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Prescription Drug Monitoring Programs and the Opioid Crisis: Assessment of State Operating Agency on Reducing Prescription Rates and Opioid Deaths

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Abstract

ABSTRACT

Importance: A number of strategies and policies have been implemented to mitigate the opioid crisis, including state Prescription Drug Monitoring Programs (PDMPs) that are used to track and compile patient prescription data. Because PDMPs are run independently by states, different characteristics of PDMPs can impact success rates of the programs in controlling opioid prescriptions and overdose deaths.

Objective: To assess the association between PDMP operating agency type and opioid prescriptions and opioid overdose death rates.

Research Design: The study utilized time-series data provided by the CDC and KFF, which included information for 49 states and Washington D.C. with effective PDMPs. The impact of state operating type was analyzed using regressions that controlled for the presence of a mandate. A qualitative portion was conducted through an online opt-in survey that was sent out to emergency medicine, pain management, and primary care physicians.

Main Outcome and Measures: The unit of observation was state-years, and the study period was 2006 to 2016 for opioid prescription rate and 2000 to 2017 for opioid overdose death rates.

Results: Using opioid prescription rates, PDMPs with health-facing agencies combined with a mandate decreased prescriptions by approximately 26 prescriptions per 100 individuals, which was statistically significant at the 0.1% level. While most of the specific six agency types also decreased prescription rate, most coefficients were not statistically significant. Looking at opioid overdose death, PDMPs with health-facing agencies showed approximately 6 fewer deaths per 100,000 population, reaching statistically significance at the 0.1% level. Similarly, broken down by specific agency type, most of these coefficients did not reach similar statistically significant. The qualitative survey revealed that the majority of physicians are aware of Pennsylvania's PDMP operating agency. In addition, these physicians routinely check the PDMP for patient prescription information, and 75.5% of participants have changed their patients' prescription plan after viewing the PDMP.

Conclusions and Relevance: These findings suggest that operating agency type impacts effectiveness of PDMPs in controlling for prescription rates and opioid overdose deaths. To maximize impact, health-facing agencies should implement and operate PDMPs.

Keywords

opioid, prescription, death, overdose, policy

Disciplines

Health Law and Policy | Health Policy | Patient Safety

PRESCRIPTION DRUG MONITORING PROGRAMS AND THE OPIOID CRISIS:
Assessment of State Operating Agency on Reducing Prescription Rates and Opioid Deaths

By

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INTRODUCTION

The opioid epidemic is one of this country's most pressing health concerns, affecting public health in addition to social and economic welfare. The U.S. Department of Health and Human Services (HHS) declared a public health emergency in 2017 and announced accelerated appointments of specialized personnel to develop regulations and policy guidelines to address the emergency (Haffajee and Frank 2018). Earlier this year, HHS announced it would provide almost $2 billion in funding for opioid-specific activities, including to support state and local society groups, education, treatment and recovery services, response assistances, and more (Mishra 2019). A recent study from researchers Florence, Zhou, Luo, and Xu (2016) conducted by the Centers of Disease Control and Prevention estimates an "economic burden" of over $78 billion per year in 2013, caused specifically by misuse of opioid prescriptions. This accounts for a variety of societal implications, including productivity losses, healthcare costs, public health expenditures, legal and criminal justice involvement, and addiction treatment. Abuse and misuse of prescription opioids has caused over 17,000 drug overdose deaths in 2016 (CDC Wonder 2017), a number that has been increasing steadily over the past decade (*Figure 1*). In addition, approximately 21-29% of patients will misuse opioids prescribed for chronic pain (NIDA 2019). Such statistics depict the urgency and need of better policymaking in the face of crisis.

Opioids are a specific class of drugs that work through activating opioid receptors on nerve cells, which block the feelings of pain between the brain and the body (Muldoon 2019). Over the past decade, deaths involving opioids have skyrocketed, from just under 10,000 deaths in 1999 to more than 42,000 in 2016, as noted by Jones et al. (2018). A few select key reasons can be attributed to this increase, starting with a shifting notion that pain, as a medical symptom, was highly undertreated. The World Health Organization addressed this undertreatment of pain in its

Cancer Pain Monograph in the early 1990s and prompted a rapid progress of pain treatment in various types of cancers. However, up to this point, opioids were only treated for cancer pain and strictly avoided in chronic pain conditions, with the fear that increasing the length of time a patient was on opioid medication was associated with a higher likelihood of abuse or misuse (Rosenblum, Marsch, Joseph, and Portenoy 2008). The combination of physicians questioning why opioids were only used in high-intensity cancer pain and launch of American Pain Society's impactful "pain as the fifth vital sign" paved the way for opioids to be medically prescribed for chronic non-cancer pain treatment, as explained by Morone and Weiner (2013). The Joint Commission, Federation of State Medical Boards, and Drug Enforcement Agency all approved measures that encouraged opioid prescriptions to adequately manage pain and lessened the regulatory scrutiny over physician prescribers (Baker 2017). Concurrently during this time period in 1996, Purdue Pharma released and aggressive marketed OxyContin as the first line of treatment for non-malignant, non-cancer pain (Van Zee 2009). While OxyContin was designed to provide 12 hours of continuous pain relief, the pill could be crushed easily, allowing users to experience an intense high. As a result, OxyContin became one of the most commonly abused drugs (Alpert, Evans, Lieber, and Powell 2019). All of these activities laid the foundation for the dramatic uptake of prescription-based opioid for cancer pain, and most importantly, non-cancer chronic pain.

