BMJ Open

Development and design of a mobile application for prescription opioid clinical decision-making: a feasibility study in New York City, USA

Megan E Marziali ![ORCID],[1] Mirna Giordano,[2] Zachary Gleit,[3] Jake Prigoff,[3] Ruth Landau,[4] Silvia S Martins[1]

For numbered affiliations see end of article.

Correspondence to
Dr Silvia S Martins;
ssm2183@cumc.columbia.edu

ABSTRACT

Objectives Excessive opioid prescribing is a contributing factor to the opioid epidemic in the USA. We aimed to develop, implement and evaluate the usability of a clinical decision-making mobile application (app) for opioid prescription after surgery.

Methods We developed two clinical decision trees, one for opioid prescription after adult laparoscopic cholecystectomy and one for posterior spinal fusion surgery in adolescents. We developed a mobile app incorporating the two algorithms with embedded clinical decision-making, which was tested by opioid prescribers. A survey collected prescription intention prior to app use and participants' evaluation. Participants included opioid prescribers for patients undergoing (1) laparoscopic cholecystectomy in adults or (2) posterior spinal fusion in adolescents with idiopathic scoliosis.

Results Eighteen healthcare providers were included in this study (General Surgery: 8, Paediatrics: 10). Intended opioid prescription before app use varied between departments (General Surgery: 0–10 pills (mean=5.9); Paediatrics: 6–30 pills (mean=20.8)). Intention to continue using the app after using the app multiple times varied between departments (General Surgery: N=3/8; Paediatrics: N=7/10). The most reported reason for not using the app is lack of time.

Conclusions In this project evaluating the development and implementation of an app for opioid prescription after two common surgeries with different prescription patterns, the surgical procedure with higher intended and variable opioid prescription (adolescent posterior spinal fusion surgery) was associated with participants more willing to use the app. Future iterations of this opioid prescribing intervention should target surgical procedures with high variability in both patients' opioid use and providers' prescription patterns.

INTRODUCTION
Background

Excessive opioid prescribing has been identified as one of the many contributing factors to the ongoing opioid epidemic in the USA.[1] Opioid prescription patterns after surgery are of concern, with persistent opioid use a potential complication among opioid-naïve

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ A major strength of our study is the detail of the development of a mobile application for clinical decision-making regarding opioid prescription, which could be applied to other surgical procedures.

⇒ We collected information pertaining to barriers to long-term use of mobile applications in clinical decision-making, informing the implementation of other mobile applications in a clinical setting.

⇒ A limitation of this study is the limited sample size, which could be a result of recruitment during a period in the COVID-19 pandemic when elective surgeries were paused.

patients, occurring in up to 6% of patients after both minor and major surgery.[2] Opioid overprescribing, a discrepancy between predischarge opioid use and the number of opioids prescribed at hospital discharge (occurring in approximately 15% of patients),[3] continues to occur. For instance, patients who have not used opioids within 24 hours prior are frequently prescribed opiates unnecessarily on discharge.[3] The majority of patients undergoing an obstetric, thoracic, orthopaedic or urological procedure have an unused supply of prescription opioids (67%–92%),[4] and a majority of the unused opioid pills prescribed are improperly disposed of,[4] creating sources for opioid diversion. While opioid prescribing was trending downwards with a 44.4% decrease in opioid prescriptions from 2011 to 2020,[5] longer and more potent prescriptions were more likely to be prescribed to patients with pain during the COVID-19 pandemic in comparison to 2019,[6] with a modest increase in non-chronic opioid prescriptions after restrictions were lifted.[7]

Clinical decision trees
Individualised treatment plans to better address postoperative pain needs should

include judicious opioid prescriptions.[8] Clinical decision support systems and medical applications (apps) have been advocated to guide the workflow of healthcare providers. There is very little data demonstrating the use of smartphone apps, other than the American Society for Regional Anesthesia publication on the use of their app to guide anaesthesiologists performing regional procedures in anticoagulated patients.[9]

