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Leveraging the Prescription Drug Monitoring Program to Curb Opioid Prescribing in Arkansas

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Declarations

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Conflict of Interest

Dr. Goree receives consulting fees from Stratus Medical. All other authors declare they have no conflicts of interest.

Ethics Approval: This research study was conducted retrospectively from data obtained for clinical purposes. We consulted extensively with the IRB of the University of Arkansas for Medical Sciences who determined that our study did not need ethical approval. An IRB official waiver of ethical approval was granted from the IRB of the University of Arkansas for Medical Sciences.

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Abstract

Effective means of accurately identifying problematic opioid prescribing are needed. Using an iterative approach with the Arkansas State Medical Board Pain Subcommittee, we modified existing opioid prescriber criteria to create seven metrics to be deployed in Arkansas. These included metrics of dose and days' supply, concomitant use of opioid and benzodiazepines, solid dosage units, and numbers of opioid patients and certain opioid prescriptions. Two of these metrics (average MME daily dose per prescription and total oxycodone 30 mg or hydromorphone prescriptions) were weighted by 2, creating a maximum score of 9 of which each prescriber could receive. Twenty prescribers with a score of 7 or greater were identified and referred to the Arkansas State Medical Board Pain Subcommittee for review and subsequent investigation if deemed necessary. Of those 20 prescribers, four were previously investigated and under disciplinary action, and three were under current investigation for misconduct related to prescribing practices. Five prescribers had new investigations opened due to the findings from the metrics, and disciplinary action was taken. Therefore, 12 of the 20 prescribers referred to the Arkansas State Medical Board were deemed worthy of investigation and disciplinary action. The Arkansas opioid prescriber metrics are able to accurately identify prescribers with potentially problematic opioid prescribing.

Keywords

Opioids; Opioid prescribing; Policy; Pain

Introduction

The United States (U.S.) is currently facing an opioid epidemic (Compton & Volkow, 2006). Nationally, opioid overdose deaths rose six-fold from 1999 to 2017 (CDC WONDER, n.d.; Overdose Death Rates | National Institute on Drug Abuse (NIDA), n.d.). From July 2016 to September 2017, opioid overdoses rose 30% in 45 states within the U.S. (70%) (Vivolo-Kantor et al., 2018). Although under-documented in electronic health records, lifetime rates of opioid use disorder (OUD) rose from 1.4% in 2002 to 2.9% in 2013 (Saha et al., 2016). The rise in OUD and opioid-related deaths is driven partly by an increase in rates of opioid prescribing. For example, opioid prescriptions issued for chronic pain rose drastically from the 1980s until 2012, despite clinical practice guidelines published in the 2000s advising caution (Alford, 2013; Chou et al., 2009).

The U.S. has implemented many national- and state-level policies in an attempt to curb the opioid epidemic. The U.S. Centers for Disease Control and Prevention (CDC), for example, issued opioid prescribing guidelines for primary care settings that emphasize alternative means of managing chronic pain (Dowell et al., 2016a). Some insurance companies and statewide policy efforts have limited the number of days' supply of acute pain prescriptions (Shah et al., 2017; The Physicians' Quandary with Opioids: Chronic Pain vs. Addiction, n.d.). Most states have also implemented prescription drug monitoring programs (PDMPs).

Most of these are statewide electronic databases that serve as repositories for collected records of controlled substance dispensations from all retail pharmacies in the given state, as mandated by law in that jurisdiction (State Prescription Drug Monitoring Programs, n.d.). PDMPs were implemented to decrease "doctor shopping," i.e., the receipt of duplicate prescriptions of controlled substances from multiple providers, and thereby reduce the availability of inappropriate prescriptions of controlled substances.

Because of these various national and state-level policies and interventions, opioid prescribing is slowly declining; however, the evidence on the effectiveness of PDMPs is mixed (Haegerich et al., 2014). Several studies have shown improved clinical decision-making (Baehren et al., 2010; Green et al., 2012; Weiner et al., 2013), less diversion (Surratt et al., 2014), and decreased doctor shopping (Bonifas, 2014; Pradel et al., 2009; Scott et al., 2013; Viriginia Prescription Monitoring Program: 2010 Statistics, 2010). Other studies have shown that PDMP implementation has been associated with slight decreases in opioid prescribing rates (Curtis et al., 2006; Reisman et al., 2009), including Schedule II opioid prescriptions (Bao et al., 2016) and opioid-related overdose deaths (Patrick et al., 2016). However, another study among disabled Medicare beneficiaries from 2006 to 2012 found no association between reductions in the potentially hazardous use of opioids or overdose and the adoption of controlled-substance laws, including implementation of PDMPs (Meara et al., 2016). Therefore, the current practice of using PDMPs to monitor patient use of controlled substance treatment may be minimally effective.