Opioid Prevention Strategies

With this increase in opioid prescription rates, a large focus over the past few years has been on prevention and reduction of prescription opioid use. The U.S. Food and Drug Administration outlines four key strategies: reducing the harm associated with opioid use, decreasing opioid demand, limiting the lawful supply of opioid medications, and influencing physicians' prescribing practices (Gross and Gordon 2019). Harm reduction policies focus on

limiting and reducing the level of harm associated with opioid and narcotic use, including increased access to naloxone, an opioid antagonist that can reverse the respiratory effects caused by overdoses, and clean syringe exchanges (Lynn and Galinkin 2017). Demand-reduction policies concentrate on limiting the demand of opioid through substance abuse programs, addiction treatment programs, and special medication-assisted treatment programs through FDA-approved opioids such as methadone, buprenorphine, and extended-release, injectable naltrexone as described by Alderks (2017). While demand-reduction policies can be effective, such efficacy relies on those to experience opioid abuse to self-enroll in substance abuse and addiction treatment prgrams. However, many believe that the most useful types of programs focus on reducing opioid supply and changing prescriber patterns (Bonnie, Ford, and Phillip 2017). Such programs include state-run Prescription Drug Monitoring Programs, increased prescriber education and training, abuse-deterrent drug reformulations, and additional black box drug warnings to avoid possibility of overprescribing, reduce diversion, and discouraging drug misuse (Alpert, Powell, and Pacula 2017; Clark and Schumacher 2017).

Prescription Drug Monitoring Programs

Prescription Drug Monitoring Programs (PDMPs) are one type of supply-side programs that focus on changing prescriber programs to reduce opioid supply. Characteristics of PDMPs differ across states, as implementation of these programs is on a state-by-state basis. Such features that vary across states' PDMPs include various operational and administrative differences, such as the operating agency, levels of drug schedules tracked, data collection and updating frequency, mandated physician and prescriber viewing, inter-state data sharing, among other factors (Manasco et al. 2016). While the majority of these factors have been studied by a variety of researchers, one such operational feature that has been lacking in current research is the impact of the operational

agency. There are six different types of agencies that run PDMPs: state Pharmacy Boards, state Department of Health, Law Enforcement, Professional Licensing Agency, Substance Abuse Agency, and Consumer Protection Agency. Because such agencies have different missions and goals, it is important for policymakers and law officials to determine which agency can best run the PDMPs and have the greatest impact on limiting prescription opioid access. This paper will attempt to quantify the impact operating agency has opioid prescription rates and opioid overdose deaths. Because each state is responsible for enforcing their own PDMP, it is important to understand specific features of efficient PDMPs to better provide states policy makers with a guideline of how they should structure and operate their PDMPs. Given this information, policy makers and public health officials can develop more operationally successful PDMPs.

OVERVIEW OF CURRENT RESEARCH

Prescription Drug Monitoring Programs (PDMP)s are state-level programs that that collect, monitor, and analyze prescription dispensing data submitted by physicians and practitioners. Used to support public health efforts in education, research, and abuse prevention, PDMPs have been implemented to help physicians track and control certain prescriptions, which is especially useful for highly addictive medicines such as opioids (Calvert and Campo-Flores 2016). This prescription data is provided to physicians, pharmacists, and health practitioners with the goal of providing prescribing entities broader information of a patient's health history to minimize opioid misuse or abuse (Islam and McRae 2014). Such information is also shared with insurance programs, healthcare licensure boards, state and federal public health departments, and law enforcement to better develop policies and procedures (*Figure 2*). PDMPs have been utilized in the past in reducing prescription drug abuse and diversion, including for narcotics, tranquilizers, and stimulants. While these programs serve as information databases, PDMPs do not interfere with

appropriate medical use, and PDMPs do not serve as a barrier to necessary prescribing for patients with legitimate concerns (Finklea, Sacco, and Bagalman 2014).