This study aimed to develop an opioid prescribing tool in a mobile app format for two common procedures: laparoscopic cholecystectomy in adults and posterior spinal fusion in adolescents with idiopathic scoliosis. We set out to develop a mobile application based on these clinical decision trees, hypothesising that having a tool to aid practitioners at the time of prescribing would be useful to promote tailored, judicious prescribing. The primary aim of this study is to explore the feasibility of this clinical decision-making app in two different surgical settings. Previous studies have explored the implementation of enhanced discharge pathways, which involve coordination between multiple teams, including pain management, surgery and nursing teams.[10] These pathways involved multimodal analgesics and stopping opioids earlier, to diminish adverse side effects associated with opioids in adolescents.[11] These methods have been suggested to provide improved postoperative pain management.[12]

METHODS
Literature review
A scoping review of the literature was conducted to examine opioid prescribing patterns, available opioid prescribing guidelines for the selected procedures, and the use of a clinical decision-making process. For pragmatic reasons, we focused on two distinct surgical procedures: laparoscopic cholecystectomies and posterior spinal fusion (PSF) in adolescents with idiopathic scoliosis (AIS). We opted to include a simple, straightforward general surgery procedure (eg, laparoscopic cholecystectomies) and a complicated paediatric surgery procedure (eg, PSF in AIS) to explore the feasibility of the app in different surgical settings. Publications reporting on opioid prescription and clinical considerations that are relevant for decision-making in opioid prescribing were reviewed.

Laparoscopic cholecystectomy
Laparoscopic cholecystectomy is classified as a minor procedure; however, opioid prescription increased from 190.1 morphine milligram equivalents (MME) in 2004 to 211.9 MME in 2012,[13] which is more than 25 5 mg oxycodone pills. Prescription of opioids at discharge occurs in up to 94% of cases after urgent and non-urgent laparoscopic cholecystectomies,[14] and is associated with persistent opioid use among approximately 6% of patients.[2] Among a recent cohort of patients undergoing both laparoscopic cholecystectomies and appendectomies, the average number of opioid pills taken postdischarge was 1.8 oxycodone pills.[15] Recent opioid prescribing recommendations for patients undergoing a laparoscopic cholecystectomy range from 0 to 15 oxycodone or equivalent pills.[16 17]

Posterior spinal fusion in adolescents with idiopathic scoliosis
Posterior spinal fusion in adolescents is a major procedure associated with severe postoperative pain.[18] This is further complicated by the younger age of patients undergoing this procedure, which is a noted predictor of postoperative pain.[19] Pain catastrophising on the part of either the adolescent or the parent is an indicator of postoperative pain, emphasising the complex nature of recovery among adolescents undergoing surgical procedures.[19] Paediatric opioid prescriptions frequently exceed the standard amount across specialties, leading to calls to standardise opioid prescriptions and develop strategies to optimise pain management[8] within the paediatric population.

The number of opioid pills prescribed for adolescents with idiopathic scoliosis undergoing posterior spinal fusion ranges from a mean of 53 (SD=12) to 69 (SD=13).[20] Prior work suggests that 67% of patients planned on disposing of unused opioids, whereas 33% kept the unused supply.[20] In the interest of both minimising opioid over-prescription and the occurrence of opioid-related adverse effects (nausea, vomiting, constipation, etc) in adolescents,[21] stepwise opioid-sparing multimodal analgesia has been encouraged.[18]

Development of clinical decision trees
The research team met to discuss (1) the structure of the app and (2) the algorithms that would be used by the prescribers. The clinical experts agreed on all patient-specific and procedure-specific parameters included in the algorithm, with several rounds of review leading to the development of the final algorithm.

