in case scheduling and improved resident perception of balance between education and service.

Significance: Schedules are the cornerstone of trainees' clinical experiences. The inequity of experiences can influence the trainees' perception of the quality of the training program, which can lead to issues with Accreditation Council for Graduate Medical Education accreditation for the program. Additionally, variations in case experiences can also influence the curriculum itself. Finding ways to track and manage the experiences of trainees on a more granular level and allow for modifications to schedules based on these data can improve the equity of exposure to certain case types.

Dishman D, Fallacaro MD, Damico N, et al. Adaptation and validation of the situation awareness global assessment technique for nurse anesthesia graduate students. *Clin Simul Nurs*. 2020;43:35-43.[9]

Description: This validation study examined the development of a direct situation awareness assessment tool in a simulation setting. Following creation of components of the evaluation tool, the finalized list of assessment items measured highly on content validity indices.

Significance: As we move toward competency-based progression in medical training, validated tools to assess complex aspects of practice will be necessary to determine readiness for independence or areas in need of improvement. This assessment technique focuses on situation awareness, which is an essential component of anesthesiology practice and is different from the more common validated tools seen in the literature that focus on learning procedures.

Hewson DW, Knudsen R, Shanmuganathan S, et al. Effect of mental rotation skills training on ultrasound-guided regional anaesthesia task performance by novice operators: a rater-blinded, randomised, controlled study. *Br J Anaesth*. 2020;125(2):168-74.[10]

Description: This study evaluated training in mental rotation skills to enhance performance in an ultrasound-guided regional anesthesia task among participants with low baseline mental rotation ability. This rater-blinded randomized controlled study showed that the intervention group made fewer errors with higher overall performance in an ultrasound-guided regional anesthesia needling task than their pretraining results and than participants with no training.

Significance: While there are many studies attempting to teach procedure skills to novice learners, the background of this study focuses exclusively on why mental rotation skills are important and not on why ultrasound-guided regional anesthesia is important. In addition, mental rotation skills are useful for many procedures in anesthesiology, like transesophageal echocardiography (TEE), airway management, and vascular access, which demonstrates the applicability of this intervention.

Koh W, Khoo D, Pan LTT, et al. Use of GoPro point-of-view camera in intubation simulation—a randomized controlled trial. *PLoS ONE*. 2020;15(12):e0243217.[11]

Description: This study examined the effect of GoPro video-based feedback in enhancing intubation ability among novice learners. This rater-blinded randomized controlled superiority study showed no significant differences in scores between non-GoPro and GoPro groups in a summative assessment 3 months after initial instruction. In addition, the treatment group reported that the GoPro video improved feedback and was more effective for learning intubation.

Significance: While we may conceptualize instructional technology as consisting of more traditional tools, such as learning management systems, this study highlights how tools designed for other purposes can be used to enrich learning experiences within medical education.

Linganna RE, Patel SJ, Ghofaily LA, et al. Pilot study suggests smartphone application knowledge improves resident transesophageal echocardiography knowledge: a randomized controlled trial. *J Cardiothorac Vasc Anesth*. 2020;34(8):2126-32.[12]

Description: This study assessed whether a smartphone application would improve TEE knowledge more than traditional intraoperative teaching alone. The intervention group achieved a higher increase in scores over their baseline on a multiple-choice assessment of TEE than the control group.

Significance: This study is another attempt to teach a procedure using an online, asynchronous application. The authors note that because the invention used a smartphone application, the intervention was more suited to the learning preferences of residents. This study had a very small sample size and included a rather familiar type of intervention to teach a common skill that needs to be taught. However, its randomized, controlled design garners more points with the evaluation tool used for this study.

Oh EJ, Lee JH, Kwon EJ, et al. Simulation-based training using a vessel phantom effectively improved first attempt success and dynamic needle-tip positioning ability for ultrasound-guided radial artery cannulation in real patients: an assessor-blinded randomized controlled study. *PLoS ONE*. 2020;15(6):e0234567.[13]

Description: This study evaluated whether simulation-based training improves first attempt success rate for ultrasound-guided radial artery cannulation. This rater-blinded randomized controlled study showed significantly higher first attempt success rates at cannulation and ability to dynamically position the needle tip among the simulation group than among the control group, which watched a video clip and passively observed expert performance.

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Significance: This study offers insight into an ideal way to teach ultrasound-guided radial artery cannulation to anesthesiology residents. A point of interest is that the study involved real patients, an ideal way to determine translation from the educational environment to the clinical environment (when appropriate).

Patel SM, Miller CR, Schiavi A, et al. The sim must go on: adapting resident education to the COVID-19 pandemic using telesimulation. Adv Simul (Lond). 2020;5:26.[14]

Description: This feasibility study explored the adaption of a complex case simulation to a virtual format. Compared with pretest scores, the telesimulation led to a significant increase in posttest knowledge and was reported by participants to be similarly realistic and challenging to an in-person simulation. In addition, the residents reported that it motivated critical thinking and reflection.

