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Original Research

Comparison of Two Learning Modalities on Continuing Medical Education Consumption and Knowledge Acquisition: A Pilot Randomized Controlled Trial

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Introduction

The optimal method for engaging busy physicians in continuing medical education (CME) remains unknown.[1-8] Research concerning established educational frameworks, such as Bloom's taxonomy and Moore's seven levels of outcomes in CME, has clearly demonstrated that passive learning is insufficient to produce higher levels of learning that lead to practice change.[9] Additionally, educational research has demonstrated that active learning with spaced education and retrieval-based practice can improve knowledge acquisition, knowledge retention, and, in some cases, clinical practice.[10-12] However, most CME offerings today continue to rely on passive learning models through lecture-style presentations in face-to-face meetings.

Spaced education and retrieval-based practice with feedback are pedagogical approaches that have been proven to be effective methods of education based on the neurobiology of learning.[13-15] Spaced education distributes the learning event over multiple, shorter encounters, allowing for effective repetition that ultimately leads to deeper learning in a more efficient manner.[16] Retrieval-based practice actively engages the learner by querying their knowledge base and then giving feedback concerning their responses.[8] Taken together, spaced education through retrieval-based practice has been shown to be a more effective and efficient means of learning for trainees and practicing physicians.[17]

The aim of this study was to compare the level of learner engagement between two educational modalities, as measured by the number of CME credits earned. A secondary aim was to compare knowledge acquisition between groups. The two methods of delivering educational content were a web application (web app) that distributes multiple-choice questions (MCQs) with immediate feedback via SMS (Short Message Service) text or email and an online learning management system where learners are required to answer MCQs after reading a journal article on a topic. Thus, the research questions this study sought to answer were (1) Do end users engage one type of learning modality over another as measured through the amount of CME consumed? and (2) Is knowledge acquisition increased if the questions are disseminated via a smartphone web application versus an online learning management system that replicates common online modules for CME (eg, as is common for journal-based CME related to review articles)? The hypothesis of the study was that the use of the web-app system would result in a greater number of CME credits earned.

Materials and Methods

This study was approved by the Vanderbilt Institutional Review Board (study no. 181415; Nashville, TN).

Recruitment emails were sent to board-certified and board-eligible anesthesiologists in the United States who were members of component state societies of the American Society of Anesthesiologists. Leaders of state societies of anesthesiologists (eg, the president of the Tennessee Society of Anesthesiologists) were contacted and asked to disseminate a recruitment email to their members. Accordingly, the exact number of anesthesiologists contacted as potential participants for this study is unknown. A web link to online enrollment materials was included in the email recruitment information (see Appendix 1). Respondents were enrolled through REDCap.[18] The duration of the enrollment period was 1 week, which commenced when the first recruitment materials were sent. Only board-eligible or board-certified anesthesiologists in the United States were included in the study. After the enrollment period concluded, participants were randomized into two groups: web-app–based CME (Webapp CME) and an online interface that replicated CME offerings through many peer-reviewed journal publishers (Online CME).*

* Details of the Vanderbilt system are provided later. To compare to a live online CME system, see https://www.asahq.org/shop-asa/e020j00w00 (accessed December 3, 2020).

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As an incentive for participation, CME credits could be earned, without cost, for participation during the intervention period and for completion of the postintervention quiz. The number of credits earned were determined by levels of engagement with the learning programs. Based on time needed for completion, 1 hour of CME credit was earned for each block of 5 items that were completed by the participants during the intervention period. For the Online CME group, participants were instructed to read the article and then answer the question items. Participants in this group received 1 hour of CME credit for every 5 questions that they answered. For the Webapp CME group, completion of an item required that the participant read the question, select an answer, review the rationale (which included a significant portion of text from the associated journal article), and confirm that the rationale was reviewed. The participants in this group were not asked to read an article before answering the question. However, the article was made available through links in the rationale after each question.

Study Procedures

Content Development

Question items were developed in a structured fashion (Appendix 2 illustrates the structure and content of a question item). First, a template for creating question items was given to all content creators and followed during the development of each item (Appendix 3). Second, the faculty (N = 6) who contributed question items received training in psychometrics and question writing in one of two forms: from the American Board of Anesthesiology or National Board of Medical Examiners to provide questions for MOCA Minute or national board exams, or from an internal training based on courses in writing exam questions. Those who received the latter underwent a 3-hour training session through the Vanderbilt School of Medicine Educator Development Program as well as a departmental training of approximately 2 hours, both of which included question-writing practice. Third, the questions were submitted to two authors (M.D.M. and G.M.F.) for review. Minor edits (eg, verb tense) were performed without further review. If major edits were required (changes to clinical stem, suggestions for different distractors), these were returned to the original authors for review. As a final round of review, the completed question set was sent to all question writers (N = 6) for approval. While about half of the questions required major edits, no questions were discarded. Fourth, all items were mapped to specific content in the published articles, with a standard of 10 question items per article. The goal of following a standardized process for item creation and review was to increase the content validity of the items themselves.[19] Using MCQs as the format for assessing learner engagement and knowledge acquisition should ensure adequate validity from a response-process perspective, as this is an accepted and frequently used format for physician assessment.[19]

Intervention. The study intervention consisted of a 6-week period during which educational content was delivered based on assigned study groups using two different modalities, as specified later (Figure 1). The educational content was based on six articles published in the past 5 years in *Anesthesia & Analgesia*, with 10 MCQs per article, as already noted.[20-25] Additionally, the educational content and questions in both learning modalities were identical.

Online CME. Access to the CME articles and questions required logging in to the Vanderbilt learning management system (https://spark.app.vumc.org). Participants were provided unlimited access to a published pdf of each CME article, with permission granted by the publisher for the study period. As a counterbalancing measure to the reminders for the Webapp group (described later), participants in this group received an email at the beginning of each week to remind them of the availability of articles and questions. As noted in the Introduction, the Vanderbilt learning management system site was configured to match the components of online CME offerings through many peer-reviewed journals. These components include access to the CME article, with instructions to read it before completing the questions; MCQs related to the article with, feedback about whether the answer to the question was correct or incorrect; and CME credit for completion of the question items (see Figure 2 for screenshots).

Webapp CME. Participants in the Webapp CME group received an email informing them that they would receive one question each weekday (Monday–Friday) for 12 weeks, for a total of 60 questions. Questions were delivered at 10 AM each day via SMS text or email, with a hyperlink to a web app that presented the question item.[†] The web app allows for one discrete delivery time per cohort of participants in a specific module. The content delivered in the questions was identical to that made available to the Online CME group. This group also had unlimited online access to the published pdf of the article through the Vanderbilt learning management system and through hyperlinks in the answers to the MCQs. Figure 3 illustrates the process of receiving a text message and being presented a question item.

Postintervention knowledge quiz. One week after the completion of the study period, participants in both groups were asked to complete a 24-MCQ quiz to assess their knowledge acquisition. The quiz contained 4 MCQs related to each CME article used in the study (see Appendix 4), a subset of the 60 questions used during the intervention period. Participants were offered an additional 3 hours of CME credit for completing this quiz.

Statistical Analysis

The primary outcome measure was the difference between cohorts in amount of CME consumed. Analyses were conducted in an intention-to-treat manner based on group randomization, regardless of user engagement. Unpaired 2-tailed *t* tests were used to evaluate the statistical significance of differences between cohorts for continuous variables, the Fischer exact test for categorical variables, and the Mann-Whitney *U* test for comparison of medians. All data are presented as mean ± 95% confidence interval unless otherwise noted. A *P* value threshold of .05 was used for determining significance.

[†] The web app used for this study is named QuizTime and was developed by the Vanderbilt University School of Medicine (https://quiztime.app.vumc.org/). It is currently not available for commercial purchase and use but likely will be in the future.

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We are unaware of previous studies that have investigated the differential consumption of educational material based on pedagogical approach. Based on prior studies reporting the preference of learners for this form of education, if we assumed that participants in the Online CME group would on average consume 66% of the CME offered (10/15 h) with a standard deviation of 2 h, then 32 participants (16 per group) would be needed to show a 20% difference in consumption between groups.[3,7]

Results

A total of 54 participants enrolled in the study (Online, N = 28; Webapp, N = 26). Participant demographic characteristics are shown in Table 1. The mean number of CME credits awarded was significantly greater in the Webapp group than in the Online CME group (12.3 ± 1.4 versus 4.5 ± 2.3, $P < .001$; see Figure 4). Webapp participants answered more questions during the 6-week intervention period than participants in the Online CME group: respectively, mean = 49.5 ± 1.4 versus 18.6 ± 2.3 MCQs answered out of 60 total ($P < .001$) and median = 56 versus 0 ($P < .001$). More specifically, 54% of learners in the Online CME group did not answer any MCQs (0 out of 60), whereas 25% answered more than 50. This explains the median of 0 CME credits awarded (out of 15 h available) for the Online CME group, compared to 14 h in the Webapp group (see Figure 4).