Originated from law enforcement mechanism, PDMPs function as a statewide electronic database that stores and analyses prescribing and dispensing data for drugs and medications classified as Federal controlled substances (Center for Medicare & Medicaid Services 2016). Physicians and dispensers in all medical fields can use this data to both better understand a patient's prescription history, which can act as an informative tool in increasing awareness of highly dangerous and active controlled medications (Irvine et al. 2014). With this increase in knowledge, physicians and dispensers are generally more motivated to be more mindful in their prescription given the medical history of a patient. For example, patients who have taken a Schedule II drug for a continuous amount of time may be labeled as high-risk for an opioid-medication, critical information that a physician should consider prior to prescribing. In many states, physicians and prescribers are mandated to view their respective states' PDMP prior to prescribing any medication as an added cautionary metric, which aims to control who is able to receive opioids. As so, PDMPs act as both a check point for patients and prescribers; patients who have long and unusual histories of being on certain medications will likely be flagged as high-risk by physicians, and physicians who have histories of over-prescribing will also likely be flagged as high-risk by law enforcement and other state and federal agencies (Irvine et al. 2014).

The first PDMP was established by California in 1939, which tracked and monitored prescriptions for various schedule II drugs, including morphine, opium, among other medications. Hawaii, Illinois, Idaho, and New York followed shortly after. A large number of states enacted PDMPs after the passing of the Harold Rogers Prescription Monitoring Program in 1996, which provided initial guidelines and funding for states that desired to develop PDMPs (Elder and Pines

2018). Currently, 49 states, D.C., and Guam have PDMPs have legislation in place that authorizes PDMPs; Missouri is the only state has not implemented a PDMP (Haffajee, Jena, and Weiner 2015), though the state has attempted to pass program over seven different times. As a result, Missouri falls among the top ranked states for overdose rates, opioid prescriptions, and arrests related to illegal drug and narcotic use (Weber 2018). A recent article estimated that if Missouri were to adopt a PDMP with robust features, overdose deaths would decrease by over 600 per year (Patrick, Fry, Jones, and Buntin 2016).

General Effectiveness of State PDMP Programs

One of the most important questions surrounding PDMPs focuses on its effectiveness, particularly in reducing rates of drug overdoses, opioid-specific overdoses, opioid prescription rates, among other metrics. The research, however, is conflicting. Most papers differ on methodology, dependent variable metrics, statistical analysis procedures, etc.

Most high-level analysis on overall effectiveness of PDMPs often find that PDMPs are not that impactful. A recent report that focuses on the wide-scale impact of opioid prescription rates after implementation of PDMP program found that there is no consistent pattern of discernible change through studying four outcome measures: opioid prescribing, opioid diversion and supply, opioid misuse, and opioid-related morbidity and mortality (Finley et al. 2017). This variation is likely due a large number of factors, variations in study design, methods, inconsistent measures of impact across the studies, and measurement of PDMPs across multiple states. In addition to study disparities, there are discrepancies in the PDMP design itself; some states update data in their PDMPs less frequently, some states mandate physicians to consult with the PDMPs before writing prescriptions and other states vary in the responsibility that they place in physicians for mis-prescribing. All these differences amount variations in accuracy, timeliness, and reliability of the

data, which inevitably interferes with the effectiveness of PDMPs. Researchers Paulozzi, Kilbourne, and Desai (2011) studied the impact the PDMPs also concluded that implementation of PDMPs were not significantly associated with lower rates of opioid overdose mortality or lower rates of opioid prescription and consumption through their six-year observational study in the US. While potentially an effective way to minimize opioid-related deaths and decrease prescription rates, the overall effect of PDMPs appeared to be quite minimal. Similar to many other research articles published, the authors ultimately from this study concluded that evidence that PDMP implementation affects overdose rates is largely insufficient to firmly conclude its effectiveness; select states actually experienced an increase in opioid and heroin abuse rates after implementation of PDMPs (Fink et al. 2018). When using drug overdose mortality rates as a unit of measurement, researchers Nam, Shea, and Shi (2017) established that PDMPs were not associated with any reductions in drug overdose mortality rates and could be actually related to increased use from other illicit drugs. As so, through this research, a majority of arguments that look at general influence of PDMPs contend that effectiveness of these programs is not highly impactful.

Specific Robust Characteristics of Select PDMPs

Because studies have generally shown the effectiveness of PDMPs to be unclear, many researchers have conducted deeper dives into understanding the association between certain characteristics of PDMPs and its specific impact on controlling opioid prescription rates. Because PDMPs are implemented on a state-by-state basis, many features are variable and are not constant across different states' program, for example mandating prescribers to access the PDMP prior to prescribing, data updating frequency, the level of drug schedule monitored, among other factors (Manasco et al. 2016). Thus, researchers have begun to break down specific characteristics of PDMPs to understand which features increase effectiveness of these programs.