Significance: As these manuscripts were all published in 2020, this publication is an example of the many educational studies about how coronavirus disease 2019 impacts training that we expect to see over the next few years. While the pandemic forced educators to include more virtual options, like telesimulation, we need to explore how we can further leverage the different modalities in a postpandemic world.

Sigwalt F, Petit G, Evain JN, et al. Stress management training improves overall performance during critical simulated situations: a prospective randomized controlled trial. *Anesthesiology*. 2020;133(1):198-211.[15]

Description: This randomized controlled trial aimed to assess whether prior training in stress management techniques with reactivation before a crisis simulation improved performance and subjective assessment of stress among anesthesiology residents. By implementing a stress reduction training to the intervention arm of the study, the authors showed that residents who received the training perceived less stress, and their performance was rated higher by 4 independent raters.

Significance: The practice of anesthesiology is centered around the management of life-or-death scenarios that are inherently stressful. Managing the emotions that arise from practice is integral to anesthesiology but seldom taught overtly. This study addresses what a curriculum could look like for stress management in the perioperative setting.

Sweeney RE, Clapp JT, Arriaga AF, et al. Understanding debriefing: a qualitative study of event reconstruction at an academic medical center. *Acad Med*. 2020;95(7):1089-97.[16]

Description: This study attempts to characterize how debriefs of actual critical events impact how residents interpret and remember these events. The authors determined that debriefing is just 1 stage of 4 core steps that include engaging in an internal dialogue, event documentation, debriefing or other proximal conversations, and lessons learned.

Significance: While other studies have looked at debriefing during simulation or how often debriefing happens for critical events in real life, this study looks at common stages that happen after residents experience a critical event. This can lead to better interventions that can provide support during each of these stages and can help further our understanding of how residents learn from these events.

Tanaka P, Park YS, Roby J, et al. Milestone learning trajectories of residents at five anesthesiology residency programs. *Teach Learn Med*. 2020;33(3):304-13.[17]

Description: This validation study applied learning analytics to examine Milestones in the Next Accreditation System in a convenience sample of 5 residency programs. Results showed significant variation in mean Milestone Level ratings, attainment of a Level 4 rating (readiness for unsupervised practice) in each subcompetency, and "straight-lining," in which the same rating is given in all 25 subcompetencies.

Significance: While the Next Accreditation System is about to reach its own milestone of 10 years of Milestone reporting, we are still learning what these data mean and how programs are reporting on the trajectory of their learners. The conclusion that there was significant "straight-lining" may indicate that programs are struggling with differentiating resident performance on individual milestones. This differentiation is necessary for a move away from time-based progression toward competency-based progression in medical education.

Thampi S, Lee CCM, Agrawal RV, et al. Ideal sequence of didactic lectures and simulation in teaching transesophageal echocardiography among anesthesiologists. *J Cardiothorac Vasc Anesth*. 2020;34(5):1244-9.[18]

Description: This study evaluated the optimal sequence of lecture- and simulation-based instruction in initial learning and knowledge retention of TEE. The authors of this study found that "it is preferable to teach simulation-based practical skills followed by lecture-based theoretical knowledge to anesthesiologists who are novices to TEE."

Significance: This study determined that sequencing simulation before lectures is optimal for learning TEE instead of having lectures precede hands-on simulation, a format that the authors note may be more common. This study offers insight into procedural teaching practices. Further studies could examine if a similar pattern exists for other types of procedures or investigate why this sequencing is beneficial from a learning sciences perspective.

Warner DO, Nolan M, Garcia-Marcinkiewicz A, et al. Adaptive instruction and learner interactivity in online learning: a randomized trial. *Adv Health Sci Educ Theory Pract*. 2020;25(1):95-109.[19]

Description: This study assessed whether adapting an online learning module to a learner's prior knowledge would affect additional knowledge acquisition or efficiency in completing the module. Compared with the nonadaptive module, the adaptive version led to faster completion with similar learning outcomes and improved motivation to learn.

Significance: This study demonstrates that learners who participate in adaptive instruction can learn the same amount of information in less time and also that motivation to learn was higher for the

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learners of the adaptive modules. As the essential curriculum continues to grow, efficient ways to teach will be a useful tool for educators. In addition, while just-in-time education can increase the motivation to learn, other methods are necessary to teach elements of practice that might not seem to be as important to learners.

Discussion

The fourth installment of this series highlights new trends in the anesthesiology education literature. For example, we noticed an interesting shift in the emerging literature on wellness and well-being. Previously, much of the literature in this area focused on measuring levels of burnout and identifying potential causes. At this point, however, the prevalence of burnout among clinicians[20] and trainees[21] has been well established, particularly in our specialty.[22] So we are beginning to see a shift toward research focused on interventions to address burnout or improve wellness.[16,23,24] As greater emphasis is placed on alleviating burnout and improving physicians' well-being, we anticipate continuing to see emerging research on interventions, curricula, and innovations in this space. While the medical community, as a whole, needs to focus on systemic changes to address the work compression and disconnection that have contributed to burnout, we as educators can develop interventions that help individuals to take care of themselves, like the interventions we saw this year, which included overtly teaching coping strategies and enhancing connections both in and out of the medical community.[16,23,24]

Distance learning was another emerging topic of importance in the anesthesiology education literature.[11,12] Studying instructional technology interventions is likely to continue to be a topic of interest due to the fundamental changes in anesthesiology education caused by the coronavirus disease 2019 pandemic.[14] While many of us scrambled to implement distance education necessitated by the pandemic to ensure the safety of both teachers and learners, the advances and new technologies we incorporated into our education are here to stay, and we have to grapple with the benefits and drawbacks of this new way of learning.