Concerning analysis of knowledge acquisition, 77% of the Webapp group versus 29% of the Online group completed the postintervention quiz ($P < .001$). The difference in postintervention quiz scores was not statistically significant (Webapp 70% ± 7% versus Online 60% ± 11%, $P = .11$; see Figure 5). Of note, those who completed the postintervention quiz had a very high completion rate of the 60 MCQs in both groups. Specifically, participants who completed the postintervention quiz answered 51.8 ± 13.9 MCQs, whereas those who did not take the quiz answered only 13.7 ± 20.1.

Discussion

The optimal method by which to engage busy clinicians in CME activities is unknown.[16] In light of this problem, the present pilot study reports several interesting findings. First, learner engagement was significantly greater with automated, system-activated education that was driven to learners on a daily basis through a web app than it was for the online education modality. Second, we found a trend toward greater knowledge acquisition with daily web-app–based spaced education as compared to a system that replicates online CME offerings. Each of these findings will be discussed in light of the current literature.

Our findings demonstrate that board-certified or board-eligible anesthesiologists receiving daily spaced education through a web app earned almost 3 times the amount of CME credits as those using an online CME system. As already noted, other than the approximately 25% of highly engaged learners in the Online CME group, this group had very little participation. This is demonstrated by the median number of CME credits earned being 0 h, compared to 14 h in the Webapp group. These findings correspond with those of prior studies showing a high rate of engagement among learners when retrieval-based spaced education is driven to them by providing MCQs via text or email either daily or multiple times each week.[1,11,12] These findings also support the popularity of one component of the Maintenance of Certification in Anesthesiology (MOCA) program from the American Board of Anesthesiology, namely, MOCA Minute.[26,27] The biggest difference between the web-app system used in this study and the MOCA Minute program is that in our system a prompt to participate is driven to the learner on a daily basis. In comparison, MOCA Minute requires the learner to remember to pick up their smartphone and choose to participate. Whether one form of engagement versus another results in increased participation and increased knowledge acquisition over time will require additional larger studies. Some learners may be engaged in earning CME credits no matter how learning is offered to them. This might be seen from the fact that completion of the postintervention quiz for 3 CME credits was associated with a very high completion rate of question items in both the Webapp and Online CME groups. Specifically, for the Webapp group, those who completed the postintervention quiz also completed 90% of the MCQs, versus 58% for those who did not complete the postintervention quiz. The respective rates of MCQ completion in the Online group were 77% and 13%.

Concerning knowledge acquisition as demonstrated by performance on the postintervention quiz, we found no significant difference between the groups. However, this should be interpreted carefully in light of the size of this pilot study. The overall participation rates in the postintervention quiz were very different, and quite low in the Online group (29%). Additionally, there was a trend toward score improvement in the Webapp group versus the Online group (absolute 10%, relative 18% higher). This might represent a substantial effect size, and should be investigated in further large studies in our specialty, as prior research in other disciplines has shown improved knowledge acquisition from spaced education through retrieval-based practice.[11,12,28-31] Of note, ongoing education through retrieval-based practice using MCQs is increasingly being used by anesthesiology trainees and may show benefit with regard to knowledge acquisition as demonstrated by improved scores on standardized exams.[32] Whether this translates into the continuing professional development of practicing anesthesiologists remains to be seen.

Our study has several important limitations. First, the size is small, and the sample consisted of a specific group of learners. It should be regarded as a pilot study that requires additional larger trials to confirm or refute its findings. Second, there may be significant selection bias regarding those who chose to participate. Even though participants were randomized to different interventions, the learners included in this study may not represent anesthesiologists as an entire group. Additionally, due to our means of contacting practicing anesthesiologists, we are uncertain of the actual number of potential participants for this study and thus do not know whether selection bias was further a factor. Therefore, care should be taken when interpreting the generalizability of our findings. It is also important to note that we were unable to gather baseline or historical CME consumption data because of the method by which the participants were contacted.

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Third, because we included participants from numerous institutions and practice settings, we were not able to assess the impact of the learning interventions on clinical practice (eg, through evaluation of any practice change noted in an electronic health record). Fourth, the 24 question items in the postintervention quiz were taken directly from the complete set of 60 used during the intervention period. We did not take into account whether the learners had previously completed any given question. This could lead to recall as a bias for those who completed more CME, and this is a limitation of the study. Future research in anesthesiology and perioperative medicine should involve larger trials to assess the effects of various approaches on knowledge acquisition as well as the impact on care delivery.

Conclusions

In a pilot prospective, randomized controlled trial, we demonstrated that delivery of daily spaced education driven to learners through a smartphone web app resulted in greater learner engagement than an online modality, as defined by the number of CME credits earned per group. Further research needs to investigate whether these findings are confirmed in larger groups of anesthesiologists and whether this pedagogical approach results in a demonstrable improvement in knowledge acquisition and change in care delivery.

Acknowledgments

We dedicate this article to our coauthor Dr Geoffrey Fleming, who passed away in December 2020. Geoffrey is an exemplar of excellence as a physician, educator, and leader, and most importantly as a husband, father, and friend.

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Abstract

Background: Research has demonstrated that active learning, spaced education, and retrieval-based practice can improve knowledge acquisition, knowledge retention, and clinical practice. Furthermore, learners prefer active learning modalities that use the testing effect and spaced education as compared to passive, lecture-based education. However, most research has been performed with students and residents rather than practicing physicians. To date, most continuing medical education (CME) opportunities use passive learning models, such as face-to-face meetings with lecture-style didactic sessions. The aim of this study was to investigate learner engagement, as measured by the number of CME credits earned, via two different learning modalities.

Methods: Diplomates of the American Board of Anesthesiology or candidates for certification through the board (referred to colloquially and for the remainder of this article as board certified or board eligible) were provided an opportunity to enroll in the study. Participants were recruited via email. Once enrolled, they were randomized into 1 of 2 groups: web-app–based CME (Webapp CME) or an online interface that replicated online CME (Online CME). The intervention period lasted 6 weeks and participants were provided educational content using one of the two approaches. As an incentive for participation, CME credits could be earned (without cost) during the intervention period and for completion of the postintervention quiz. The same number of CME credits was available to each group.

Results: Fifty-four participants enrolled and completed the study. The mean number of CME credits earned was greater in the Webapp group compared to the Online group (12.3 ± 1.4 h versus 4.5 ± 2.3 h, $P < .001$). Concerning knowledge acquisition, the difference in postintervention quiz scores was not statistically significant (Webapp 70% ± 7% versus Online 60% ± 11%, $P = .11$). However, only 29% of the Online group completed the postintervention quiz, versus 77% of the Webapp group ($P < .001$), possibly showing a greater rate of learner engagement in the Webapp group.

Conclusion: In this prospective, randomized controlled pilot study, we demonstrated that daily spaced education delivered to learners through a smartphone web app resulted in greater learner engagement than an online modality. Further research with larger trials is needed to confirm our findings.

Keywords: Retrieval-based learning, spaced education, continuing medical education, web app, active learning

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Appendices

Appendix 1. Recruitment Email

Dear Anesthesiologist Colleague:

You are being asked to participate in a research study because you are an anesthesiologist in the United States. The purpose of the study is to compare two modalities for providing CME learning opportunities. Upon completion of this study, you will be eligible to claim up to 15 AMA PRA Category 1 Credits related to content from 6 CME published in *Anesthesia & Analgesia* in 2017. These credits will count toward your MOCA Part 2 CME requirements. Your study participation is completely voluntary and anonymous, and collected information will not be shared with your employer or the American Board of Anesthesiology. You will not be paid to take part in this study.

Your contact information (name, phone number, and email address) is necessary to randomize you for this study and will be stored in REDCap, which is a secure research database. All identifiers will be removed prior to analysis. Study information will be stored in REDCap until destruction of the database. Only the study team will have access to the information you provide.

Your participation in the study would last approximately 2 months. Participants in this study will complete a brief survey and set up a CME profile to receive their credits. After enrollment is closed, participants will receive an email assigning them to one of two learning groups for a 6-week period.

- The Journal-Based CME Group will receive weekly emails concerning online availability of articles and related questions in the Vanderbilt Learning Management System. This system mimics what you would see online for journal-based CME for *Anesthesia & Analgesia*.
- The QuizTime-Based CME Group will receive two SMS texts each weekday. Each text will contain 1 question along with online access to a PDF of the article.
- About 1 week after the study, all participants complete the study period they will receive a 24-question quiz. Three CME credits will be earned for completing the quiz. A post-study survey will also be sent.