PDMPs could be used to identify prescribers with potentially problematic prescribing practices to further curtail diversion, overprescribing, and the use of dangerous combination therapy (e.g., concomitant opioid and benzodiazepine prescriptions) in the U.S. where, despite our declining rates, we prescribe four times the amount of opioids as does Europe (Guy et al., 2017). Since PDMPs capture all controlled substance dispensations in a state or locality as well as authorizing prescriber information, PDMPs provide an innovative method for measuring the prescribing practices of all prescribers in a given area. In general, providers with potentially problematic prescribing practices are identified through patient complaints, medical record audits, and pharmacist reporting (Finucane et al., 2003). Previous studies and policy makers have expressed a need for systematic methods that identify potentially problematic prescribers with the intent of referring them to their respective licensing boards and law enforcement (FOSTER, 2012). One analysis of high-risk (e.g., concomitant opioid and benzodiazepine users, patients on chronic opioid therapy) patients in the U.S. found that low-volume prescribers accounted for 18–56% of opioid prescriptions for high-risk patients, indicating a need for opioid prescribing metrics that do not focus simply on opioid prescribing volume (Chang et al., 2018).

Previous opioid prescribing metrics have been created using PDMP data from two states (Kreiner et al., 2017; Ringwalt et al., 2015). Using North Carolina PDMP data, Ringwalt et al. developed and validated a set of prescriber metrics using the association between the individual metrics and whether or not the prescribers' patients for which the prescriber wrote prescriptions for opioids have died of a medication-related overdose (Ringwalt et al., 2015). While a focus on prescriber metrics related to overdose is important, it likely does not adequately capture all inappropriate prescribing, as overdose deaths are only one adverse

outcome of the opioid epidemic (Kolodny et al., 2015). Using Maine PDMP data, Kreiner et al. validated certain prescriber metrics using medical board disciplinary actions as the outcome, which likely better captures inappropriate prescribing as compared to overdose deaths. However, Kreiner et al. validated their metrics relative to past disciplinary action by licensing boards which are generated mostly through complaints, and thus may not capture inappropriate prescribing behavior in which no board action was taken (Kreiner et al., 2017). Therefore, further research is needed to prospectively develop and validate prescriber metrics that are developed in collaboration with investigative and governing bodies such as state medical boards.

Using Arkansas PDMP data, we developed collaborations between healthcare teams from the University of Arkansas for Medical Sciences (UAMS), Arkansas Department of Health (ADH), and Arkansas State Medical Board (ASMB) Pain Subcommittee to create prospective and clinically-driven opioid prescribing metrics to evaluate the opioid prescribing practices of Arkansas health care providers (e.g., physicians, nurse practitioners). Unlike the two previous studies mentioned above, this study describes a process of implementing prescriber metrics and collaborating with the ASMB Pain Subcommittee to determine if the metrics identify, in real time, prescribers with problematic prescribing practices. The objectives of this article are to (i) describe the iterative process of developing the opioid prescribing metrics and (ii) report the results of real-time investigative outcomes secured from the ASMB Pain Subcommittee.

Materials and Methods

Setting

Arkansas was selected because of the collaboration developed in the State among UAMS, ADH, and the ASMB Pain Subcommittee. Furthermore, Arkansas, despite declining opioid prescribing rates, is still second in the nation in the number of opioid prescriptions issued per capita (U.S. State Prescribing Rates, 2016 | Drug Overdose | CDC Injury Center, n.d.). In 2016, Arkansas also ranked third for non-medical use of prescription pain relievers, with 5.21% of Arkansans having used prescription pain relievers for non-medical purposes in the past year (Lipari et al., 2017).

Data Source

Operational since 2013, the Arkansas PDMP collects data concerning dispensed prescriptions for Schedule II-V substances (e.g., hydrocodone, alprazolam). All dispensing pharmacies and veterinary clinics in Arkansas, as well as out-of-state and mail order pharmacies that fill prescriptions for the State’s residents, are required to report to the Arkansas PDMP. The Veterans Affairs medical centers and associated community-based outpatient clinics in Arkansas also willingly report to the Arkansas PDMP. Since 2013, the Arkansas PDMP, operated by the ADH, has captured over 60.5 million prescription records dispensed from pharmacies within Arkansas or from out-of-state pharmacies who mail prescriptions to Arkansas.

Study Design

We conducted a prospective cohort study of Arkansas prescribers from December 2018 through September 2020. This time span encompassed five phases of the study: (1) presentation of prescriber metrics used by Ohio to the ASMB Pain Subcommittee, (2) presentation of the results of a first modification of the Ohio metrics using 2018 Arkansas PDMP data based on ASMB Pain Subcommittee feedback, (3) presentation of the results of a second modification of the Ohio metrics using 2018 Arkansas PDMP data based on ASMB Pain Subcommittee feedback, (4) presentation of results (prescribers with scores ≥ 7) to the ASMB Pain Subcommittee of new Arkansas prescriber metrics (as modified from Ohio's metrics) using January through June 2019 Arkansas PDMP data, and (5) feedback from the ASMB Pain Subcommittee on the results of their investigations of potentially "problem prescribers"—that is, those identified as such by the metrics based on the ASMB's normal investigative processes. Each of these phases are described in more detail below and represented in Figure 1.