Algorithm development
The research team developed procedure-specific algorithms. At first, members of the research team met separately to develop the procedure-specific algorithms; for example, clinical researchers with an expertise in general surgery did not meet initially when developing the PSF in AIS algorithm, and vice versa. Both groups provided final recommendations regarding doses of opioid pills based on clinical considerations and notable risk factors for potential prescription opioid misuse. General surgeons, including both an attending and resident physician to account for different workflows, were consulted over a series of meetings to generate the initial algorithm for laparoscopic cholecystectomies. Once this initial algorithm was developed, it was shared with the paediatrics research team, feedback and recommendations were solicited, and a different, more complex algorithm was developed for AIS patients. The Paediatrics team opted to include a feature in the app to notify the provider that the patient would benefit from formal pain counselling in addition to a recommendation for the opioid prescription. This

Table 1 Questions included in the laparoscopic cholecystectomy algorithm

Questions	Response options
Is the patient an outpatient?	Yes/no
Does the patient have any of the following: low pain tolerance, contraindication to NSAIDs and acetaminophen, and/or chronic opioid use?	Yes/no
Does the patient have a history of a pain disorder(s)?	Yes/no
Did the patient require four or more pills in the last 24 hours of admission?	Yes/no
Was the patients' pain adequately controlled with **no** opiates in the last 24 hours prior to discharge?	Yes/no
Did the patient receive education about pain expectations?	Yes/no
Does the patient want opioids on discharge?	Yes/no
Can the patient take both NSAIDs and acetaminophen?	Yes/no

Table 2 Questions included in the posterior spinal fusion for adolescents with idiopathic scoliosis algorithm

Questions	Response options
Does the patient experience preoperative chronic pain?	Yes/no
Has the patient taken opioids prescribed to them for chronic pain for more than 5 days in the past 6 months?	Yes/no
Is there opioid use within the household in which the patient resides?	Yes/no
Has the patient taken any opioids that have not been prescribed to them for more than 5 days in the past 6 months?	Yes/no
Was the patient discharged on POD 4 or later?	Yes/no
Is the patient interested in trying non-pharmacological pain treatments (ie, self-managed breathing exercises, distraction strategies, etc)?	Yes/no
Would the patient be interested in trying to avoid opioids?	Yes/no
Does the patient have a contraindication to NSAIDs or acetaminophen?	Yes/no
Has the patient experienced severe or peak pain ranging from 8 to 10 on the pain scale in the past 24 hours?	Yes/no
Has the patient been taking opioids around the clock (ie, Q 4 hours) to control severe pain during the postoperative period?	Yes/no
Has the patient taken opioids in the last 24 hours?	Yes/no
Has the patient been using benzodiazepines for another medical disorder, for more than 5 days in the past 6 months?	Yes/no
Is there benzodiazepine use in the household in which the patient resides in?	Yes/no
Has the patient been using benzodiazepines that have not been prescribed to them, for more than 5 days in the past 6 months?	Yes/no
What is the patient's weight?	<70 kg, >70 kg

would occur through affirmative responses to questions such as 'Is there opioid use within the household in which the patient resides?' or 'Has the patient taken any opioids that have not been prescribed to them for more than 5 days in the past 6 months?', among others. We did not include this feature in the laparoscopic cholecystectomy algorithm due to concern that it may overcomplicate the app and be too time-consuming.

The two decision trees were reviewed by the full research team. Subsequent changes were made based on expert feedback. However, it was evident that the team needed to develop decision trees to be both procedure-specific and patient-specific. The procedures were intrinsically different, and they differed in terms of their length, and degree and duration of expected postoperative pain. Furthermore, adolescents were admitted with caregivers who needed to be included in the decision-making for pain treatment strategies, while adults having cholecystectomies were making decisions regarding pain treatments on discharge on their own.

The laparoscopic cholecystectomy algorithm (used in the General Surgery department) followed a more straightforward approach, with the final decision tree including seven questions with four possible recommendations, including zero need, low need (two pills), average need (five pills) and high need (ten pills) (table 1). The PSF in AIS algorithm (used in the Paediatrics department) was more complex to account for paediatric patients' age, weight, previous opioid exposure/use and laminectomy levels included. The PSF in AIS algorithm involved 16 questions and 5 possible recommendations: zero need, low need (6–8 pills), low-average need (10–12 pills), average need (18 pills) and high need (24–26 pills) (table 2). All opioid pills were noted to be 5 mg hydrocodone/oxycodone or equivalent.