We noticed an increase in articles on teaching and learning procedures that used rigorous designs. For example, rather than focusing on self-reported improvements or improved performance demonstrated in a simulated setting, articles focused on measuring performance through patient care[25] or patient outcomes, like first attempt success rates of certain procedures.[26–28] While we will continue to advocate for studies that address the more complex parts of anesthesiology practice, like situational awareness or crisis management, there are benefits to well-designed studies about learning procedures.[9,15] For example, in assessing the effectiveness of these interventions, authors are developing ways to assess trainee performance and connecting those to patient outcomes, which can help with evaluations needed for trainee progression.

The benefits of expanding e-learning to provide opportunities for distance, adaptive, and asynchronous education are well established. Since the late 1990s and early 2000s, medical educators have been discussing how to use emerging technology to support learners and the benefits of making education virtual.[29] Whether one considers the access to just-in-time education, the adaptability of education for residents on different rotation, or the difficulty of scheduling teachers and learners together, technology can help with many of these barriers. Yet, the pandemic has highlighted the shortcomings of this modality. The loss of engagement and lack of interactivity, even when advances in technology make engagement and interaction possible, highlight two major problems with e-learning.[30] While we rushed to adopt these technologies to solve the specific problems associated with learning during the pandemic, we must now determine how to move forward embracing the flexibility and adaptability while still encouraging engagement and interaction. Studies on distance learning will help inform these conversations.

Additionally, we have noted that a majority of the articles we reviewed used quantitative methodology. We do not know if it is because fewer research studies were done using qualitative methods or if journal submissions of quantitative studies are more likely to be accepted than qualitative research. It is possible that anesthesiology education researchers, in general, might be more comfortable with the quantitative methods. In addition, qualitative studies can be more time consuming in both the data collection and analysis stages, which may be a barrier for researchers to adopt this method in research. Qualitative research methods can focus more on the complexity of perceptions and contexts of medical education to answer questions about how and why certain phenomena exist.[31] Qualitative research has the ability to develop pragmatic theory to help guide educational interventions in unique settings. While quantitative research can answer some questions of how and why something works, qualitative research can focus on these questions, especially in areas where there are gaps in our understanding.

This study has limitations. As a critical appraisal, the opinion of the expert authors is central to the study and may vary depending on the individual perspectives of each author. While our search criteria were designed to cast a wide net to ensure inclusion of all relevant articles, we may have missed some articles in the initial screening process. None of the 3 authors who conducted the initial screening were anesthesiologists; however, all of them are experienced anesthesiology education researchers, and each abstract was double screened by 2 authors. As long as 1 of the authors coded inclusion for an abstract, it was included for full text review. Therefore, the lack of involvement of clinical anesthesiologists should impose no more than minimal bias to the inclusion decisions. As for the full-text review, rater characteristics (clinical versus nonclinical) and leniency may be a source of bias in scoring. To address that, we randomly assigned reviewers and used z scores to minimize the potential bias attributed to raters and obtained an acceptable level of interrater reliability results based on this design. Furthermore, our tool contains a bias toward certain research designs, an issue that may result in articles that are of importance to anesthesiology education

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but take a different methodological approach being ranked lower. To ensure that we capture important and high-quality articles that may not make it to the top score based on the analytical assessment, we incorporated an overall impression score in the ranking process, which also achieved acceptable interrater reliability results.

Conclusion

In this critical appraisal of the 2020 anesthesiology education research literature, we found interesting trends in the topics of learning procedures, wellness, and distance learning. With the fifth installment of this series for the year 2021, our next step will be to include a more comprehensive view of anesthesiology medical education literature over the last 5 years.

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continued on next page

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Abstract

Background: This study reviews and appraises the articles published about anesthesiology education in 2020. The objective is to highlight high-quality evidence while showcasing articles with innovative ideas and high relevance to the practices of the anesthesiology education community.

Methods: Three Ovid MEDLINE databases, Embase.com, ERIC, PsycINFO, and PubMed were searched, followed by a manual review of articles published in the highest impact factor journals in both the fields of anesthesiology and medical education. Abstracts were double screened, and quantitative articles were subsequently scored by 3 randomly assigned raters. Qualitative studies were scored by 2 raters. Two different rubrics were used for scoring quantitative and qualitative studies. In addition, reviewers rated each article on its overall quality to create an additional list of top articles based solely on the opinion of the reviewers.