Phases 1–3: Opioid Prescribing Metric Development

We used an iterative approach to metric development. In conjunction with the ASMB Pain Subcommittee, we reviewed the current literature (Kreiner et al., 2017; Ringwalt et al., 2015) and the metrics used in Ohio under their PDMP program, called the Ohio Automated Rx Reporting System (OARRS). This system is housed in the State of Ohio Board of Pharmacy, which also has an investigative arm. Like Arkansas, Ohio required OARRS to develop a system of evaluating prescribing practices and reporting potentially problematic prescribers to its investigative arm. They developed metrics (e.g., number of opioid patients, total morphine milligram equivalents (MME) prescribed) similar to those observed in the current literature (Garner, n.d.).

We presented the OARRS metrics to the ASMB Pain Subcommittee in December 2018. Based on this meeting, the ASMB Pain Subcommittee suggested changes to the OARRS metrics. Using 2018 Arkansas PDMP data, we presented the results of the first modification of the OARRS metrics to the ASMB Pain Subcommittee in April 2019. Based on this meeting, the ASMB Pain Subcommittee again provided suggested changes to the modified OARRS metrics. Again using 2018 PDMP data, we presented the results of the second modification of the OARRS metrics to the ASMB Pain Subcommittee in July 2019. Based on this meeting, the ASMB Pain Subcommittee again provided suggested changes to the second modification of the OARRS metrics, which we now consider as the Arkansas prescriber metrics, as described in detail in the next section. The new Arkansas prescriber metrics were then presented to other expert panels for review and approval including the Arkansas PDMP Advisory Board, ADH administration, and Arkansas State Board of Health.

Description of the Finalized, Arkansas Opioid Prescribing Metrics

We developed a total of 7 metrics. These metrics are (1) average MME daily dose per prescription, (2) total MME prescribed over the time period (January-June 2019), (3) number of concomitant opioid and benzodiazepine prescriptions from the same prescriber, (4) average number of solid dosage units (i.e., tablets and capsules) prescribed per opioid prescription, (5) number of opioid days' supply prescribed, (6) number of opioid patients,

and (7) total number of oxycodone 30 mg or hydromorphone prescriptions. A prescriber who was in the top 5% relative to all other opioid prescribers in the state on a given metric received a score of 1 for that metric. Two metrics were weighted (average MME daily dose per prescription and total number of oxycodone 30 mg or hydromorphone prescriptions), as they warranted additional emphasis per the ASMB Pain Subcommittee due to the explicit thresholds set for dosing by CDC guidelines (Dowell et al., 2016b) (average MME daily dose per prescription) and the black market values for oxycodone 30 mg tablets and hydromorphone (Dasgupta et al., 2013). Therefore, the maximum weighted score a prescriber could obtain was 9. The finalized metrics are shown in Table 1 with their corresponding definitions.

Phases 4–5: Metric Assessment: Arkansas State Medical Board Investigations

Using Arkansas PDMP data from January to June 2019, we evaluated the prescribing practices of all prescribers who wrote at least one opioid prescription filled in Arkansas according to the finalized Arkansas metrics. Opioid prescriptions were identified using National Drug Code identifiers for opioid analgesics compiled by the CDC Injury Center (Data Resources | Drug Overdose | CDC Injury Center, n.d.). Prescribers who received a weighted metric score of 7 or greater were identified as potential “problem” prescribers and a roster of those identified as such was presented to the ASMB Pain Subcommittee in August 2019. ASMB investigations were conducted from September 2019 through August 2020. These investigations included an initial review of the prescribers and their respective values for each of the metrics. Next, the ASMB deployed their investigators to review the practice records of each prescriber and assessed their prescribing practices according to current federal and Arkansas laws and statutes.

Data Analysis

Arkansas PDMP data were combined for quarters 1 and 2 of 2019 and merged by National Drug Code with the CDC Oral MME table (Data Resources | Drug Overdose | CDC Injury Center, n.d.). The Oral MME table was used to identify opioid and benzodiazepine prescriptions (Data Resources | Drug Overdose | CDC Injury Center, n.d.). MME conversion factors were also based on CDC publications (Data Resources | Drug Overdose | CDC Injury Center, n.d.). Prescribers were identified using Drug Enforcement Agency (DEA) numbers. Veterinarians were excluded from the analysis as determined by prescriber role type (e.g., DDS, MD, DVM), a self-identifying variable in the Arkansas PDMP that prescribers complete when registering for the PDMP.