To take part in this study, you must be a member of the following group:

ABA Diplomate or a candidate in the ABA Examination System

Your participation is voluntary, and you may leave the study at any time by notifying the Principal Investigator. If you would like to take part in this study or would like more information, please click here to complete the Demographics Survey. The Vanderbilt IRB has approved this study. If you have questions regarding this study please contact: Matt McEvoy, MD or Leslie Fowler, Ed.D, MEd, at (615) 343-4034 or by email at AnesthesiaEducationResearch@vumc.org. You may also contact the Vanderbilt Human Subjects Protection Program (IRB) office at (866) 224-8273. Thank you again for your consideration.

Sincerely,

Matt McEvoy, MD Amy Robertson, MD Brian Gelfand, MD Leslie Fowler, Ed.D, M.Ed

You may open the survey in your web browser by clicking the link below: CME Project A & A If the link above does not work, try copying the link below into your web browser: https://redcap.vanderbilt.edu/surveys/?s=JgIRiLMSmN

This link is unique to you and should not be forwarded to others.

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Appendices *continued*

Appendix 2. Questions Mapped to Article

NARRATIVE REVIEW ARTICLE

CME

Chronic Opioid Use After Surgery: Implications for Perioperative Management in the Face of the Opioid Epidemic

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Physicians, policymakers, and researchers are increasingly focused on finding ways to decrease opioid use and overdose in the United States both of which have sharply increased over the past decade. While many efforts are focused on the management of chronic pain, the use of opioids in surgical patients presents a particularly challenging problem requiring clinicians to balance 2 competing interests: managing acute pain in the immediate postoperative period and minimizing the risks of persistent opioid use after the surgery. Finding ways to minimize this risk is particularly salient in light of a growing literature suggesting that postsurgical patients are at increased risk for chronic opioid use. The perioperative care team, including surgeons and anesthesiologists, is poised to develop clinical- and systems-based interventions aimed at providing pain relief in the immediate postoperative period while also reducing the risks of opioid use longer term. In this paper, we discuss the consequences of chronic opioid use after surgery and present an analysis of the extent to which surgery has been associated with chronic opioid use. We follow with a discussion of the risk factors that are associated with chronic opioid use after surgery and proceed with an analysis of the extent to which opioid-sparing perioperative interventions (eg, nerve blockade) have been shown to reduce the risk of chronic opioid use after surgery. We then conclude with a discussion of future research directions. (Anesth Analg 2017;125:1733–40)

Q1

The United States is facing an opioid crisis as the rate of opioid overdoses has roughly tripled since 1999, and continues to climb.[1] At present, the most commonly prescribed opioids, oxycodone and hydrocodone, are also the most co[illegible]volv[illegible]opioids in overdose deaths.[1] Opioid pre[illegible]bing [illegible] qu[illegible]pled since 1999 and has risen in paralle[illegible]ith the [illegible]mbe[illegible] overdoses from the most commonly pr[illegible]oids. [illegible]he economic cost of prescription opioid-r[illegible]erdos[illegible] abuse, and dependence exceeds $78.5 billion annually with the majority of costs related to health care, substance abuse treatment, and lost productivity.[2] To address this opioid crisis, a collaborative effort of stakeholders including law enforcement, the general public, and health care providers is needed to encourage appropriate opioid prescribing and monitoring for misuse, abuse, and diversion; expand prescription drug monitoring programs; and widen access to rescue naloxone and opioid use disorder treatment programs.

Q2

A particularly difficult aspect of this crisis is the use of opioids among surgical patients. Approximately 51 million Americans undergo inpatient surgery annually, and opioids remain a primary modality for postoperative acute pain management.[3–8] Over 80% of patients receive opioids after low-risk surgery, and over 80% of these prescriptions involve oxycodone or hydrocodone.[9] Thus, surgical patients routinely receive the most commonly pr[illegible]opioi[illegible] are also most commonly implicated in[illegible]g ov[illegible]. In the inpatient setting, patients und[illegible]going o[illegible]ations [illegible]st often receive a variety of opioids ad[illegible]nis[illegible]thro[illegible] multiple routes, and the majority of patient[illegible]hospital discharge have had surgery.[10,11] Surgery represents a critical event where the majority of patients are exposed to opioids regardless of whether or not they have had a prior opioid-related adverse event including overdose.[12] Opioid-tolerant patients typically require higher doses over extended postoperative periods further compounding the risks of persistent opioid use, misuse, addiction, and overdose.[12–17] Thus, tangible risks exist for both opioid-naive and opioid-tolerant patients undergoing surgery.

The perioperative care team, including anesthesiologists, now face the challenge of optimizing perioperative pain management while limiting the impact of prescription opioid exposure both in the hospital and long after discharge. Through interdisciplinary collaboration with primary care providers, surgeons, and other specialists, anesthesiologists now have the opportunity to provide the bridge between acute inpatient care and remote outpatient recovery, which will serve a critical role to optimize the safety of all surgical patients who are exposed to prescription opioids.

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November 2017 • Volume 125 • Number 5 www.anesthesia-analgesia.org 1733

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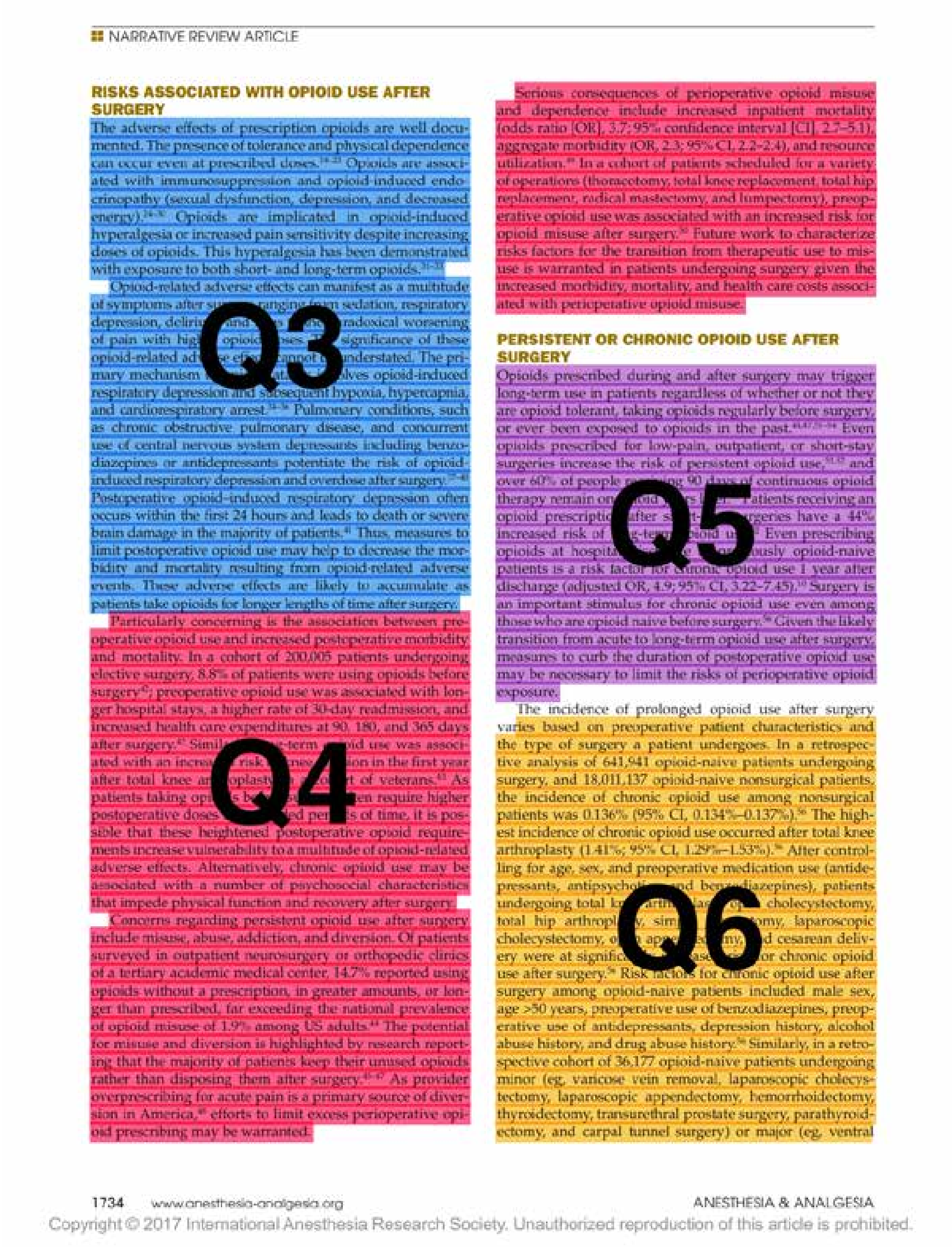
Appendices *continued*