Results: A total of 2,491 citations were identified through the search criteria and the manual review. Of those, 61 articles met the inclusion criteria (57 quantitative and 4 qualitative). The top 12 quantitative papers and the top qualitative papers with the highest scores are reported and summarized.

Conclusions: We found that teaching clinical procedures continues to be a topic of interest, with more studies of improved rigor identified. New trends in wellness studies and increasing attention to distance learning and technology-assisted instructional methods were additional topics covered over the year.

Keywords: Medical education, bibliometric, anesthesiology

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Tables

Table 1. *Database Search Used in Ovid MEDLINE*

1	(exp anesthesiology/ or exp anesthetists/ or (anesthe* or anaesthe*).tw.) and (exp education/ or education.sh. or (academic* or class or classes or course* or curricul* or educat* or fellow or fellows or fellowship or instruct* or intern or interns or internship or learn or learner or learning or lesson* or resident or residents or residenc* or school* or student* or teach* or train* or workshop*).ti.) and english.la.
2	limit 1 to yr="2020"

Table 2. *Quantitative Scoring Rubric*

Domain	Item	Item Score	Max Score 25
Introduction (select all that apply)			3
	Appropriate description of background literature	1	
	Clearly frame the problem	1	
	Clear objective/hypothesis	1	
Measurement			
1. Methodology (select one)			2
	Has no pretest or posttest	1	
	Has a posttest only (if has a pretest, do NOT select)	1	
	Has a pretest and a posttest	2	
2. Groups (select all that apply)			2
	Both experimental and control group	1	
	Random assignment to groups	1	
Data Collection			
1. Institutions (select one). Number of institutions refers to origin of study participants (not study authors).			2
	One institution	0	
	Two institutions	1	
	Three or more institutions	2	
2. Response rate (select one) • Response rate is the proportion of those eligible who completed follow-up assessment. • Use "N/A" only if a response rate truly does not apply (e.g., data obtained from a medical record or professional organization database).			2
	<50% or not reported	0	
	50% to 74%	1	
	≥75%	2	
	N/A	0	

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Tables *continued*

Data Analysis			
1. Appropriateness (select one). Considered "0" if there is statistical error or if authors failed to analyze data.			1
	Data analysis inappropriate for study design/type of data	0	
	Data analysis appropriate for study design and type of data	1	
2. Sophistication (select all that apply). Any test of statistical inference is considered "beyond descriptive."			2
	Descriptive analysis only	0	
	Beyond descriptive analysis	1	
	Includes power analysis	1	
Discussion (select all that apply)			3
	Data support conclusion	1	
	Conclusion clearly addresses hypothesis/objective	1	
	Conclusions placed in context of literature	1	
Limitations (select one)			2
	Limitations not identified accurately	0	
	Some limitations identified	1	
	Limitations well addressed	2	
Innovation of Project (select one)			2
	Previously described methods	0	
	New use for known assessment/intervention	1	
	New assessment/intervention methodology	2	
Relevance of Project (select one)			2
	Impractical to most programs	0	
	Relevant to some	1	
	Relevant to many programs	2	
Clarity of Writing (select one)			2
	Unsatisfactory	0	
	Fair	1	
	Excellent	2	
Total			25
Overall, how would you rate this article? This should take into consideration your overall feelings about the article. If you were to recommend that people read something good from this year, would you recommend this article? Is it relevant, well done, innovative?			1–10

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Tables *continued*

Table 3. *Qualitative Scoring Rubric*

Domain	Item	Item Score	Max Score
Introduction (select all that apply)			3
	Appropriate description of background literature	1	
	Clearly frame the problem	1	
	Clear objective/hypothesis	1	
Measurement			3
1. Methodology (select all that apply)			
	Appropriate for study question	1	
2. Sampling of participants (select all that apply)			
	Appropriate study population	1	
	Enrolled full range of cases/settings beyond convenience	1	
Data Collection			
1. Institutions (select one). Number of institutions refers to origin of study participants (not study authors).			3
	One institution	0	
	Two institutions	1	
	Three or more institutions	2	
2. Sample size determination (select one)			
	Appropriate sample size determination	1	
Data Analysis (select all that apply)			5
	Clear and reproducible "audit trail" documenting systematic procedure for analysis	1	
	Data saturation through a systematic iterative process of analysis	1	
	Addressed contradictory responses	1	
	Incorporated validation strategies (e.g., member checking, triangulation)	1	
	Addressed reflexivity (impact of researcher's background, position, biases on study)	1	
Discussion (select all that apply)			3
	Data support conclusion	1	
	Conclusion clearly addresses hypothesis/objective	1	
	Conclusions placed in context of literature	1	
Limitations (select one)			2
	Limitations not identified accurately	0	
	Some limitations identified	1	
	Limitations well addressed	2	