We calculated the seven Arkansas opioid prescribing metrics as follows: (1) *Total MME per prescriber:* Total MME per prescription were calculated by multiplying the strength of the medication by the CDC MME conversion factor and the quantity and days’ supply of the prescription. Total MME per prescriber was then calculated by summing the total MME per prescription per DEA number. (2) *Daily MME per prescription:* Daily MME per prescription was calculated by multiplying the strength of the medication by the CDC MME conversion factor and the quantity of the prescription and dividing by the days’ supply of the prescription. Average daily MME per prescription per prescriber, then, was calculated by taking the average of the daily MME per prescription for all prescriptions

for each prescriber. (3) *Concomitant opioid and benzodiazepine prescriptions:* Using the dispense date and days' supply of the prescription, a start and end date was determined for each opioid and benzodiazepine prescription. A patient was considered to have concomitant opioid and benzodiazepine prescriptions if at least one day between the start and end date of both prescriptions was the same. Given that a prescriber may not be aware of a subsequent prescription written by another prescriber, we identified only those patients with overlapping prescriptions where both prescriptions were written by the same prescriber. (4) *Solid dosage units:* After eliminating opioid prescriptions that were liquids, sprays, or patches, the quantity was averaged for each prescriber to derive the average number of solid dosage units prescribed per opioid prescription. (5) *Opioid days' supply:* Total opioid days' supply was calculated by summing the days' supply of each opioid prescription written by each prescriber. (6) *Number of opioid patients per prescriber:* Opioid patients were identified as those patients who were prescribed opioids and were unique individuals as identified by the APPRISS consolidation identifier, a unique identification number given to each unique patient in the PDMP data. (7) *Oxycodone and hydromorphone prescriptions:* Oxycodone and hydromorphone prescriptions were identified using the CDC MME conversion table variable titled "Drug." Oxycodone prescriptions written for 30 milligram tablets were identified if the "Drug" variable had values of "oxycodone LA" or "oxycodone SA." Hydromorphone prescriptions were identified if "Drug" equaled "hydromorphone LA" or "hydromorphone SA." The total number of oxycodone and hydromorphone prescriptions were summed per prescriber. Analyses were conducted using SAS Enterprise Guide 7.1 (SAS Institute Inc., Cary, NC, USA). This study was determined to be non-human subjects' research by the UAMS Institutional Review Board (IRB).

Results

Sample Derivation and Characteristics

Prescribers who wrote at least one opioid prescription from January through June 2019 numbered 5,665. The vast majority of these prescribers were physicians (79.5%), and the second most prevalent group of opioid prescribers were dentists (18.9%). Primary specialties ranged broadly, however; family medicine/general practice (20.1%), dentist/oral and maxillofacial surgery (16.9%), and internal medicine/hospitalist (14.0%) constituted the top three primary specialties. Secondary specialties were mostly unspecified (72.6%). The number of opioid prescriptions issued by individual prescribers ranged from 1 to 11,793 in the 6-month time frame. On average, prescribers issued 198 opioid prescriptions during the period, and the mean average daily dose per prescription was below the CDC guidelines of 50 MME per day (31.1 average daily dose in MME per prescription). The highest percentage of prescribers were from the central (n=722; 21.0%) and the northwest Arkansas areas (n=727; 16.2%), which are the two largest population centers in Arkansas. However, a significant number of providers had practices in several different 3-digit zip code areas of Arkansas (see Table 2; 11.3%).

Arkansas Opioid Prescribing Metrics Results

For each of the seven metrics, the histograms presented in Figure 2A through 2G depict medical providers reported to the Arkansas PDMP as being conservative prescribers (Figure

2A–G). For example, the normal distribution curves for daily MME per prescription show that most prescribers write prescriptions for less than 50 MME each (Figure 2B). However, a few prescribers are writing for greater than 200 MME per prescription, on average. In addition, very few prescribers write concomitant opioid and benzodiazepine prescriptions for the same patient (Figure 2C); however, some prescribers wrote close to 1500 concomitant opioid and benzodiazepine prescriptions for the same patient.

Out of 5,665 prescribers who issued one opioid prescription filled in Arkansas pharmacies, 20 (0.35%) prescribers received a score of 7 or greater on the metrics (see Table 3). Seven (0.12%) prescribers received the max score of 9. Four (0.07%) and nine (0.16%) prescribers received a score of 8 and 7, respectively. Of the 20 prescribers, nine self-identified as family medicine or general practitioners, three identified as pain specialists, two identified as internists, one as an orthopedic surgeon, two as hospice/palliative care specialists, one as a cardiologist, one as a hematologist/oncologist, and one did not specify a specialty.

Results of Arkansas State Medical Board Investigations

In interviews with the ASMB Pain Subcommittee, we found that four on the roster of 20 potential problem prescribers submitted to the ASMB Pain Subcommittee had previously been investigated within recent months by the ASMB before being provided the metric results. Three additional prescribers on the roster of 20 were already under current investigation for misconduct reports related to their prescribing practices. However, the metric results sparked the opening of five new prescriber investigations. After investigation of these prescribers, the ASMB found issues with the number of patients receiving: (1) high MME doses, (2) concomitant use of opioid, benzodiazepines, and stimulants, (3) codeine cough syrup, (4) oxycodone 30 mg tablets, and (5) combinations of oxycodone 30 mg, codeine cough syrup, and cyclobenzaprine. The ASMB also found concerns in lengthy drive times for patients, calls from concerned pharmacists, prescribing of opioids to patients who have children with substance use disorders in the home, failure to address aberrant drug screens, lack of use of urine drug screens overall, prescriptions written without a correlated medical record, cash payments, 5-minute patient time slots, lack of adequate medical record documentation, and overuse of routine labs (e.g., CBC, BMP). All five prescribers are being monitored and undergoing disciplinary action as specified by the ASMB and the Pain Subcommittee.