Appendix 2. Questions Mapped to Article



NARRATIVE REVIEW ARTICLE

RISKS ASSOCIATED WITH OPIOID USE AFTER SURGERY

The adverse effects of prescription opioids are well documented. The presence of tolerance and physical dependence can occur even at prescribed doses.[18–23] Opioids are associated with immunosuppression and opioid-induced endocrinopathy (sexual dysfunction, depression, and decreased energy).[24–30] Opioids are implicated in opioid-induced hyperalgesia or increased pain sensitivity despite increasing doses of opioids. This hyperalgesia has been demonstrated with exposure to both short- and long-term opioids.[31–33]

Opioid-related adverse effects can manifest as a multitude of symptoms after su[illegible] ranging from sedation, respiratory depression, deliri[illegible] and [illegible] paradoxical worsening of pain with hig[illegible] opioid [illegible]ses. [illegible] significance of these opioid-related ad[illegible] cannot [illegible] understated. The primary mechanism [illegible] involves opioid-induced respiratory depression and subsequent hypoxia, hypercapnia, and cardiorespiratory arrest.[34–36] Pulmonary conditions, such as chronic obstructive pulmonary disease, and concurrent use of central nervous system depressants including benzodiazepines or antidepressants potentiate the risk of opioid-induced respiratory depression and overdose after surgery.[37–40] Postoperative opioid-induced respiratory depression often occurs within the first 24 hours and leads to death or severe brain damage in the majority of patients.[41] Thus, measures to limit postoperative opioid use may help to decrease the morbidity and mortality resulting from opioid-related adverse events. These adverse effects are likely to accumulate as patients take opioids for longer lengths of time after surgery.

Particularly concerning is the association between preoperative opioid use and increased postoperative morbidity and mortality. In a cohort of 200,005 patients undergoing elective surgery, 8.8% of patients were using opioids before surgery[42]; preoperative opioid use was associated with longer hospital stays, a higher rate of 30-day readmission, and increased health care expenditures at 90, 180, and 365 days after surgery.[42] Simil[illegible]-term [illegible]oid use was associated with an increa[illegible] risk [illegible] ion in the first year after total knee ar[illegible]oplasty [illegible] t of veterans.[43] As patients taking op[illegible]s b[illegible] en require higher postoperative doses [illegible]ed per[illegible]s of time, it is possible that these heightened postoperative opioid requirements increase vulnerability to a multitude of opioid-related adverse effects. Alternatively, chronic opioid use may be associated with a number of psychosocial characteristics that impede physical function and recovery after surgery.

Concerns regarding persistent opioid use after surgery include misuse, abuse, addiction, and diversion. Of patients surveyed in outpatient neurosurgery or orthopedic clinics of a tertiary academic medical center, 14.7% reported using opioids without a prescription, in greater amounts, or longer than prescribed, far exceeding the national prevalence of opioid misuse of 1.9% among US adults.[44] The potential for misuse and diversion is highlighted by research reporting that the majority of patients keep their unused opioids rather than disposing them after surgery.[45–47] As provider overprescribing for acute pain is a primary source of diversion in America,[48] efforts to limit excess perioperative opioid prescribing may be warranted.

Serious consequences of perioperative opioid misuse and dependence include increased inpatient mortality (odds ratio [OR], 3.7; 95% confidence interval [CI], 2.7–5.1), aggregate morbidity (OR, 2.3; 95% CI, 2.2–2.4), and resource utilization.[49] In a cohort of patients scheduled for a variety of operations (thoracotomy, total knee replacement, total hip replacement, radical mastectomy, and lumpectomy), preoperative opioid use was associated with an increased risk for opioid misuse after surgery.[50] Future work to characterize risks factors for the transition from therapeutic use to misuse is warranted in patients undergoing surgery given the increased morbidity, mortality, and health care costs associated with perioperative opioid misuse.

PERSISTENT OR CHRONIC OPIOID USE AFTER SURGERY

Opioids prescribed during and after surgery may trigger long-term use in patients regardless of whether or not they are opioid tolerant, taking opioids regularly before surgery, or ever been exposed to opioids in the past.[44,47,51–54] Even opioids prescribed for low-pain, outpatient, or short-stay surgeries increase the risk of persistent opioid use,[51,55] and over 60% of people r[illegible] 90 days of continuous opioid therapy remain on [illegible]oid[illegible] Patients receiving an opioid prescriptio[illegible] after s[illegible] surgeries have a 44% increased risk of [illegible]g-term [illegible]oid u[illegible] Even prescribing opioids at hospita[illegible] usly opioid-naive patients is a risk factor for [illegible] opioid use 1 year after discharge (adjusted OR, 4.9; 95% CI, 3.22–7.45).[10] Surgery is an important stimulus for chronic opioid use even among those who are opioid naive before surgery.[56] Given the likely transition from acute to long-term opioid use after surgery, measures to curb the duration of postoperative opioid use may be necessary to limit the risks of perioperative opioid exposure.

The incidence of prolonged opioid use after surgery varies based on preoperative patient characteristics and the type of surgery a patient undergoes. In a retrospective analysis of 641,941 opioid-naive patients undergoing surgery, and 18,011,137 opioid-naive nonsurgical patients, the incidence of chronic opioid use among nonsurgical patients was 0.136% (95% CI, 0.134%–0.137%).[56] The highest incidence of chronic opioid use occurred after total knee arthroplasty (1.41%; 95% CI, 1.29%–1.53%).[56] After controlling for age, sex, and preoperative medication use (antidepressants, antipsychot[illegible] and ben[illegible]diazepines), patients undergoing total k[illegible] arth[illegible] [illegible] cholecystectomy, total hip arthropl[illegible]y, sim[illegible]omy, laparoscopic cholecystectomy, o[illegible] ap[illegible]my, [illegible]d cesarean delivery were at signific[illegible] for chronic opioid use after surgery.[56] Risk factors for [illegible] opioid use after surgery among opioid-naive patients included male sex, age >50 years, preoperative use of benzodiazepines, preoperative use of antidepressants, depression history, alcohol abuse history, and drug abuse history.[56] Similarly, in a retrospective cohort of 36,177 opioid-naive patients undergoing minor (eg, varicose vein removal, laparoscopic cholecystectomy, laparoscopic appendectomy, hemorrhoidectomy, thyroidectomy, transurethral prostate surgery, parathyroidectomy, and carpal tunnel surgery) or major (eg, ventral

1734 www.anesthesia-analgesia.org ANESTHESIA & ANALGESIA

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continued on next page

continued from previous page

Appendices *continued*

Appendix 2. Questions Mapped to Article

Chronic Opioid Use After Surgery

incisional hernia repair, colectomy, reflux surgery, bariatric surgery, and hysterectomy) operations, the rates of new persistent opioid use varied between 5.9% and 6.5%.[57] The incidence in a nonoperative control cohort was only 0.4%. Risks factors for new persistent opioid use after surgery included preoperative tobacco use, alcohol and substance abuse disorders, mood disorders, anxiety, and preoperative pain disorders.[57] The higher incidence of new persistent opioid use noted in this second study may relate to defining the outcome as any opioid prescription filled between 90 and 180 days after the surgical procedure,[57] whereas the first study defined chronic opioid use as 10 or more prescriptions, or more than a 120-day supply of an opioid within the first year after surgery excluding the first 90 days.[56]

Regardless of whether or not patients are taking opioids before surgery, undergoing surgery in and of itself is a risk factor for instigating persistent and chronic opioid use after surgery. When examining the surgical population as a whole, including patients taking opioids before surgery, postoperative chronic opioid use ranges from 9.2% to 13%.[58,59] In the context of the current opioid crisis, measures to decrease the overall prevalence of chronic opioid use after surgery will decrease opioid-related adverse events including opioid misuse, abuse, addiction, diversion, respiratory depression, and overdose.