One significant feature is the impact of mandatory PDMPs, in which physicians and dispensers are required to view a patient's prescription history from the PDMPs before prescribing. In the specific case of emergency physicians, researchers Suffoletto, Lynch, Pacella, Yealy, and Callaway (2018) established that opioid prescribing did decrease significantly, and its findings support mandating PDMP programs. Such "must access" PDMPs meaningfully reduce opioid misuse metrics in Medicare Part D when compared with PDMPs that do not implement this provision, a finding critical to a paper by Buchmueller and Carey (2018). In another conducted by researchers in the journal Drug and Alcohol Dependence, researchers Strickler et al. (2019) discussed how mandatory use laws for PDMPs increased prescriber registration and utilization of the program, which resulted in lower rates of opioid prescribing and overlapping opioid prescribing in two specific states.

Other robust characteristics that have been studied are the frequency of data reporting, schedules of drugs monitored, inter-state data reporting, and access to PDMP information by law enforcement. Not surprisingly, those programs in states with higher frequency of data reporting tend to see a slower increase in prescription opioid-related poisoning rates in a nationally-represented study of privately insured adults (Pauly, Slavova, Delcher, Freeman, and Talbert 2018). Researcher Bryce Pardo (2017) concluded that states with generally stronger PDMPs have fewer prescription opioid overdose drug deaths than states with weaker PDMPs in the period between 1999 and 2014. Pardo defines strength as the presence and importance of certain characteristics, such as data reporting frequency, the amount of drug schedules monitored, access for law enforcement, inter-state data sharing, and the presence of an oversight board. The importance of high data reporting and greater drugs supervised is further advanced by this study, which discovered that while PDMPs had great variation, they were in general associated with

reductions in opioid-related death rates, especially if the PDMP had a higher number of robust characteristics, such as monitoring four or more drug schedules and updating data on a weekly or daily basis (Patrick, Fry, Jones, and Buntin 2016). Pauly et al. (2018) also concluded that states that monitored more schedules experienced fewer increases in the risk of prescription opioid-related poisoning over time. Lastly, operational PDMPs, defined as being accessible to both law enforcement and prescribers, was noted as another key characteristic that strongly correlates with decreasing prescriptions rates over time (Pauly et al. 2018).

Proposed Research Goals

In addition to the differences in characteristics of PDMPs, the implementation agency also varies on a state-by-state level. No studies have currently been conducted examining the effects of these administrative differences on opioid overdose death rates and opioid prescription rates. Each state is able to enact and authorize their PDMPs through the department they believe has the resources to properly oversee and handle this database. A variety of state agencies administers PDMPs, including state Pharmacy Boards, state Department of Health, Law Enforcement, Professional Licensing Agency, Substance Abuse Agency, and Consumer Protection Agency (*Figure 3*). Because each agency may have slightly different objectives, effectiveness of PDMPs may relate heavily with the administering agency.

PROPOSED METHODS & ANALYSIS

Research Question

This paper will aim to analyze and discuss the effects of overall agency type and effects of the specific operating agency on opioid overdose death rates and opioid prescription rates. Different agency types that run such PDMP programs may have conflicting interests that may make them more or less strict when defining specific terms and characteristics of their PDMP.

Regression analysis will be based on similar methods outlined in a paper by Buchmueller and Carey (2018), which looked at the impact of PDMPs on rates of opioid misuse, and a paper by Wang (2019), which examined the influence of health information technology in reducing opioid related mortality.

Research Data

The independent variable will be the specific operating agency that runs the PDMP. The website *Prescription Drug Monitoring Program Training and Technical Assistance Center* contains detailed information about each states' PDMP program; for each state, the websites list the specific agency responsible for monitoring the PDMP (ex. Alabama's PDMP is run by the Alabama Department of Public Health).

Dependent variables will be the opioid overdose death rates and opioid prescription rates. Age-adjusted opioid overdose death rates are archived on the *Kaiser Family Foundation* website, broken down by year and by state. In analyzing prescription opioid rates, the *Center for Disease Control* or CDC has available data for both rates of medically recorded opioid prescriptions on a yearly state-by-state basis.

Empirical Strategy: Effect of Agency Type & Specific Operating Agency

The principal empirical analysis will be split into two parts. First, the overall impact of an *agency type* will be analysis by determining the differences on opioid prescription rate and opioid overdose deaths. Agency type will be defined by determining the main industry focus or goal of who that agency serves to benefit. The six different agencies that run PDMPs are state Pharmacy Boards, state Department of Health, Law Enforcement, Professional Licensing Agency, Substance Abuse Agency, and Consumer Protection Agency. *Health-facing* agency types will be defined as agency types that focus specifically on the medical and health implications of any policy. Out of