Discussion

Our process of opioid-prescribing metric development led to the creation of seven metrics: (1) average MME daily dose per prescription; (2) total MME prescribed; (3) number of concomitant opioid and benzodiazepine prescriptions from the same prescriber; (4) average number of solid dosage units prescribed per opioid prescription; (5) number of opioid days' supply; (6) number of patients receiving opioids; and (7) total number of oxycodone 30 mg or hydromorphone prescriptions. If the prescriber was in the top 5% as compared to all other opioid prescribers in the state on a given metric, the prescriber received a score of 1 for that metric. Two of these metrics (average MME daily dose per prescription and total number of oxycodone 30 mg or hydromorphone prescriptions) were weighted by a factor

of 2, creating a maximum score of 9. A roster of prescribers with a score of 7 or greater (total of 20 prescribers) was submitted to the ASMB for review and subsequent investigation if deemed necessary. Of the 20 prescribers sent to the ASMB, 12 were either previously investigated, under current investigation, or deemed worthy of investigation and disciplinary action taken by the ASMB. Therefore, the Arkansas metrics accurately identified prescribers with problematic opioid prescribing practices.

Our metrics are similar to others that have been validated. Ringwalt et al., using North Carolina PDMP data, validated the following 14 metrics against patients who have experienced medication-related overdoses: higher prescriber rates of (1) prescriptions for daily doses of opioids with ≥ 100 MMEs; (2) average daily dose of MMEs; (3) total MMEs for each prescription written; (4) prescriptions for benzodiazepines; (5) prescriptions for stimulants; (6) co-prescribed benzodiazepines and high doses of opioids; (7) temporally overlapping prescriptions for controlled substances; (8) patients who travel the furthest from their homes to their pharmacies; (9) patients who travel the furthest to their providers; and providers with patients who: (10) filled prescriptions for any controlled substance received from the highest number of providers; (11) filled prescriptions for benzodiazepines from the highest number of providers; (12) filled prescriptions for stimulants from the highest number of providers; (13) filled prescriptions for opioids from the highest number of providers; and (14) visited the highest number of pharmacies to fill prescriptions for any controlled substance (Ringwalt et al., 2015). Using Maine PDMP data, Kreiner et al. validated 12 metrics, namely: (1) number of patients for whom one or more controlled substances were written; (2) prescription rates by year, major opioids; (3) prescription rates by year, major stimulants; (4) prescription rates, major benzodiazepines; (5) prescriptions per day; (6) opioid prescriptions per day; (7) MMEs per day prescribed; (8) patients prescribed more than 100 MMEs per day; (9) prescriptions involved in multiple provider episodes; (10) prescriptions purchased with cash; (11) distanced patients traveled to their prescriber; and (12) prescriptions to opioid-naive patients (Kreiner et al., 2017). Our goal was to compile a list of metrics that were not as computationally complex and to reduce their number so that they could be adopted more easily by states. In addition, our metrics were validated in a prospective fashion whereas the Ringwalt et al. and Kreiner et al. metrics were validated retrospectively, which has limitations in adequately capturing inappropriate opioid prescribing practices. For example, the rate of opioid overdoses among a prescriber's patient population may not completely correlate with inappropriate opioid prescribing practices.

During trial hearings before the ASMB, the prescribers under investigation noted several reasons for their prescribing practices. Most commonly, they noted they had inherited these patients from other prescribers, and that these patients had been on these opioid regimens for many years before the current prescriber inherited the patient. Other reasons for their prescribing practices included failed rotations of different opioids, failed tapers or alternative therapies, failed pain management procedures/injections, and lack of pain specialists to whom to refer patients. These reasons suggest the need for more training within primary care for appropriate, evidence-based pain management as well as improved access to multidisciplinary and inter-professional teams for chronic pain management (Peng et al., 2008; Seal et al., 2017).

Some of the existing literature on discontinuing opioid therapy among chronic pain patients suggest an increased risk of opioid overdoses and other opioid-related morbidity. Cicero et al. and Dart et al. evaluated policy-driven reductions in opioids prescribing; both found associations between implementation of these policies and increased rates of heroin use (Cicero et al., 2012; Dart et al., 2015). However, heroin overdoses began rising prior to the implementation of many of the restrictive opioid-prescribing policies (Compton et al., 2016). Studies of patients who have discontinued chronic opioid therapy have noted high rates of suicidal ideation, self-directed violence, (Demidenko et al., 2017) and substance use disorder-related adverse events (Mark & Parish, 2019). Given these findings of potential increased risks with opioid discontinuation, PDMP-based opioid prescribing metrics should be implemented with caution ensuring that harm to the patients is not an unintended byproduct. In addition, research is needed to understand how implementing PDMP-based metrics and more progressive monitoring of these metrics by medical boards may influence unintended outcomes for patients.