Development of feedback form

The research team developed a feedback form embedded within the app to solicit feedback and comments from participants. The questions were formulated to assess whether providers found the app to be helpful if the final recommendations were in line with what they would expect, and if they would continue using the app. The providers were asked to complete a questionnaire after going through the app initially, and again after using the app multiple times, to identify differences between first impressions and continued use. The first question on the feedback form asked participants to specify the amount of opioids they would intend to prescribe for this procedure (ie, either PSF in AIS or a laparoscopic cholecystectomy), prior to using the app. A complete list of the questions on whether the app could be incorporated into providers' practice is available in table 3.

Table 3 Feedback form with potential responses to be completed after one case and after multiple cases

Questions	Responses
Initial case	
Which option did you select from the main menu?	▶ General Surgery ▶ Paediatrics
Would you continue using this app for prescribing purposes?	▶ Yes ▶ No
If no, why not?	▶ I knew the recommendation and don't need to use the app ▶ I didn't like the interface/it's not user-friendly ▶ I disagree with the final recommendation ▶ It's too complicated ▶ I don't have time ▶ I don't like using apps ▶ Other (please specify)
Please leave any additional comments	
Multiple cases	
Which option did you select from the main menu?	▶ General Surgery ▶ Paediatrics
Would you continue using this app for prescribing purposes?	▶ Yes ▶ No
If no, why not?	▶ I knew the recommendation and don't need to use the app ▶ I didn't like the interface/it's not user-friendly ▶ I disagree with the final recommendation ▶ It's too complicated ▶ I don't have time ▶ I don't like using apps ▶ Other (please specify)
If you did not like the app at the beginning, did it become more useful over time?	▶ Yes ▶ No
Did you learn anything about prescribing practices through using this app?	▶ Yes ▶ No
Please leave any additional comments	

App development

App development was accomplished using online software provided by AppyPie, a no-code app development platform.[22] Using this platform, the decision trees were converted into a series of questions in a survey format within the app, which could be used with either Android or iPhone devices. App users had the option of selecting their specialty (either General Surgery or Paediatrics), which would lead to the opioid prescribing algorithm or the feedback questionnaire from the app's main menu.

The app was subsequently deployed in beta-testing mode to the research team, for feedback regarding the layout, usability and interpretability of the app. Each member of the research team was asked to go through the app as many times as necessary, to be able to explore different pathways and ensure that the paths through the decision tree within the app were accurate.

Participants and recruitment

Potential participants in each specialty were identified by the research team. Eligibility criteria included: (1) acting in a role as a healthcare provider and (2) prescribing opioids to patients undergoing either laparoscopic cholecystectomies or PSFs.

Medical residents, attending physicians, nurse practitioners and physician assistants at Columbia University Irving Medical Center in the Departments of Surgery and Paediatrics were contacted to take part in the study (N=40). Study recruitment began during the COVID-19 pandemic. Participants in the Paediatrics department were originally contacted in August 2020, and participants in the General Surgery department were contacted in September 2020. All participants were contacted via email. Consent was obtained remotely, with participants either signing and scanning consent forms or signing forms electronically. Once consent was obtained, participants were sent a link and instructions for piloting the app in beta-testing mode. If needed, appointments were made with participants over the phone or via Zoom to facilitate downloading the app and answering any questions about the study. Participants were instructed to use the app at least two times, and to complete the feedback form two times: once after a single event (ie, using the app once), and once after multiple events. We instructed participants to test the app as if they were to use it with a patient; healthcare providers were not testing the app alongside the patient, meaning that we did not collect any patient input.

Patients and public involvement

Patients and other members of the public were not involved in the design or conduct of this study. The research questions, study design and interpretation of the findings were informed by researchers and clinicians working in substance use epidemiology, surgery and anaesthesia.

RESULTS
Participants
General Surgery department

A total of 27 opioid prescribers were contacted; 15 consented to participate, and 8 agreed to complete the study. All participants were physicians (N=4 residents, N=4 attendings).

Paediatrics department

A total of 13 opioid prescribers were contacted; 11 consented to participate and 10 agreed to complete the study. All participants were nurse practitioners.