the six agencies, state Pharmacy Boards, state Department of Health, and Substance Abuse Agencies will be categorized as *health-facing* agency types. *Consumer-facing* agency types will be defined as agency types that exist to serve the interests of the end consumer through enacting policies that impact consumer safety and product usage. Three agency types, Law Enforcement, Professional Licensing Agency, and Consumer Protection Agency will be categorized as *consumer-facing* agency types. I hypothesize that *consumer-facing* agencies would likely have greater reduction in opioid overdose rates and opioid prescription rates given these agencies exist to purposely serve consumers and protect consumers' well-being. These agencies have fewer ties to physicians and prescribers, and perhaps would be less likely to be influenced by advice and recommendations provided by medical clinicians. The first regression model will test the impact of state operating agency type on a yearly basis on opioid prescription rate and opioid overdose deaths. The regression model will be:

$$y_{st} = \delta_s + \delta_t + \beta_2(mandate) + mandate*(healthagencies) + \varepsilon_{st}$$

where y is an outcome variable aggregated over a state-year and *mandate* is an indicator variable that equals one if a state has mandated physician/prescriber enrollment or query and equals zero if a state does not have mandated physician/prescriber enrollment or query. The variable *healthagencies* will also be coded similarly as healthagencies will equal 0 and consumer-facing agencies will equal zero. Two different outcomes (y_{st}) will be tested: age-adjusted opioid overdose death rates and opioid prescription rates. Each regression will contain fixed effects for states (δ_s) and years (δ_t) to account for any differences between states and years, respectively. In addition, standard errors will be clustered at the state-level (ε_{st}).

Second, the effect of each specific agency on PDMP effectiveness will be tested by determine the differences in the same two dependent variables opioid prescription rate and opioid

overdose deaths. Six different operating agencies will be tested: state Pharmacy Boards, state Department of Health, Law Enforcement, Professional Licensing Agency, Substance Abuse Agency, and Consumer Protection Agency. I hypothesize that agencies targeted with managing consumer behavior such as Law Enforcement and Consumer Protection Agencies will result in a more effective PDMP with lower opioid overdose rates and opioid prescription rates. The second regression model will be:

$$y_{st} = \delta_s + \delta_t + \beta_2(mandate) + mandate*(deptofhealth) + mandate*(consumerprotection) + mandate*(professionallicensing) + mandate*(lawenforcement) + mandate*(substanceabuse) + \varepsilon_{st}$$

where similarly, *y* is an outcome variable aggregated over a state-year and *mandate* is an indicator variable that equals one if a state has mandated physician/prescriber enrollment or query and equals zero if a state does not have mandated physician/prescriber enrollment or query. Likewise, the variable *healthagencies* will equal one and consumer-facing agencies will equal zero. Two different outcomes (y_{st}) will be tested: age-adjusted opioid overdose death rates and opioid prescription rates in each of the six operating agency types. This regression will also contain fixed effects for states (δ_s) and years (δ_t) with standard errors clustered at the state-level (ε_{st}).

In both empirical analyses, only states with mandated PDMPs will be used in this study. Many research papers have proved that the statutory mandates that require prescribers to register with their respective state's PDMP and use it are significantly more effective in opioid prescriptions and opioid-related deaths (Suffoletto et al. 2018; Buchmueller and Carey 2018; Wen, Schackman, Aden, and Bao 2017). Because this metric is fairly common one where over half of states have instituted this policy, analysis for this paper will look at the effect of operating agency in states with mandated PDMP programs.

Qualitative Analysis: General Perception of PDMPs

A second part of the analysis will contain a qualitative portion that determines the general sentiment and behavior associated with Pennsylvania's PDMP. More specifically, this section will aim to address how Pennsylvania's PDMP, which is by the PA Department of Health, impacts effectiveness in lowering opioid prescription rates and opioid overdose rates by concentrating on physician and prescriber behavior patterns and overall usage. Perceptions of a PDMP could affected by how intensely and carefully users view and utilize information provided by PDMPs. These insights can be analyzed through a structured survey of physicians that contain qualitative data that question about the usage of PDMPs, such as how often physicians check PDMPs before prescribing, and if physicians ever change prescription schedules due to uncovered PDMP data (Hildebran et al. 2014; Leichtling et al. 2016). Physicians who have shown to find PDMP utilization the most valuable, including emergency medicine physicians, pain management, and primary care physicians, will be the participants in this survey (Irvine et al. 2014). The goals of this analysis aim to determine how the presence of PDMP operated by a certain agency qualitatively impact clinical use and analyze potential patterns of PDMP use by physicians.

EMPIRICAL RESULTS

Effect of Operating Agency on Opioid Prescription Rates

Operating agency type for each state can be found on *Table 1* in addition to information regarding the presence of a mandate. Having a mandate is defined as a PDMP mandating physician/prescriber enrollment or query, information provided by the *Prescription Drug Monitoring Program Training and Technical Assistance Center*. *Table 2* and *Table 3* report the results of the time series regression analysis using retail opioid prescription rates dispensed per 100 individuals as the dependent variable. Years 2006 to 2016 for all 49 states including

Washington D.C. are included in the time series, which were provided in the CDC data set. Missouri is eliminated as it is the only state that has not implemented a PDMP at the time of study. The effect of the mandate was accounted for as an indicator variable as shown in both *Tables 2* and *3*.