In summary, the Arkansas opioid prescribing metrics could be used by other states as a screening tool for further investigation of prescribers with potentially problematic opioid prescribing practices. However, there may be justifiable reasons for these prescribing practices that can be identified only through further, in-depth investigation. Within Arkansas, the ASMB Pain Subcommittee and the ADH have agreed to provide the ASMB with the results of this analysis on a biannual basis. However, the ASMB is clear that these metrics should not be used to justify a prescriber's decision to withhold opioid therapy entirely should it be deemed appropriate. Overall, other states and state medical boards should consider these metrics within their states and localities to validate them further.

Limitations

We acknowledge several limitations to our study. First, PDMP data are limited on prescribers practicing along the state border, because prescriptions written by prescribers there that are filled in a different state are not captured by the state's PDMP. Second, PDMP data does not contain information on the clinical indication for the prescription. Third, the Arkansas PDMP does not capture inpatient opioid exposure. Therefore, we may be underestimating the amount of opioids a hospitalized patient may receive. Fourth, prescribers have many roles. In a rural state like Arkansas, a physician may serve as a family medicine or primary care physician, emergency room physician, and hospice director. Our metrics cannot differentiate in which role a given provider may have written any given prescription. However, the purpose of an array of metrics, as compared to one, is to better assess opioid prescribing practices holistically.

Conclusions

The Arkansas-based opioid prescribing metrics provide a data-driven way to identify potentially problematic opioid prescribers within a state. Collection of the prescribing metrics and close monitoring of problematic opioid prescribers will potentially help in changing the prescribing practices of the providers and thereby reduce the opioid epidemic in the U.S.

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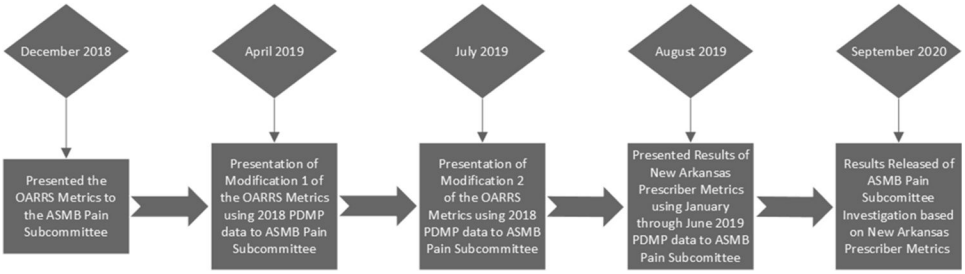
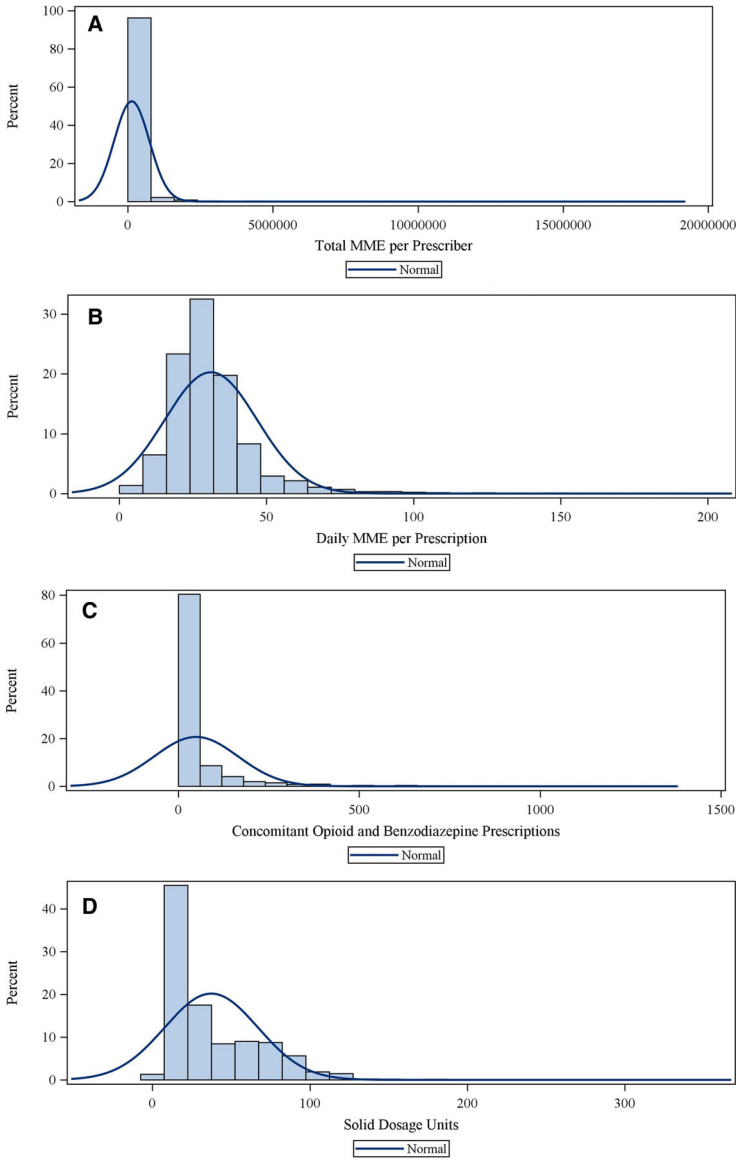