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Tables *continued*

Innovation of Project (select one)			2
	Previously described methods	0	
	New use for known assessment/intervention	1	
	New assessment/intervention methodology	2	
Relevance of Project (select one)			2
	Impractical to most programs	0	
	Relevant to some	1	
	Relevant to many programs	2	
Clarity of Writing (select one)			2
	Unsatisfactory	0	
	Fair	1	
	Excellent	2	
Total			25
Overall, how would you rate this article? This should take into consideration your overall feelings about the article. If you were to recommend that people read something good from this year, would you recommend this article? Is it relevant, well done, innovative?			1–10

Table 4. *Trends for All Reviewed Manuscripts in Anesthesiology Education for 2020*

Variable	All Publications (*n* = 61)		Highlighted (*n* = 13)	
	%	*n*	%	*n*
External Funding	28	17	31	4
Main Setting (manuscripts could cover more than one group)				
Data from nonclinical settings (surveys, assessment of nonclinical environments)	51	13	8	1
Simulation	49	30	62	8
Clinical setting	5	3	15	2
Classroom setting	18	11	8	1
Purpose of the Study				
Teaching methods	37	23	54	7
Assessment of learner	21	13	15	2
Program/intervention evaluation	21	13	23	3
Assessment of environment	8	5	0	0
Wellness	6	4	8	1
Recruitment	3	2	0	0
Professionalism	2	1	0	0
Medical knowledge improvement	2	1	0	0

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Tables *continued*

Study Design				
Observational	47	29	15	2
Experimental	50	31	77	10
Validation	2	1	8	1
Learner Group (manuscripts could cover more than one group)				
Residents	69	43	69	9
Practicing anesthesiologists/physician	18	11	0	0
Medical students	8	5	23	3
Nurses	11	7	8	1
Topic being Studied (manuscripts could cover more than one group)				
Learning procedure	34	21	31	4
Assessment/evaluation of learner	16	10	8	1
Clinical practice	13	8	0	0
Curriculum development/evaluation	13	8	15	2
Nontechnical skills	13	8	0	0
Wellness	10	6	8	1
Assessment of environment	5	3	0	0
Assessment of teaching	5	3	0	0
Recruitment	5	3	0	0
Equity and inclusion	2	1	0	0
Professionalism	2	1	0	0

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Table 5. *Score for Quantitative Articles for Scoring Sheet and Reviewers' Impression*

Score Type	All Articles	Top Articles[a]
	Average Score (Range)	Average Score (Range)
Quantitative		
Scoring sheet	16.94 out of 25 (6.67–23.00)	20.83 out of 25 (19.67–23.00)
	n = 57	*n = 12*
Reviewers' impression	5.53 out of 10 (3–8.67)	7.19 out of 10 (6–8.67)
	n = 57	*n = 12*
Combined score	22.50 out of 35 (9.67–29.67)	28.03 out of 35 (27–29.67)
	n = 57	*n = 12*
Qualitative		
Scoring sheet	18 out of 25 (14–22)	22 out of 25
	n = 4	*n = 1**
Reviewers' impression	6.75 out of 10 (5–9)	9 out of 10
	n = 4	*n = 1**
Combined score	24.75 out of 35 (24–31)	27 out of 35
	n = 4	*n = 1**

[a] Only two qualitative articles received scores high enough to qualify for inclusion in the top list based on the scoring sheet and reviewers' impression scores.

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Appendices

Appendix A. Database searches to identify best articles in anesthesiology education

Ovid MEDLINE; Ovid MEDLINE In-Process and Other Nonindexed Citations; Ovid MEDLINE Epub Ahead of Print; Daily and Versions (676 results on May 25, 2021).

1. (exp anesthesiology/ or exp anesthetists/ or (anesthe* or anaesthe*).tw.) and (exp education/ or education.sh. or (academic* or class or classes or course* or curricul* or educat* or fellow or fellows or fellowship or instruct* or intern or interns or internship or learn or learner or learning or lesson* or resident or residents or residenc* or school* or simulation or student* or teach* or train* or workshop*).ti.) and english.la.

2. limit 1 to yr="2020"

Elsevier Embase (672 results on May 25, 2021).

(('anesthesiology'/exp OR 'anesthetists'/exp) AND 'education'/exp OR ((anesthesia*:ti OR anesthesio*:ti OR anaesthesio*:ti) AND (academic*:ti OR class:ti OR classes:ti OR course*:ti OR curricul*:ti OR educat*:ti OR fellow:ti OR fellows:ti OR fellowship:ti OR instruct*:ti OR intern:ti OR interns:ti OR internship:ti OR learn:ti OR learner:ti OR learning:ti OR lesson*:ti OR resident:ti OR residents:ti OR residenc*:ti OR school*:ti OR simulation*:ti OR student*:ti OR teach*:ti OR train*:ti OR workshop*:ti)) OR (((anesthesia* OR anesthesio* OR anaesthesio*) NEAR/5 (academic* OR course* OR curricul* OR educat* OR fellow OR fellows OR fellowship OR instruct* OR intern OR interns OR internship OR learn OR learner OR learning OR lesson* OR resident OR residents OR residenc* OR school* OR student* OR teach* OR train* OR workshop*)):ab)) AND [english]/lim AND [2020-2020]/py NOT ('conference abstract':it OR 'conference paper':it OR 'conference review':it)

FirstSearch ERIC (5 results on May 25, 2021).