Prescribing patterns
General Surgery department

There was a total of 35 responses from the 8 physicians, as all participants used the app multiple times. Before

Table 4 Open responses describing reasons for not using the app

Responses	Specialty
Don't think the decision to prescribe 2 or 5 pills is significant	General Surgery
Don't think the app helps make a clinically significant decision	General Surgery
Ideally would be integrated into EMR	General Surgery

using the clinical decision-making app, the intended number of prescribed opioids ranged from 0 to 10 pills (mean=5.89).

Paediatrics department

There was a total of 20 responses from the 13 nurse practitioners, with some of the participants using the app more than once. Before using the clinical decision-making app, the intended number of prescribed opioids ranged from 6 to 30 pills (mean=20.76).

Feedback forms

A total of 31 responses were collected; two responses were removed due to missing information, resulting in 29 completed feedback surveys (General Surgery: 37.9% (N=11); Paediatrics: 62.1% (N=18)).

General Surgery department

Of 11 completed feedback forms, 5 were completed after using the app in a single instance, of which 3 answered wanting to continue using the app. Six participants responded after using the app in multiple instances; two participants responded that they would be willing to continue using the app. Reasons for not wanting to continue using the app (four respondents) after using the app multiple times were lack of time (N=2) and not liking apps (N=2). Open-text responses were included by some participants describing reasons for not using the app (table 4). Most participants (N=4) did not find the app to be useful over time (N=7 provided complete responses to this question). However, most respondents (N=6) reported they learnt something from the app (N=8 completed this question).

Paediatrics department

Of 18 completed forms, 8 were after using the app once and all 8 answered wanting to continue using the app; for the 10 responding after using the app more than once, 7 answered wanting to continue using the app. Reasons for not wanting to continue using the app (three respondents) were lack of time (N=3) or knowing the recommendation and not needing the app (N=2). Most participants (N=8) found the app to be useful over time (11 completed this question). Nine respondents reported they learnt something from the app (14 completed this question).

DISCUSSION

This project evaluated the design and implementation of an app proposing an algorithm with embedded clinical decision-making for opioid prescription in two distinct surgical populations with known different prescription patterns. The surgical procedure with higher intended opioid prescription (posterior spinal fusion surgery in adolescents) was associated with study participants being more willing to continue to use the app, compared with study participants prescribing opioids after laparoscopic cholecystectomies.

We acknowledge several notable differences between the two surgical arms of the study, that highlight the need for context-specific, patient-specific and procedure-specific opioid prescriptions. Laparoscopic cholecystectomy is a minor surgical procedure in comparison to posterior spinal fusion surgery,[23] and prescribers from the General Surgery department were already following minimal opioid prescription recommendations (narrow range between 0 and 10 pills), with little variability in prescribing patterns.

In the Paediatric cohort, we noted that (1) the algorithm that was developed by the clinical experts was more complex due to the possible differences in surgical procedure (multiple vertebral levels could result in more pain and opioid use), (2) the intended number of prescribed opioid before using the clinical decision-making app had a wide range (6–30 pills), (3) the known perceived value of clinical decision-making for medical prescription in paediatrics and (4) the opioid prescribers were all nurse practitioners rather than physicians. Therefore, it may have been expected that feedback would differ between the General Surgery and Paediatrics departments; though respondents from both departments found the app to be educational, most found the app to be more useful over time in the Paediatrics department, while this was not the case for respondents in the General Surgery department.

Previous research has demonstrated that opioid prescribing differs between physicians, nurse practitioners and physician assistants, with healthcare providers in the latter two roles exhibiting higher rates of opioid prescribing in comparison to physicians.[24] This is important, as up to 20% of all opioid prescriptions between 2016 and 2017 were by non-physician prescribers, such as nurse practitioners and physician assistants,[25] highlighting the need to tailor interventions to non-physician opioid prescribers. Our study indicates that participants trialling the PSF in AIS algorithm were more willing to continue using the app; these participants were all nurse practitioners, suggesting mobile apps geared towards healthcare providers in this role may be well-used.