Figure 1.
Study timeline.



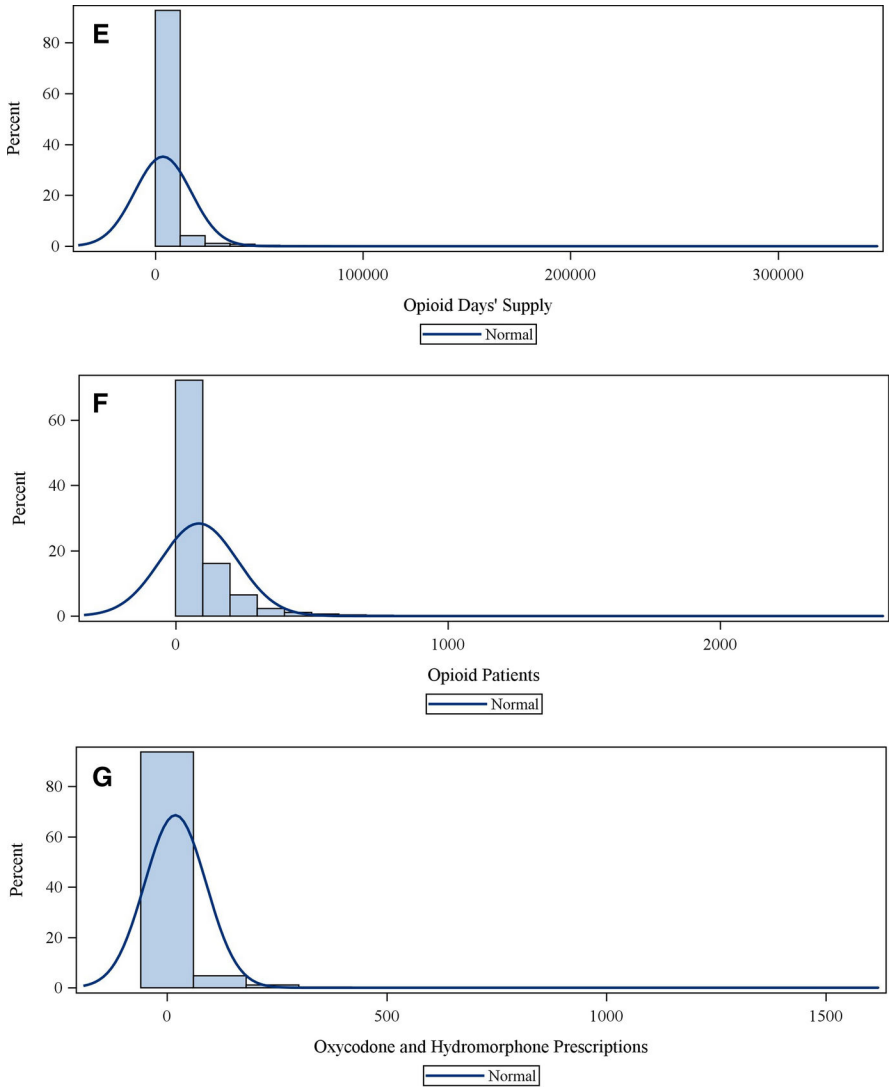


Figure 2.

Histogram of (A) total MME per prescriber, (B) daily MME per prescriber, (C) concomitant opioid and benzodiazepine prescriptions, (D) solid dosage units, (E) opioid days' supply, (F) number of prescribers' opioid patients, (G) oxycodone and hydromorphone prescriptions.

Table 1.

Opioid prescribing metrics

Measure	Definition
Total morphine milligram equivalents (MME) per prescriber	Total morphine milligram equivalents prescribed in the given time frame as defined by multiplying the dose of the prescription by the MME conversion factor and the total number of dosage units for each prescription
Daily MME per prescription	Mean daily dosage per opioid prescription in MME as defined by taking the average of the total number of MME prescribed per provider
Concomitant opioid and benzodiazepine prescriptions	Number of opioid prescriptions where the fill and run out date of the prescription overlapped at least one day with a benzodiazepine prescription issued by the same prescriber for the same patient
Solid dosage units	Mean number of capsules or tablets issued per opioid prescription
Opioid days' supply	Total days' supply of all opioid prescriptions written
Opioid patients	Number of patients for whom one or more Schedule II, III, or IV opioid prescriptions were written
Oxycodone and hydromorphone prescriptions	Total number of oxycodone 30 mg and hydromorphone prescriptions, of any strength, written

Table 2.