(ti: anesthe* OR ti: anaesthe*) or (ab: anesthe* OR ab: anaesthe*) or de: anesthesiology and yr: 2020-2020

EBSCOhost PsycInfo (27 results on May 25, 2021, limited to 2020).

(TI (anesthe* OR anaesthe*) OR AB (anesthe* OR anaesthe*)) AND (TI (academic* OR class OR classes OR course* OR curricul* OR educat* OR fellow OR fellows OR fellowship OR instruct* OR intern OR interns OR internship OR learn OR learner OR learning OR lesson* OR resident OR residents OR residenc* OR school* OR student* OR teach* OR train* OR workshop*))

PubMed—anesthesia in medical education journals (15 results on May 25, 2021).

(anesthesiology[mh] OR anesthetists[mh] OR anesthesia[tiab] OR anaesthesia[tiab] OR anesthesiology[tiab] OR anaesthesiology[tiab]) AND ("Acad Med"[Journal] OR "Med Educ"[Journal] OR "Adv Health Sci Educ Theory Pract"[Journal] OR "Med Teach"[Journal] OR "Simul Healthc"[Journal]) AND 2020[dp]

PubMed—education in anesthesiology journals (145 results on May 25, 2021).

(education[mh] OR education[sh] OR academic[ti] OR class[ti] OR classes[ti] OR course[ti] OR courses[ti] OR curricula[ti] OR curriculum[ti] OR educate[ti] OR educated[ti] OR educating[ti] OR education[ti] OR educator[ti] OR educators[ti] OR instructing[ti] OR instruction[ti] OR instructor[ti] OR instructors[ti] OR learn[ti] OR learned[ti] OR learning[ti] OR lesson[ti] OR lessons[ti] OR residencies[ti] OR residency[ti] OR school[ti] OR schools[ti] OR student[ti] OR students[ti] OR teach[ti] OR teacher[ti] OR teachers[ti] OR teaching[ti] OR train[ti] OR trained[ti] OR training[ti] OR trainer[ti] OR trainers[ti] OR workshop[ti] OR workshops[ti]) AND ("Anesthesiology"[Journal] OR "anesthesia and analgesia"[journal] OR "british journal of anaesthesia"[journal] OR "J Educ Perioper Med"[journal]) AND 2020[dp]

PubMed—journal Table of Contents handsearch (1,705 results on May 25, 2021).

("Anesthesiology"[Journal] OR "anesthesia and analgesia"[journal] OR "british journal of anaesthesia"[journal] OR "J Educ Perioper Med"[journal] OR "Acad Med"[Journal] OR "Med Educ"[Journal] OR "Adv Health Sci Educ Theory Pract"[Journal] OR "Med Teach"[Journal] OR "Simul Healthc"[Journal]) AND 2020[dp] AND hasabstract[text] NOT (editorial[pt] OR letter[pt]) NOT pubstatusaheadofprint

PubMed—journal Table of Contents handsearch (107 results on May 2, 2023).

("Journal of Clinical Anesthesia"[Journal]) AND 2020[dp] AND hasabstract[text] NOT (editorial[pt] OR letter[pt]) NOT pubstatusaheadofprint

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Appendices *continued*

Appendix B. Additional Questions

Questions to Code Articles Reviewed
Funding
None (or internally funded by department)
Yes, please specify
Target Audience (select all that apply)
Residents
Medical students
Practicing anesthesiologists
Nurse
Other
Nonphysician/Nonprovider Author[a]
Yes, first, second, or last
Yes, but not first, second, or last
No
Unclear
Primary Setting
Simulation
Real life
Other
Purpose
Teaching methods
Learner evaluation of programs
Learner assessment
Intervention description
Environment assessment
Other
Topic
Case management/general practice
Learning procedures
Crisis resource management
Anesthesiology nontechnical skills
Professionalism
Resident selection
Interprofessionalism
Other

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continued from previous page

Appendices *continued*

Competency[a]
Patient care
Medical knowledge
Practice-based learning and improvement
Interpersonal and communication skills
Professionalism
Systems-based practice
N/A
Theme Topic (open-ended question)
Additional Questions Piloted to Enhance Scoring Tool (not used for scoring in this review)
Sampling
The sampling was not rigorous (small and/or convenience sample) = 0
The sampling was rigorous (larger and/or purposeful sample) = 1
Study design appropriateness
The study design was inappropriate to answer the research question = 0
The study design was appropriate to answer the research question = 1
Rigorous
The study design lacked rigor = 0
The study design was somewhat rigorous = 1
The study design was very rigorous = 2

[a] We did not report on Nonphysician Author and Competency categories because the data collected were not useful. For the Nonphysician Author category, 43% of the articles reviewed did not include the degrees of the authors. For the Competency category, many of the articles were not about competencies. For example, articles about the clinical competency committee work or patient dignity were not about a specific competency, and, therefore, the coding was not useful.