Future iterations of this opioid prescribing intervention should target surgical procedures with high variability in both patients' opioid use and providers' prescription patterns, for a maximal yield of opioid prescription strategies. Finally, a barrier to not using the app in both the General Surgery and Paediatrics departments was noted to be a lack of time. Given

the emphasis on time constraints as a barrier to using the clinical decision-making tool, it is possible that an intervention integrated into the electronic health record would be more beneficial and cost-effective. Additionally, it is possible that provider characteristics (eg, age, gender) could impact willingness to use mobile applications. We did not collect sociodemographic information pertaining to participants, impeding our ability to examine potential associations which should be explored in future studies. Further investigations should explore app usage involving patients to incorporate shared decision-making principles. These strategies are effective in educating patients regarding expected postoperative pain and anticipated analgesic needs and for prompting a conversation between prescribers and patients to minimise excessive opioid prescriptions.[26] Future apps may involve more subjective aspects of the decision-making process, such as the anxiety from patients or caretakers, patient-reported opioid use, pain control and other characteristics to inform appropriate pain management.

Limitations are noted. Recruitment and follow-up with study participants during the COVID-19 pandemic was complex. Initial recruitment began during a period when elective surgery was not being conducted, and medical professionals were being reassigned to COVID-19 duties. This made it difficult to contact potential participants during this period. Further, healthcare workers have been crucial for combatting the pandemic, which has been undoubtedly challenging; being already overworked[27] and experiencing a high burden of psychological distress,[28] participating in an additional study was likely not a top priority. Additionally, participants included in this study occupied one healthcare role per tested algorithm; for example, physicians tested the laparoscopic cholecystectomy algorithm as we did not receive responses from nurse practitioners or physician assistants. Due to the limited number of participants and homogeneity of healthcare roles per algorithm tested, results are not generalisable to the larger medical population. Finally, it is feasible that people who consented to participate in this study were more interested in using mobile applications in clinical practice. It is possible that our study population included people more inclined to indicate that they would continue using the developed app; therefore, we cannot extrapolate findings to the larger medical population.

CONCLUSIONS

In this project evaluating the design and implementation of an app proposing an algorithm with clinical decision-making for opioid prescription after two common surgeries with different prescription patterns, the surgical procedure with higher intended and more variable opioid prescription (posterior spinal fusion surgery in adolescents) was associated with study participants being more likely to continue to use the app. Future iterations of this opioid prescribing intervention might include parents and caregivers, to incorporate their insight and concerns regarding opioid use.

Author affiliations
¹Department of Epidemiology, Columbia University Mailman School of Public Health, New York, New York, USA
²Department of Pediatrics, Columbia University Irving Medical Center, New York, New York, USA
³Department of Surgery, Columbia University College of Physicians and Surgeons, New York, New York, USA
⁴Department of Anesthesiology, Columbia University Vagelos College of Physicians and Surgeons, New York, New York, USA

Twitter Megan E Marziali @marzialimegan

ORCID iD
Megan E Marziali http://orcid.org/0000-0002-8845-663X

REFERENCES

1 Manchikanti L. Opioid epidemic in the united states. *Pain Phys* 2012;3S;15(3S;7):ES9–38.
2 Brummett CM, Waljee JF, Goesling J, *et al*. New persistent opioid use after minor and major surgical procedures in US adults. *JAMA Surg* 2017;152.
3 Chen EY, Marcantonio A, Tornetta P. Correlation between 24-hour predischarge opioid use and amount of opioids prescribed at hospital discharge. *JAMA Surg* 2018;153:e174859.
4 Bicket MC, Long JJ, Pronovost PJ, *et al*. Prescription opioid analgesics commonly unused after surgery: A systematic review. *JAMA Surg* 2017;152:1066–71.
5 American Medical Association. Physicians' actions to help end the nation's drug-related overdose and death epidemic —and what still needs to be done. 2021.

6 Lee B, Yang K-C, Kaminski P, *et al*. Substitution of nonpharmacologic therapy with opioid prescribing for pain during the COVID-19 pandemic. *JAMA Netw Open* 2021;4:e2138453.

7 Rikin S, Perez HR, Zhang C, *et al*. Changes in outpatient opioid prescribing during the COVID-19 pandemic: an interrupted time series analysis. *J Prim Care Community Health* 2022;13:21501319221076930.