Table 2 looks at the significance of and compares retail opioid prescription rates health-facing agencies against consumer-facing agencies. All of the point estimates, including the year measurements, presence of a health-facing agency, and presence of a health-facing agency combined with a mandate, show statistical significance. The presence of a mandate, which has been previously identified as an importance factor in PDMP effectiveness, is statistically significant in this analysis as well and corroborates similar studies on mandates. The presence of just a health agency alone reduces opioid prescription rates by approximately 15 prescriptions per 100 individuals, resulting in a statistically significant at the 5% level. Examining the combined impact of a mandate with a PDMP that is implemented and operated by a health-facing agency further reduces the rate of opioid prescriptions by almost 26 prescriptions per 100 individuals compared with consumer-facing operating agencies. The presence of a health-facing agency such as the Department of Health, State Pharmacy Board, and Substance Abuse Agency, operating the PDMP displays statistical significance at the 1% level, showing statistically significant to a high degree. Hence, this data reflects the overall benefit of having a health-facing agency operate and implement a PDMP compared to a consumer-facing agency.

A second analysis using opioid prescription rates was conducted on the individual impact of the four most common operating agencies, Department of Health, Pharmacy Boards, Law Enforcement, Professional Licensing. The results are reported in *Table 3*. Similar to the previous analysis, 49 states and Washington D.C. were included for years 2006 to 2016. Given there were

only three states—Maine, Maryland, and North Carolina—with a PDMP run by a Substance Abuse Agency, and only one state—Connecticut—with a PDMP operated by a Consumer Protection Agency, both Substance Abuse Agency and Consumer Protection Agency coefficients should be interpreted with caution. Due to collinearity, the interaction between mandate and Consumer Protection Agency and mandate Substance Abuse Agency were not available. Compared to a state Pharmacy Board, the presence of the Department of Health and Professional Licensing Agency alone, respectively, both show a decrease in retail opioid prescription rates. However, both these points estimates are not statistically significant at the 5% level. The individual impact of a Law Enforcement department operating and implementing a PDMP resulted in an opposite intended effect, in which opioid prescription rates increased by 26 prescriptions per 100 individuals, reaching statistically significance at the 1% level. This outcome may be affected by a relatively smaller sample of four states with Law Enforcement, which may create limitations in identifying the actual impact. Once combined with the effects of a mandate present in the PDMP, both Department of Health and Professional Licensing experienced decreased retail prescribing rates by one and 16 prescriptions per 100 individuals, respectively, although both did not reach statistically significance. The only operating agency, when combined with a mandate, that shows significance is Law Enforcement, likely for similar reasons as stated previously. The data shows that once effectiveness of PDMPs are broken down into each specific operating agency type, operating agency type likely does not matter given only one operating agency reached statistical significance.

Effect of Operating Agency on Opioid Overdose Death Rates

In addition to analyzing the effects on opioid prescription rates, another consideration is the impact of operating agency type on opioid overdose death rates per 100,000 population, as

provided by the Kaiser Family Foundation. The presence of a DPMP program not only encourages prescribers to be more aware of the frequency and dosage of opioid medications, but also further impacts usage and drives down adverse death rates from opioid overdose. Years 1999 to 2017 for 49 states, excluding Missouri, and Washington D.C. are included in this model.

Table 4 looks at the significance of and compares opioid overdose death rates for health-facing agencies against consumer-facing agencies. The first analysis from *Table 4* examines the impact of a state health-facing agency implementing and operating the PDMP. Both the presence of a mandate and the presence of a health-facing agency running and operating the PDMP lead to decreases in opioid overdose death rates of two deaths and four deaths per 100,000 population, respectively. The health-facing agency impact also show statistical significance, with a reaching statistically significance at 1%. After accounting for the effects of the mandate, the combined impact of the mandate in addition to the presence of a health-facing agency shows an even larger drop of six deaths per 100,000 population in opioid overdose death rates. With statistical significance of 5%, such results show very high statistical significance for the effectiveness of PDMPs implemented and operated by health-facing agencies.