PREDICTORS OF CHRONIC OPIOID USE AFTER SURGERY

Preoperative opioid use is an important risk factor for persistent or chronic opioid use after surgery. In a national, population-based study of patients undergoing upper extremity surgery, opioid use before surgery was associated with longer opioid prescriptions, and more refills after surgery.[60] Patients using opioids before operations including bariatric surgery, lumbar fusion, total joint arthroplasty, and kidney transplantation are at increased risk for chronic postoperative opioid use.[61–65] Between 64% and 77% of chronic opioid users before surgery continue chronic opioid use after surgery.[62,63] In a perioperative model of time to postoperative opioid and pain cessation using Cox regression, legitimate pre… op… was a risk factor for persistent opioid … in a …ed su…cal cohort.[58] Higher preoperative opi… doses …d to … incremental risk of chronic use after s…ery; …ents …king >60-mg oral morphine equivalents pr…ely …ve an 80% likelihood of chronic use 6 months after total knee or hip arthroplasty.[57]

Q7

Additional risk factors for postoperative chronic opioid use include lower socioeconomic status, preoperative pain, medical comorbidities (eg, pulmonary disease, heart failure), depression, and a history of drug, alcohol, or tobacco abuse.[54,56] Use of specific medications including preoperative benzodiazepines and antidepressants are also associated with persistent opioid use after surgery.[54,56,58]

Prior research highlights preoperative depression and use of antidepressants as important risk factors for chronic opioid use after surgery.[56,59] Clinically diagnosed depression (rather than anxiety or adjustment disorders) increases the odds of chronic opioid therapy after lumbar fusion (OR, 2.34; $P < .001$), and 77% of patients with depression receive chronic opioid therapy after lumbar fusion compared to 50% without a depression diagnosis.[64] Similarly, depression is a risk factor for new chronic opioid use after total hip arthroplasty rather than anxiety or psychoses.[58] This mirrors trends in long-term opioid therapy for noncancer pain, as patients with a history of depression are more likely to receive chronic opioid therapy at higher daily doses, and for extended durations.[69] In a mixed surgical cohort, elevated preoperative Beck Depression Inventory-II scores were a significant predictor of prolonged opioid use independent of pain in a mixed surgical cohort.[66] Further factor analysis identified self-loathing symptoms of the Beck Depression Inventory-II as a significant predictor of prolonged opioid use rather than somatic symptoms, which could be confounded by pain and other medical comorbidities in a surgical cohort.[70–72] The primary determinants of postoperative opioid cessation appear unrelated to the duration of postoperative pain and preoperative pain intensity both at the future surgical site and elsewhere over the entire body.[58] Thus, specific efforts to promote opioid cessation are warranted aside from focusing solely on optimizing pain management in the postoperative period.

STRATEGIES TO PROMOTE OPIOID CESSATION AFTER SURGERY

Regional and Neuraxial Anesthesia

Nerve blockade of peripheral nerves (regional anesthesia) or the central nervous system (neuraxial anesthesia) has been proposed as a possible way of reducing the risk of persistent opioid use after surgery. Nerve blockade could reduce the risk of persistent postoperative opioid use through one of 2 mechanisms. The first, a theory known as preventative analgesia[73–75] suggests that nerve blockade can prevent the transition from acute to chronic pain by directly blocking transmission of pain impulses during the perioperative period and thereby preventing central sensitization and chronic neuropathic pain. Second, nerve blocks are a well-established modality for treating acute postoperative pain, which when severe, is predictive of the development of chronic pain.[76]

Despite these th… bene… …nd several studies showing that nerve …ckad… …ia… with reduced opioid requirements in …e imme…ate… …erative period,[77–79] whether nerve blo…de … …ng… …m opioid use following in practice … …cl… …eta-analysis of 23 randomized control trials found that epidural anesthesia was associated with decreased persistent postoperative pain for patients undergoing thoracotomy and that paravertebral blocks were associated with decreased persistent postoperative pain for breast cancer surgery.[80] However, while these studies suggest that nerve blocks are associated with a decreased risk for persistent postoperative pain, whether nerve blocks decrease persistent postoperative opioid use itself remains an open question. Indeed, recent observational studies have found no association between nerve blockade and the risk of persistent postoperative opioid use for patients undergoing abdominal surgery,[81] total knee arthroplasty,[82] or shoulder arthroplasty.[83]

Q8

Intravenous Local Anesthetic

There is increasing interest in the intraoperative use of intravenous local anesthetics—typically lidocaine—for

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continued on next page

continued from previous page

Appendices *continued*

Appendix 2. Questions Mapped to Article

Q9

the purpose of reducing perioperative opioid consumption. When given as part of a nerve block, local anesthetics exert an analgesic effect by blocking the sodium channels responsible for neural transmission of pain impulses. The effect of intravenou[illegible]esth[illegible]n opioid consumption is thought to [illegible]ur via [illegible] of proinflammatory responses to [illegible]gery.[84] A[illegible]eview found that intravenous lidoca[illegible] w[illegible]ociated [illegible]ith decreased opioid requirements in [illegible]operative period for a variety of surgeries (eg, abdominal and thoracic procedures), although the literature suggested no benefit in some others (eg, total hip arthroplasty).[84] With regard to long-term outcomes, 2 studies found that intraoperative lidocaine use was associated with decreased chronic pain at 3[87] and 6 months[88] a[illegible]procedu[illegible] for p[illegible]s undergoing mastectomy, w[illegible] ano[illegible] s[illegible]ou[illegible]im[illegible]ved quality of life scores at[illegible]months[illegible]er sp[illegible] su[illegible]ry.[illegible]he duration of follow-up fo[illegible]ll 3[illegible]es w[illegible]airl[illegible]hor[illegible] maximum 6 months after pr[illegible]nd w[illegible]e the[illegible]es examined the incidence of persistent postoperative pain, none of the 3 studies directly measured opioid use itself. More research is needed to characterize the extent to which the perioperative use of intravenous local anesthetics can reduce persistent opioid use after surgery.

Q10

Other Nonopioid Medications

Numerous studies have examined whether the intraoperative use of nonopioid medications with analgesic properties is associated with decreased opioid consumption after surgery. Ketamine is an *N*-methyl-D-aspartate receptor antagonist frequently used for induction. Its analgesic properties as an *N*-methyl-D-aspartate receptor antagonist have led researchers to examine whether its intraoperative use is associated with reduced opioid consumption. While studies have generally found intraoperative ketamine to be associated with decreased opioid consumption in the immediate postoperative period and for up to 6 weeks after procedure,[90–92] to date no studies have examined its effect on opioid consumption at longer time windows after surgery.

Acetaminophen is frequently used for pain management or as part of multimodal analgesia protocols. As with ketamine, while numerous studies suggest that it is associated with decreased opioid consumption in the immediate perioperative period,[93,94] there is a lack of research examining its effectiveness at reducing opioid use in the longer term.

Perioperative gabapentin appears to reduce the incidence and intensity of postoperative pain up to 6 months after otolaryngology, orthopedic, mastectomy, and abdominal/pelvic operations.[95–98] Furthermore, perioperative gabapentin is often cited as a component of multimodal analgesia,[99] but results have been mixed regarding gabapentin's efficacy to reduce acute pain in the context of multimodal analgesia. Usual care varies across operations and hospitals nationwide.[100–104] Previous trials examining gabapentin's effect on opioid consumption have reported immediate reductions in 24–72 hours postoperative use during hospital admission.[101,102,105] In contrast, a meta-analysis of 9498 patients found a negligible reduction in 24-hour morphine consumption with use of gabapentin, with an even more diminished effect in the context of multimodal analgesia.[106] These findings were limited by low-quality evidence due to small study sizes and inconsistency.[106] Studies examining the utility of perioperative gabapentin for remote postoperative opioid cessation are needed to fully understand the utility of gabapentin alone or as part of multimodal analgesia protocols.

Multimodal Analgesia

Multimodal analgesia consists of 2 or more medications or nonpharmacologic interventions (eg, transcutaneous electrical nerve stimulation) with varying mechanisms of action for postoperative pain relief.[99] Components of multimodal analgesia often include gabapentenoids, acetaminophen, ketamine, nonsteroidal anti-inflammatory drugs (NSAIDs), and regional anesthesia.[107] It is thought that the combination of treatments is likely to have an additive or synergistic effect on opioid sparing as well. In a meta-analysis of 52 randomized trials including 4893 adults, acetaminophen, NSAIDs, or selective cyclooxygenase-2 inhibitors significantly reduced 24-hour morphine consumption after surgery.[108] Similarly, a systematic review found that coadministration of paracetamol, NSAIDs, and cyclooxygenase-2 inhibitors with opioids decreases 24-hour postoperative morphine consumption without a clear benefit of one category versus another in terms of adverse effects.[109] Future studies examining extended multimodal analgesic techniques with postoperative follow-up long after hospital discharge are needed to determine the utility of multimodal analgesia in preventing chronic opioid use after surgery. Furthermore, given the significant variation in implementing multimodal analgesia techniques across the United States, randomized trials are needed to inform best practices for clinical care.[104]

FUTURE DIRECTIONS

Multiple professional societies have focused efforts on reducing prescription opioid exposure after surgery. Guidelines now strongly recommend instituting a plan for opioid tapering after surgery. For example, the Agency Medical Directors' Group Interagency Guidelines on Prescribing Opioids for Pain recommend tapering opioids by 6 weeks after most major surgeries to preoperative doses or lower in the absence of clinically meaningful improvements in function and pain, with 20% weekly dose reductions.[110] However, the standard of care is to advise patients to discontinue opioids when they no longer have pain, and patients usually self-taper their opioids with minimal instructions after surgery.