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Appendices *continued*

Appendix C. Full List of Articles Included in the Critical Appraisal

Article No.	First Author	Title	Journal	Type
1	Alexandrino H	Improving intraoperative communication in trauma: the educational effect of the joint DSTC TM-DATC TM courses	*World J Surg*	Quantitative
2	Andersen BR	Social ties between team members affect patient satisfaction: a data-driven approach to handling complex network analyses	*Adv Health Sci Educ Theory Pract*	Quantitative
3	Arbelot C	Lung ultrasound in emergency and critically ill patients: number of supervised exams to reach basic competence	*Anesthesiology*	Quantitative
4	Ballard HA	Use of a simulation-based mastery learning curriculum to improve ultrasound-guided vascular access skills of pediatric anesthesiologists	*Paediatr Anaesth*	Quantitative
5	Berger-Estilita JM	Simulated patient-based teaching of medical students improves pre-anaesthetic assessment: a rater-blinded randomised controlled trial	*Eur J Anaesthesiol*	Quantitative
6	Block RI	Is exhaustion more sensitive than disengagement to burnout in academic anesthesia? A study using the Oldenburg nurnout inventory	*Psychol Rep*	Quantitative
7	Bressers G	Patient safety in medical residency training: balancing bravery and checklists	*Acad Med*	Qualitative
8	Brzezinski M	An analysis of successful features of anesthesiology journal clubs	*J Educ Perioper Med*	Quantitative
9	Buhl LK	More even distribution of ACGME-mandated cases improves residents' perceptions of fairness and balance	*J Educ Perioper Med*	Quantitative
10	Castanelli DJ	Shadow systems in assessment: how supervisors make progress decisions in practice	*Adv Health Sci Educ Theory Pract*	Qualitative
11	Chowdhury AR	Ultrasound is a reliable and faster tool for confirmation of endotracheal intubation compared to chest auscultation and capnography when performed by novice anaesthesia residents—a prospective controlled clinical trial	*Saudi J Anaesth*	Quantitative
12	Dabbagh A	Relationship between "simulated patient scenarios and role-playing" method and OSCE performance in senior anesthesiology residents: a correlation assessment study	*Anesth Pain Med*	Quantitative
13	Deshpande R	Resource utilization in implementation of a point of care ultrasound curriculum for resident training in anesthesiology	*Yale J Biol Med*	Quantitative
14	Dishman D	Adaptation and validation of the situation awareness global assessment technique for nurse anesthesia graduate students	*Clin Simul Nurs*	Quantitative
15	Doshi TL	Representation of women in pain medicine fellowships in the United States, 2017–2018	*Pain Med*	Quantitative
16	Fowler JG	Sticks or carrots? How an easy-to-implement incentive plan improved our performance on the in-training exam	*J Educ Perioper Med*	Quantitative
17	Golden A	Simulation-based examination of arterial line insertion method reveals interdisciplinary practice differences	*Simul Healthc*	Quantitative

continued on next page

continued from previous page

Appendices *continued*

18	Goldstein S	Assessment of didactic transesophageal echocardiography education during anesthesia residency	*J Educ Perioper Med*	Quantitative
19	Hastings RH	Predicting trainee clinical success from performance at simulated endotracheal intubation	*Simul Healthc*	Quantitative
20	Hauglum SD	Use of computer-assisted instrument guidance technology by student registered nurse anesthetists for simulated invasive procedures	*AANA J*	Quantitative
21	Hewson DW	Effect of mental rotation skills training on ultrasound-guided regional anaesthesia task performance by novice operators: a rater-blinded, randomised, controlled study	*Br J Anaesth*	Quantitative
22	Huang J	Methods of orienting new anesthesiology residents to the operating room environment: a national survey of residency program directors	*J Educ Perioper Med*	Quantitative
23	Huang L	Application of an education model using the WeChat public platform in the standardized training of anesthesiology residents	*Ann Palliat Med*	Quantitative
24	Kang FG	Medical malpractice lawsuits involving anesthesiology residents: an analysis of the National Westlaw Database	*J Educ Perioper Med*	Quantitative
25	Kerrey BT	Developing a profile of procedural expertise: a simulation study of tracheal intubation using 3-dimensional motion capture	*Simul Healthc*	Quantitative
26	Koh W	Use of GoPro point-of-view camera in intubation simulation—a randomized controlled trial	*PLoS ONE*	Quantitative
27	Kraus MB	Speaker gender representation for anesthesiology grand rounds at a large academic medical center	*J Educ Perioper Med*	Qualitative
28	Kurup V	The feasibility of incorporating a flipped classroom model in an anesthesia residency curriculum—pilot study	*Yale J Biol Med*	Quantitative
29	Linganna RE	Pilot study suggests smartphone application knowledge improves resident transesophageal echocardiography knowledge: a randomized controlled trial	*J Cardiothorac Vasc Anesth*	Quantitative
30	Love ER	Interview data highlight importance of "same-state" on anesthesiology residency match	*Anesth Analg*	Qualitative
31	Markham TH	Anesthesiology resident performance on the US Medical Licensing Examination predicts success on the American Board of Anesthesiology BASIC Staged Examination: an observational study	*J Educ Perioper Med*	Quantitative
32	Martinelli SM	Family comes first: a pilot study of the incorporation of social support into resident well-being	*J Educ Perioper Med*	Quantitative
33	Miles LF	Anesthesia resident training experience minimally impacts emergence time, making correlation of resident competency with this operational metric difficult	*J Educ Perioper Med*	Qualitative
34	Miller C	Anesthesia simulation boot camp—a decade of experience enhancing self-efficacy in first-year residents	*J Educ Perioper Med*	Quantitative
35	Mohamed Ali H	Learning curve for spinal anesthesia as a basic skill in the training program of the anesthesia resident in faculty of medicine, Cairo University	*Egypt J Anaesth*	Quantitative