The second analysis that utilized opioid overdose death rates looked at the individual impact of the four most common operating agencies, Department of Health, Pharmacy Boards, Law Enforcement, and Professional Licensing. Substance Abuse Agency and Consumer Protection Agency are again excluded due to the low number of states. Results are shown in *Table 5*, and again, 49 states excluding Missouri, and Washington D.C. are included in this analysis. Similar to the previous regression, the interaction between mandate and Consumer Protection Agency and mandate Substance Abuse Agency were not available due to collinearity reasons. Excluding the impact of the mandate and examining the isolated impact of each operating agency

types reflect findings opposite of previous models. This set of outcomes reflects a shift in overall PDMP effectiveness as opioid overdose death rates increase for PDMPs run by the Department of Health, Law Enforcement, and Professional Licensing agencies by five deaths, six deaths, and 4 deaths, respectively, when compared to Pharmacy Boards. In addition, both Department of Health and Law Enforcement reaches statistically significance of 1%. However, due to the small number of states with Law Enforcement as their operating agency, this data may reveal a trend over a correlation. When the impact of the mandate is considered in this analysis, the model shows decreases in opioid overdose death rates for Department of Health, Law Enforcement, and Professional Licensing Agency of eight, 12, and seven deaths per 100,000 individuals when compared to Pharmacy Boards. In addition, all three operating agencies, when combined with the effect of the mandate, display statistical significance of 5%. Such results may signal that it may not be the operating agency responsible for the decreases in opioid overdose death rate, but the overall presence of a mandate.

Regression Analysis: Model Assumptions and Limitations

This analysis rests upon a variety of assumptions made in the model. While year fixed effects are included in the regression, state fixed effects could not be included due to effects of collinearity as operating agency type does not vary within a state. Therefore, the exact degree of coefficients calculated in opioid prescription rates and opioid overdose death rates does not account for state by state variations, which is a limitation in robustness of this analysis. However, data does seemingly argue that the presence of health-facing agency effectively reduces opioid prescription rates by 25.9 prescriptions per 100 prescriptions and opioid overdose death rates by six deaths per 100,000 individuals, both coefficients of which are statistically significant at the 1% level.

A second important assumption that rests on the interpretation of these results is the limited impact of other opioid-related policies that may have biased the effectiveness of a specific operating agency type. While the presence of the mandate has been repeatedly shown as a key characteristic in measuring effectiveness of a PDMP due to numerous studies stating its efficacy, other potentially influential characteristics were not included. Most of these characteristics were eliminated from the model due to high degrees of similarity across states; for example, 40 out of 49 states plus Washington D.C. had PDMPs that covered drugs in Schedules II through IV while nine out of 49 states had PDMPs that covered drugs in Schedules II through V. Schedule V drugs are generally used for antidiarrheal, antitussive, and analgesic purposes and do not include opioid medications such as hydrocodone and acetaminophen, which fall in Schedule II. As all states included Schedule II drugs, the class in which opioid medications fall, the impact of drug schedules was excluded from the regression model. In addition, another key assumption that was omitted due to the high degrees of similarity across all states is the impact of data collection frequency. All states except four states—California, Hawaii, Oklahoma, and Pennsylvania—collect updated data for the PDMP daily or during the next business day. California and Hawaii both collect data every seven day, Oklahoma collects data at point of sale, and Pennsylvania collects data every two to three business days. EHR integration and interstate data sharing were two other variables ignored as the majority of states had not completed EHR integration or interstate data sharing.

Physician Perception of PA's PDMP and Usage Patterns

A second part of this study looks at the how the implementation and operation of Pennsylvania's PDMP, which is run by the Pennsylvania Department of Health, affected physicians' prescribing behavior. Emergency medicine, pain management, and primary care physicians at the University of Pennsylvania Health System are targeted given the frequency

PDMP usage. The participants are asked if they are aware of the operating agency that runs PA's PDMP, how often they refer and check the PDMP before prescribing any controlled medications, if they have ever changed a patient's prescription plan after viewing the PDMP, and how knowledgeable they perceive they are about the functionalities of the PDMP. The survey questions were developed by the author and were run online via Qualtrics survey form. *Table 6* details the questions asked in the survey. After reaching out to 256 physicians via email messaging, 94 physicians responded to the survey.

Survey responses are reported in *Table 7*, which breaks down the responses to each question and answer choice. In the survey of 94 participants, 100% of physician participants knew what a PDMP was, and 46 (48.9%) physicians stated that they knew the operating agency that operates PA's PDMP, which was the Department of Health. Among the 46 physicians who first stated they knew the operating agency, 89.13% correctly selected the Department of Health. Among the 48 physicians who initially did not know what the operating agency was, a large majority, 72.92%, guessed and selected the correct agency type out of a multiple-choice question that provided the following six options: Department of Health, Pharmacy Board, Substance Abuse Agency, Law Enforcement, Professional Licensing Agency, and Consumer Protection Agency. Those who did not select the correct agency type most commonly guessed Substance Abuse Agency, Pharmacy Board, and Professional Licensing Agency. A graphic of such results is depicted in *Figure 3*.

The survey also aimed to uncover physician prescribing patterns given their knowledge about PA's PDMP, which is shown in *Table 8*. 62 or 65.96% of the physician respondents stated they "always" check the PDMP prior to prescribing any controlled medications including opioids medications, while another 22 physicians or 23.40% only check the PDMP "most of the time".