There are efforts focused on providers' prescribing patterns. This is being done by providing recommendations on number of pills or limiting the number prescribed. Currently, a disconnect exists between opioids prescribed and opioids used after surgery. The amount prescribed does not influence patients' decisions to continue or discontinue opioid use, and patients exhibit wide variability in opioid needs after similar procedures.[2,47,59,60] Research is needed to address a critical knowledge gap regarding optimal mechanisms for postoperative opioid weaning with supportive psychosocial interventions in the form of randomized controlled trials to support expert opinion.[111] Evidence and evaluation of new programs are required to ensure the best balance of pain control with minimal opioid exposure.

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Appendices *continued*

Appendix 3. Item Structure for Content Development[a]

[Question #: Topic (contributors/reviewer)]

Question 1: Likelihood of Chronic Opioid Use (ALLEN/RICE)

Stem:

[Make as concise as possible; only include essential info; only test 1 principle per question.]

A 52-year-old opioid naive woman presents to the emergency department with a migraine headache. Evaluation and management of her condition by a physician who frequently prescribes opioids increases the likelihood of which of the following:

Answers:

[List 4 answers; cannot use "all of the above" or "none of the above"; only 1 correct answer; should be parallel in verb tense and length.]

A. Long-term opioid use

B. Future hospitalization

C. Respiratory failure

D. Cardiac arrest

Practice Implication:

[This is the key take-home point that you would like for learners to know.]

The approach to treatment of acute pain varies widely amongst healthcare professionals. In opioid-naïve patients, treatment by a clinician who prescribes opioids more frequently than their peers is strongly correlated with subsequent long-term opioid use in patients. Additionally, risk of long-term opioid use increases rapidly with commonly prescribed doses and durations of therapy. Strategies to mitigate risk should be employed with every patient encounter in which opioids are prescribed.

Rationale:

[This is a longer explanation that will contain the Practice Implications.]

Increasing overuse of opioids in the United States may be driven in part by prescribing habits of healthcare professionals.

In a recent study of almost 400,000 patients (Barnett ML *et al*, NEJM 2017), ED physicians were categorized as being **high-intensity** or **low-intensity opioid prescribers** according to relative quartiles of prescribing rates within their hospital. **Long-term opioid use** was defined **≥180 days** of opioids supplied in the 12 months after the index ED visit, ***excluding prescriptions within 30 days after the index visit***. Rates of long-term opioid use were compared in patients treated by high or low-intensity prescribers. Overall, patient characteristics and diagnoses treated were similar across all prescribers. There was **>3-fold increase in opioid prescription rates** by the high-intensity prescribers **as compared to** low-intensity (24.1% vs. 7.3% of ED visits, see figure below). Patients treated by high-intensity opioid prescribers had a **30% increased risk of long-term opioid use**.

A similar study (Deyo RA *et al*, JGIM 2017) evaluating **500,000 opioid-naïve patients** demonstrated that both the number of prescriptions in the **1st month of opioid consumption** and **total morphine milligram equivalents (MMEs) prescribed** were highly correlated with **risk of long-term use**, defined as **≥6 opioid prescriptions** in the subsequent 12 months. After excluding patients with cancer pain and non-cancer chronic pain conditions, compared to the group that only filled 1 prescription in the first month, **those who filled ≥2 were 4 to 10 times as likely to become long-term users.** Additionally, those who were dispensed **>120 morphine milligram equivalents total** (MME; e.g. 120 MME = oxycodone 5mg PO q6h PRN x 4 days) were **2-16 times** as likely to be **long-term opioid users**, with increasing MME dispensed associated with increased risk.

If a prescription is given for opioids for acute non-cancer pain, **the shortest duration and the lowest number of MMEs (by total dose and pill count) possible should be given**. Per latest CDC guidelines, 3 days of opioid therapy is often sufficient and >7 days is rarely needed for acute pain; Appendix 3 Figure 1.

[Any type of media can be used in QuizTime: images or video.]

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Appendices *continued*

References:

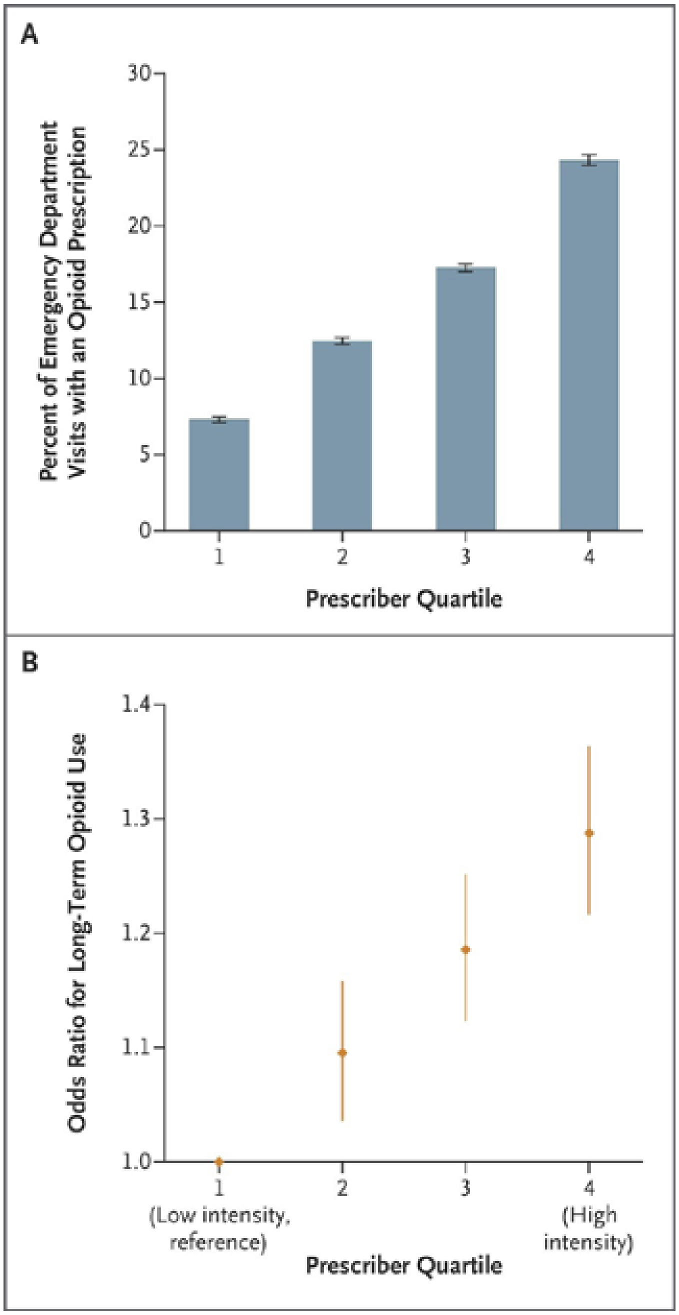
[Include 1-3 references with PubMed link to online abstract.]

[Format: first author, et al. *Journal Name*, Year;Volume:page numbers. pubmed hyperlink]

Barnett ML, et al. *NEJM* 2017;376:663-673. https://www.ncbi.nlm.nih.gov/pubmed/28199807

[a] Boldface indicates correct answer.

Appendix 3 Figure 1: *Item structure for content development.*



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Appendices *continued*

Appendix 4. CME Knowledge Quiz

Confidential

A & A CME Knowledge Quiz

Please complete the survey below.

Thank you!