continued on next page

continued from previous page

Appendices *continued*

36	Moore JN	The impact of the Safer Anaesthesia from Education (SAFE) Obstetric Anaesthesia training course in Ethiopia: a mixed methods longitudinal cohort study	*Anaesth Intensive Care*	Quantitative
37	Nizamuddin SL	Be active and be well? A cross-sectional survey of US anesthesia residents	*J Educ Perioper Med*	Quantitative
38	Oh EJ	Simulation-based training using a vessel phantom effectively improved first attempt success and dynamic needle-tip positioning ability for ultrasound-guided radial artery cannulation in real patients: an assessor-blinded randomized controlled study	*PLoS ONE*	Quantitative
39	Park SJ	Impact of simulation-based anesthesiology training using an anesthetized porcine model for ultrasound-guided transversus abdominis plane block	*J Int Med Res*	Quantitative
40	Patel SM	An advanced boot camp for pediatric anesthesiology fellows	*J Educ Perioper Med*	Quantitative
41	Patel SM	The sim must go on: adapting resident education to the COVID-19 pandemic using telesimulation	*Adv Simul (Lond)*	Quantitative
42	Perrone KH	Use of sensors to quantify procedural idle time: validity evidence for a new mastery metric	*Surgery*	Quantitative
43	Pius J	Learning curve and performance in simulated difficult airway for the novel C-MAC R video-stylet and C-MAC R Macintosh video laryngoscope: a prospective randomized manikin trial	*PLoS ONE*	Quantitative
44	Rossler J	Comparing classroom instruction to individual instruction as an approach to teach avatar-based patient monitoring with visual patient: simulation study	*JMIR Med Educ*	Qualitative
45	Saracoglu KT	Pecha Kucha with part-task training improves airway management in fresh frozen cadavers: a case-control observational study	*Med Princ Pract*	Quantitative
46	Shields JA	Effect of simulation training on cognitive performance using transesophageal echocardiography	*AANA J*	Quantitative
47	Sidhu NS	Interviewer bias in selection of anaesthesia fellows: a single-institution quality assessment study	*Anaesth Intensive Care*	Qualitative
48	Sigwalt F	Stress management training improves overall performance during critical simulated situations: a prospective randomized controlled trial	*Anesthesiology*	Quantitative
49	Singh D	Do fellows and faculty share the same perception of simulation fidelity? A pilot study	*Simul Healthc*	Quantitative
50	Sugiharto KD	Coping strategies potentially reduce burnout syndrome in anesthesiologists	*Syst Rev Pharm*	Qualitative
51	Swanson JR	Implementation of a self-guided focused cardiac ultrasound curriculum for anesthesiology residents	*J Educ Perioper Med*	Quantitative
52	Sweeney RE	Understanding debriefing: a qualitative study of event reconstruction at an academic medical center	*Acad Med*	Qualitative
53	Tan ECTH	Self-assessment of skills by surgeons and anesthesiologists after a trauma surgery masterclass	*World J Surg*	Quantitative

continued on next page

continued from previous page

Appendices *continued*

54	Tanaka P	Milestone learning trajectories of residents at five anesthesiology residency programs	*Teach Learn Med*	Quantitative
55	Thampi S	Ideal sequence of didactic lectures and simulation in teaching transesophageal echocardiography among anesthesiologists	*J Cardiothorac Vasc Anesth*	Quantitative
56	Toy S	Evaluation of 3 cognitive load measures during repeated simulation exercises for novice anesthesiology residents	*Simul Healthc*	Quantitative
57	Ungerman EA	Wellness principles correlate with more favorable burnout scores in junior anesthesiology residents	*J Educ Perioper Med*	Quantitative
58	Warner DO	Adaptive instruction and learner interactivity in online learning: a randomized trial	*Adv Health Sci Educ Theory Pract*	Quantitative
59	Wolpaw JT	Anesthesia learning in the digital age: are program directors and residents on the same page?	*J Educ Perioper Med*	Quantitative
60	Yagil D	Physicians' cognitive strategies for avoiding overconfidence	*J Eval Clin Pract*	
61	Yeap YL	Effect of prior formal education on successful thoracic epidural placement by anesthesia residents	*J Cardiothorac Vasc Anesth*	Quantitative