Prescriber demographics

***N*=5665**	**Prescribers *n* (%)**
Prescriber Professional Type	
MD/MBBS/DO	4505 (79.5%)
PA	11 (0.2%)
NP	1 (0.02%)
DDS/DMD	1069 (18.9%)
DPM	63 (1.1%)
PharmD	16 (0.3%)
Prescriber Specialty: Level 1	
Family Medicine/General Practice	1136 (20.1%)
Dentist/Oral and Maxillofacial Surgery	959 (16.9%)
Internal Medicine/Hospitalist	795 (14.0%)
Emergency Medicine	354 (6.2%)
Obstetrics and Gynecology	218 (3.8%)
Orthopedic Surgery	171 (3.0%)
Pediatrics	155 (2.7%)
Surgery	145 (2.6%)
Psychiatry/Neurology	138 (2.4%)
Other	585 (10.3%)
Unspecified	1009 (17.8%)
Prescriber Specialty: Level 2	
General Practice	384 (6.8%)
Hematology/Oncology	67 (1.2%)
Psychiatry (General Practice)	66 (1.2%)
Pain Medicine	54 (1.0%)
Geriatric Medicine	52 (0.9%)
Hospice/Palliative Care	45 (0.8%)
Interventional Pain Medicine	42 (0.7%)
Pediatric Dentistry	40 (0.7%)
Other	804 (14.2%)
Unspecified	4111 (72.6%)
Number of Opioid Prescriptions	
Minimum	1
Maximum	11793
Mean (Standard Deviation)	197.97 (509.31)
Median	54
Total Morphine Milligram Equivalents (MME)	
Minimum	1.8
Maximum	18895224.5
Mean (Standard Deviation)	136299.4 (607092.1)

***N*=5665**	**Prescribers *n* (%)**
Prescriber Professional Type	
Median	7267.5
Average Daily Dose in MME per Prescription	
Minimum	1.1
Maximum	204.3
Mean (Standard Deviation)	31.1 (15.75)
Median	28.7
Region (by 3-Digit Zip Codes)	
716	188 (3.3%)
717	118 (2.1%)
718	81 (1.4%)
719	265 (4.7%)
720	349 (6.2%)
721	410 (7.2%)
722	1190 (21.0%)
723	163 (2.9%)
724	425 (7.5%)
725	143 (2.5%)
726	196 (3.5%)
727	915 (16.2%)
728	137 (2.4%)
729	414 (7.3%)
Outside Arkansas	30 (0.5%)
Multiple Zip Codes	641 (11.3%)

Table 3.

Top 20 prescribers and their values on the Arkansas prescriber metrics

Prescriber	Self-Identified Specialty	Total MME	Average MME per Day	Total Days' Supply	Patient Count	Average Quantity	Total Oxycodone 30 milligrams and hydromorphone prescriptions	Concomitant Opioid and Benzodiazepine Prescriptions	Weighted Metric Count
1	Family Medicine	5323462	78.08	68352	539	117.53	263	604	9
2	Family Medicine	4045286	69.14	55074	597	108.92	139	560	9
3	Internal Medicine	4163318	70.85	60673	346	114.47	155	634	9
4	Family Medicine	4380905	64.71	66696	541	105.01	149	909	9
5	Internal Medicine (Hospice and Palliative Care)	4025384	84.83	49055	440	95.50	185	298	9
6	General Practice	5883517	58.29	100793	735	99.53	366	626	9
7	Pain Medicine	8523667	60.85	137186	1316	101.57	288	286	9
8	Family Medicine	2413809	91.99	26863	192	122.41	207	288	8
9	Orthopedic Surgery	2566464	60.38	39980	502	93.64	76	124	8
10	Internal Medicine	3335990	59.52	56047	401	118.34	202	56	8
11	Family Medicine	2561537	70.41	44711	766	63.70	116	691	8
12	Internal Medicine (Hospice and Palliative Care)	1529884	138.96	13675	474	47.73	148	537	7
13	Internal Medicine (Cardiovascular Disease)	4743128	94.60	50409	273	105.03	391	38	7
14	Family Medicine	2476899	63.31	39043	324	131.03	20	399	7
15	Family Medicine	4391408	54.26	82425	572	96.20	239	1374	7
16	Internal Medicine (Hematology and Oncology)	1681779	84.38	19691	226	106.48	109	166	7
17	Pain Medicine	12200574	56.11	219498	1379	96.04	212	473	7
18	Unspecified	2168232	65.88	33254	363	80.54	74	169	7
19	Physical Medicine and Rehabilitation (Pain Medicine)	6589523	75.61	85893	375	82.52	636	19	7
20	Family Medicine	2160571	58.72	36937	356	109.06	58	244	7