1) According to recent literature, what percentage of in-hospital surgical patients may be affected by venous thromboembolism (VTE)?
   - ○ 5%
   - ○ 12%
   - ○ 25%
   - ○ 40%

2) Venous thromboembolism is most likely to occur following which of the following types of surgery?
   - ○ Neurosurgery
   - ○ Vascular surgery
   - ○ Cancer surgery
   - ○ Cardiac surgery

3) Which of the following interventions is least effective in reducing the risk of venous thromboembolism?
   - ○ Thromboembolic deterrent stockings (TEDs)
   - ○ Intermittent pneumatic compression devices
   - ○ Aspirin
   - ○ Warfarin

4) Which of the following anti-thrombotic agents has the most favorable risk profile for postoperative thromboembolism prophylaxis?
   - ○ Dabigatran
   - ○ Apixaban
   - ○ Rivaroxaban
   - ○ Clopidogrel

5) In a patient who does not respond to fluid resuscitation, which of the following systolic blood pressures is an appropriate "trigger" for femoral arterial catheterization, in anticipation of possible endovascular aortic occlusion?
   - ○ 100 mmHg
   - ○ 90 mmHg
   - ○ 80 mmHg
   - ○ 70 mmHg

6) Which of the following is the most appropriate inflation site for balloon occlusion in a patient with pelvic fractures?
   - ○ Zone I
   - ○ Zone II
   - ○ Zone III
   - ○ Zone IV

7) Which of the following measures is recommended to optimize renal function after balloon occlusion of the aorta?
   - ○ Mannitol
   - ○ Dopamine
   - ○ Fenoldopam
   - ○ Maintenance of circulating blood volume

8) Which of the following is least likely following deflation of an aortic occlusive balloon?
   - ○ Metabolic alkalosis
   - ○ Cardiac arrhythmias
   - ○ Increased hemorrhage
   - ○ Decreased venous return

9) Which of the following is not associated with preoperative opioid use before elective surgery?
   - ○ Longer length of stay
   - ○ Increased in-hospital mortality
   - ○ Increased healthcare expenditures at 90, 18
     365 days after surgery

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continued from previous page

Appendices *continued*

Appendix 4. CME Knowledge Quiz

10) Approximately what percentage of patients who receive 90 days of continuous postoperative prescriptions will continue to take opioids for several years after surgery?	◯ < 20% ◯ 20-40% ◯ 40-60% ◯ >60%
11) Which of the following associations for reducing persistent postoperative pain has been reported?	◯ Epidural anesthesia for thoracotomy ◯ Paravertebral block for thoracotomy ◯ Regional anesthesia for breast surgery (e.g. PECSI/II, serratus blocks) ◯ Regional anesthesia for total knee replacement (e.g.femoral and sciatic blocks)
12) Which of the following is the proposed mechanism for perioperative opioid sparing by intravenous lidocaine?	◯ Sodium channel blockade of signal transmission ◯ Chloride channel opening ◯ Blockade of AMPA receptors ◯ Generalized anti-inflammatory effects
13) According to the latest research, approximately what percentage of patients have residual neuromuscular blockade in the early recovery period after anesthesia (e.g. PACU)?	◯ < 10% ◯ 20% ◯ 40% ◯ 60%
14) Which of the following muscles/muscle groups is the most sensitive to neuromuscular blocking drugs (NMBDs)?	◯ Diaphragm ◯ Eye muscles ◯ Pharyngeal muscles ◯ Adductor pollicis
15) Monitoring neuromuscular blockade at which of the following sites is associated with a higher likelihood of postoperative residual neuromuscular blockade?	◯ Adductor pollicis ◯ Orbicularis oculi ◯ Posterior tibial ◯ Common peroneal
16) Which of the following reversal and monitoring techniques is sufficient to ensure that full neuromuscular reversal has been achieved?	◯ Administering neostigmine 70 mcg/kg for a TOF ratio of 0.4-0.6 prior to reversal ◯ Assessing no fade with sustained tetanic stimulation (5 sec @ 50-Hz) 20 minutes after giving sugammadex 4 mg/kg for reversal ◯ Assessing TOF ratio as 0.9 after giving neostigmine 20 mcg/kg ◯ Administering neostigmine 40 mcg/kg for a TOF count of 4 prior to reversal
17) Which of the following is least likely to be a risk factor for postoperative kidney injury?	◯ Male sex ◯ Increased body mass index ◯ Diabetes mellitus ◯ Chronic obstructive pulmonary disease
18) Which of the following substances is least likely to harm perioperative renal function?	◯ Gentamycin ◯ Ketorolac ◯ Lactated Ringer's solution ◯ 0.9% sodium chloride solution
19) Based on current data, which of the following drugs seems most promising for the prevention of perioperative renal insufficiency?	◯ Sodium bicarbonate ◯ Mannitol ◯ Furosemide ◯ Dexmedetomidine

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Appendices *continued*

Appendix 4. CME Knowledge Quiz

20) Which of the following is least directly associated with the development of perioperative AKI?
- ○ Hypokalemia
- ○ Hypovolemia
- ○ Hypoperfusion
- ○ Inflammation

21) Which of the following is least likely to be a side effect of chronic vagal nerve stimulation?
- ○ Gasping respiratory pattern
- ○ Partial airway obstruction
- ○ Tachycardia
- ○ Exertional dyspnea

22) Stimulation of which of the following nerves may reduce the severity of obstructive sleep apnea?
- ○ Vagus
- ○ Glossopharyngeal
- ○ Hypoglossal
- ○ Spinal Accessory

23) Which of the following treatment modalities is contraindicated for all patients with implanted electronic medical devices?
- ○ Unipolar electrocautery
- ○ MRI scanning
- ○ CT scanning
- ○ Diathermy

24) When using an external defibrillator on a patient with an implanted electronic device, which of the following maneuvers is least likely to prevent damage to the device?
- ○ Use of synchronized mode
- ○ Applying electrodes at right angles to the implanted device's wires
- ○ Positioning the paddles as far as possible from the device
- ○ Use of the lowest possible energy level

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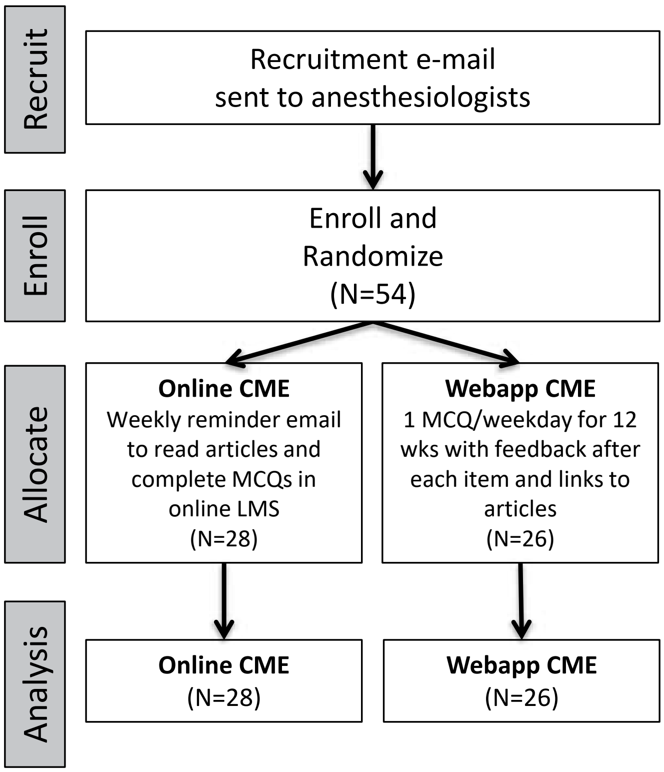
Figures

Figure 1. *CONSORT diagram.*



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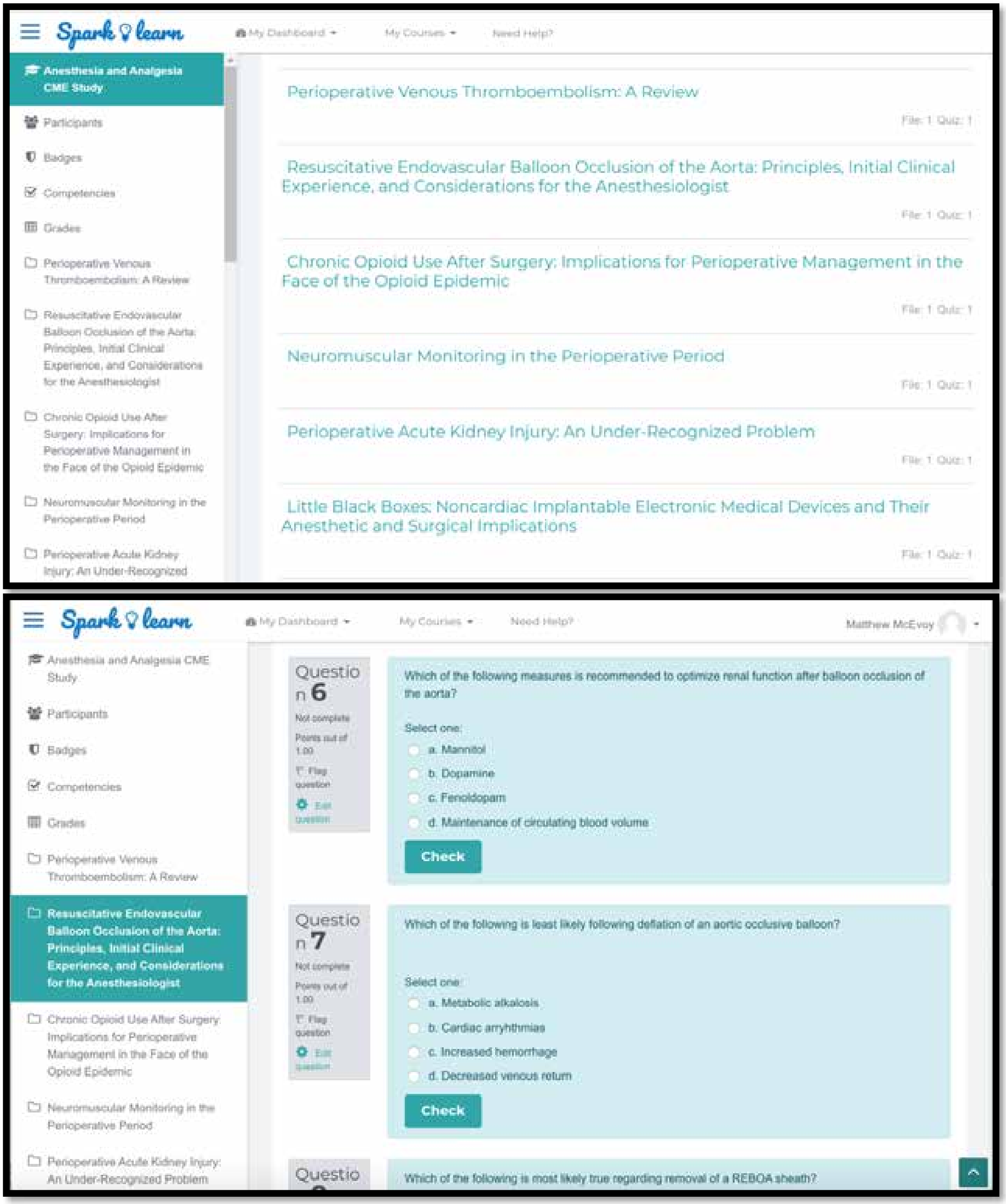
Figures *continued*