8 Kelley-Quon LI, Kirkpatrick MG, Ricca RL, *et al*. Guidelines for opioid prescribing in children and adolescents after surgery: an expert panel opinion. *JAMA Surg* 2021;156:76–90.

9 Gupta RK, McEvoy MD. Initial experience of the american society of regional anesthesia and pain medicine coags regional smartphone application: A novel report of global distribution and clinical usage of an electronic decision support tool to enhance guideline use. *Reg Anesth Pain Med* 2016;41:334–8.

10 Yang J, Skaggs DL, Chan P, *et al*. High satisfaction in adolescent idiopathic scoliosis patients on enhanced discharge pathway. *J Pediatr Orthop* 2020;40:e166–70.

11 Elsarrag M, Soldozy S, Patel P, *et al*. Enhanced recovery after spine surgery: a systematic review. *Neurosurg Focus* 2019;46.

12 Shah SA, Guidry R, Kumar A, *et al*. Current trends in pediatric spine deformity surgery: multimodal pain management and rapid recovery. *Global Spine J* 2020;10:346–52.

13 Wunsch H, Wijeysundera D, Passarella M, *et al*. Opioids prescribed after low-risk surgical procedures in the united states, 2004-2012. *JAMA* 2016;315:1654–7.

14 Hanson KT, Thiels CA, Polites SF, *et al*. The opioid epidemic in acute care surgery-characteristics of overprescribing following laparoscopic cholecystectomy. *J Trauma Acute Care Surg* 2018;85:62–70.

15 Sim V, Hawkins S, Gave AA, *et al*. How low can you go: achieving postoperative outpatient pain control without opioids. *J Trauma Acute Care Surg* 2019;87:100–3.

16 Angelo JL, Wu J, Sirody J, *et al*. Reduction in prescribed opioids after general surgery procedures at a public hospital. *Am Surg* 2019;85:1198–203.

17 Hill MV, Stucke RS, McMahon ML, *et al*. An educational intervention decreases opioid prescribing after general surgical operations. *Ann Surg* 2018;267:468–72.

18 Seki H, Ideno S, Ishihara T, *et al*. Postoperative pain management in patients undergoing posterior spinal fusion for adolescent idiopathic scoliosis: a narrative review. *Scoliosis Spinal Disord* 2018;13:17.

19 Wu CL, Raja SN. Treatment of acute postoperative pain. *Lancet* 2011;377:2215–25.

20 Grant DR, Schoenleber SJ, McCarthy AM, *et al*. Are we prescribing our patients too much pain medication? best predictors of narcotic usage after spinal surgery for scoliosis. *J Bone Joint Surg Am* 2016;98:1555–62.

21 Rullander A-C, Jonsson H, Lundström M, *et al*. Young people's experiences with scoliosis surgery: a survey of pain, nausea, and global satisfaction. *Orthop Nurs* 2013;32:327–33;

22 AppyPie. AppyPie development platform 2021. Available: https://www.appypie.com/ [Accessed Mar 2021].

23 Kwan KYH, Koh HY, Blanke KM, *et al*. Complications following surgery for adolescent idiopathic scoliosis over a 13-year period. *Bone Joint J* 2020;102-B:519–23.

24 Ellenbogen MI, Segal JB. Differences in opioid prescribing among generalist physicians, nurse practitioners, and physician assistants. *Pain Med* 2020;21:76–83.

25 Guy GP, Zhang K. Opioid prescribing by specialty and volume in the U.S. *Am J Prev Med* 2018;55:e153–5.

26 Vilkins AL, Sahara M, Till SR, *et al*. Effects of shared decision making on opioid prescribing after hysterectomy. *Obstet Gynecol* 2019;134:823–33.

27 Krystal JH. Responding to the hidden pandemic for healthcare workers: stress. *Nat Med* 2020;26:639–39.

28 Shechter A, Diaz F, Moise N, *et al*. Psychological distress, coping behaviors, and preferences for support among new york healthcare workers during the COVID-19 pandemic. *Gen Hosp Psychiatry* 2020;66:1–8.