Figure 2. *Vanderbilt University online learning management system.*



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Figures *continued*

Figure 3. *Web interface for question distribution, presentation, and answer review.*

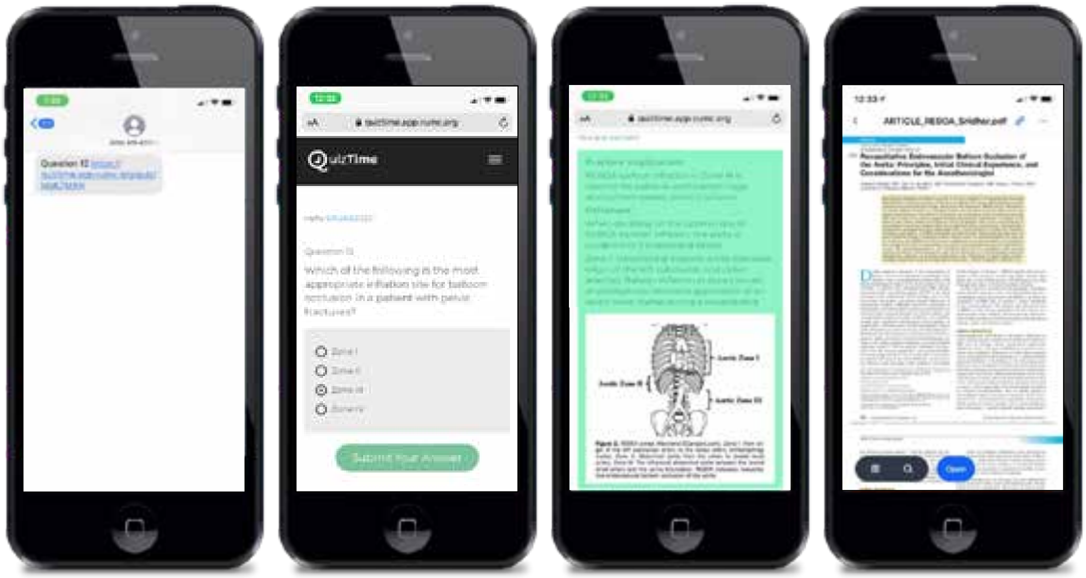
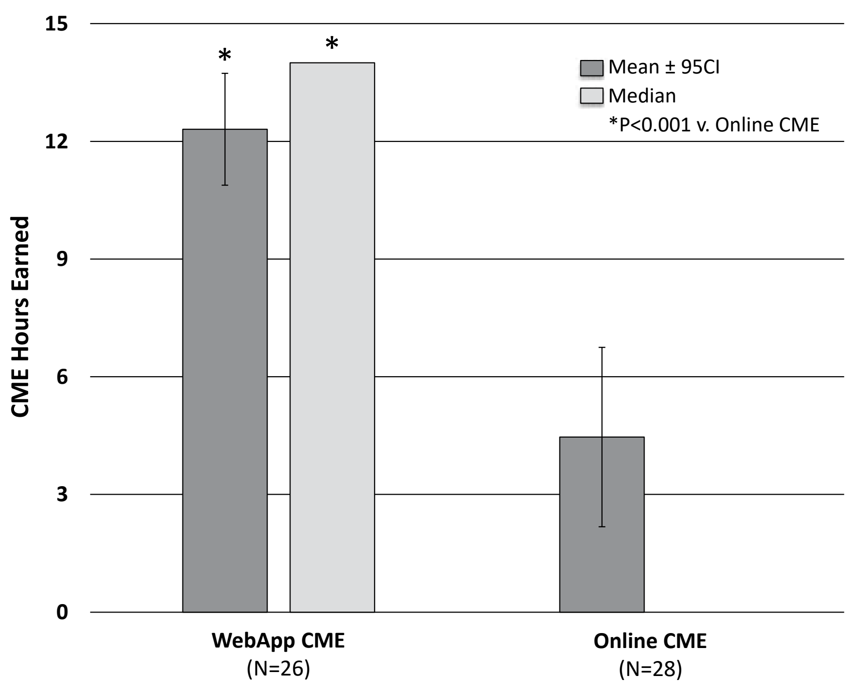


Figure 4. *Learner engagement (CME credit consumption) by educational intervention.*



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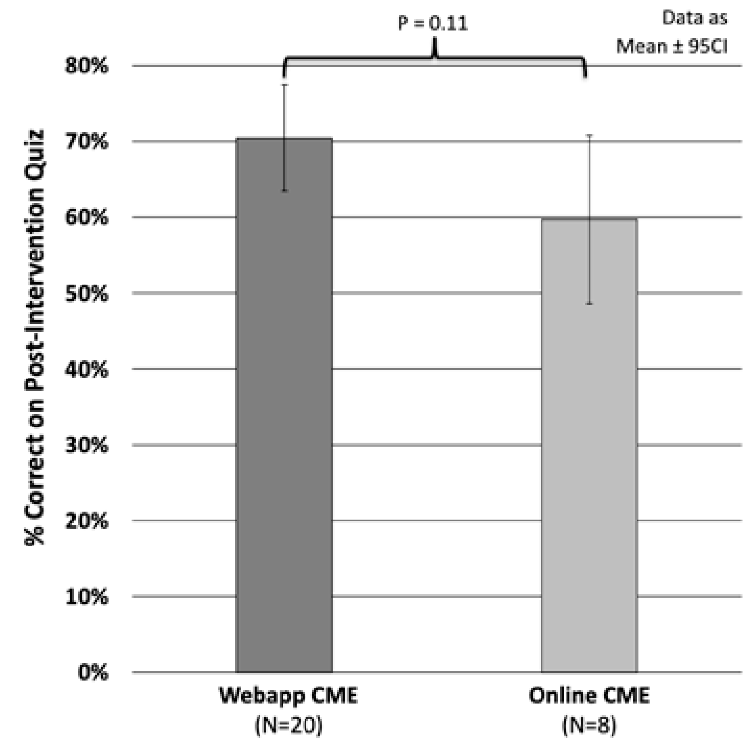
Figures *continued*

Figure 5. *Knowledge acquisition by educational intervention.*



*N for both groups represents the subset who completed the post-intervention quiz; N=20 (77% of 26) Webapp group; N=8 (29% of 28) Online group

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Table

Table 1. *Study Participant Demographics (N = 54)*

	Count, N		
Survey Question	**Webapp**	**Online**	**Category Total, N (%)**
Gender			
Female	12	11	23 (43)
Male	14	17	31 (57)
Location Setting			
Urban	22	23	45 (83)
Suburban	4	5	9 (17)
Time Zone			
Central	9	11	20 (37)
Eastern	17	17	34 (63)
Practice Setting			
Academic	13	17	30 (56)
Private	13	11	24 (44)
Years in Practice			
0-5	6	6	12 (22)
6-10	7	8	15 (28)
11-20	7	8	15 (28)
21 or more	6	6	12 (22)
Practice Size			
Small (<10)	2	1	3 (5)
Medium (10-30)	4	4	8 (15)
Large (31-100)	11	12	23 (43)
Very large (>100)	9	11	20 (37)