Figure 4 details this breakdown. Of all the participants, 71 physicians or 75.53%, have adjusted a patient's prescription plan or have made a mental health/substance abuse referral due to data provided in a PDMP. Lastly, on a sliding scale with 1 being not knowledgeable at all and 10 being very knowledge, the 14 physicians rated themselves a 10 of their knowledge of the functionalities of the PDMP. The lowest score was a 2, and the average score of 8.085. Overall, the majority of physician participants of the survey effectively utilize the PDMP's functionalities in considering an opioid medication prescription plan.

Survey Limitations

Analysis from the survey data rests upon a number of key limitations. Due to the impacts of COVID-19, in-depth personal interviews could not be conducted so surveys were substituted instead. Survey response rate was therefore suboptimal, given the lower than expected response rate of 36.7%. Surveys were sent out to all physicians listed on the University of Pennsylvania Health System's emergency medicine, pain management, and primary care team via email. While participation was encouraged, many physicians may have been surrounded with other urgent matters. Low response rates from physicians introduces potential bias as those responders may have systematically different characteristics from non-responding physicians. Moreover, this survey specifically targets University of Pennsylvania Health System physicians, which may provide another layer of bias given the University of Pennsylvania has spent much effort training their faculty on PDMP usage. As so, this data may not be generalizable to physicians in other hospital systems or states. Lastly, social desirability could provide biased results although all survey respondents remained anonymous and all answers remained confidential.

DISCUSSION & CONCLUSIONS

Several key conclusions emerge from this analysis. First, the results from the quantitative portion of the study suggest that in general, health-facing operating agencies seem to perform more effectively than consumer-facing agencies. Combined with the presence of a mandate, the effect of a health-facing agency was even more amplified. This holds true for both opioid prescribing rates, which are directly affected by PDMP usage, and opioid overdose death rates, which are connected by the decrease in accessibility of opioids available for medical use; both of which showed highly statistically significant effects. Decreasing the dosages of opioid prescriptions or adjusting prescription frequency contributes to a reduced likelihood of opioid addiction, which is highly correlated with length of use and prescription dosage levels. To best understand and limit the repercussions related to opioid additions, health-facing operating agencies such as a state's Department of Health or Pharmacy Board may in fact have the most applicable knowledge to create policies and programs to help control opioid dispensing. These operating agencies likely are already very familiar with prescribing patterns and physician behavior, especially compared with consumer-facing operating agencies which may not have such necessary insight. Consumer-facing agencies, which include Law Enforcement or Professional Licensing mainly function and manage activities outside of the scope of medical prescription activity and opioid use, and therefore these agencies are likely less successful with creating an effective PDMP targeted at changing physician prescribing behavior.

Although these results indicate that effectiveness of a PMDP can be affected by the presence of a health-facing operating agency, this study shows that there is limited impact when considering the effect of each individual operating agency type. Combined with the presence of a mandate, each operating agency type decreased the opioid prescription rate, although most of the coefficients were not statistically significant. Combined with the presence of a mandate, each

operating agency type also lead to reductions in opioid overdose death rates, with most coefficients showing statistical significance in this case. A possible explanation could be the state effects that were left out due to collinearity concerns. Another consideration could be the effect of a relatively smaller sample size when considering the impact of each individual operating agency compared to the combined impact of all health-facing and consumer-facing operating agency type. While a significant portion of states had PDMPs run by the Department of Health or Pharmacy Board, fewer states had PDMPs run by the Professional Licensing Agency or Law Enforcement, and such smaller data samples likely impacted statistical significance of the results.

The results from the qualitative survey portion of the study suggest that a portion of emergency medicine, pain management, and primary care physicians are not only aware of the functionalities of a PDMP, but also have general knowledge about the operational factors as well. Almost half of the physicians knew that Pennsylvania's PDMP was operated and implemented by the PA Department of Health, and out of those who did not initially know, a majority correctly guessed the right operating agency. Hence, such results portray the overall knowledge and familiarity that physicians may have, especially among the three physician specialty types that most commonly utilize PDMPs. From the survey responses, the majority of physicians have actively changed a patient's prescription plan after referring to patient data from the PDMP, indicating the effectiveness of Pennsylvania's PDMP, operated by the PA Department of Health, in limiting medical opioid accessibility. By reducing medical opioid prescriptions or encouraging patients to seek mental health or substance abuse treatment, opioid overdose death rates are likely negatively affected as well. As the Department of Health falls into the facing-agency operating agency category, these results align with the previous quantitative finding that health-facing

agencies show greater effectiveness in reducing opioid prescription rates and decreasing opioid overdose death rates than consumer-facing facing agencies.

Health-facing agencies, which contribute to more effective control of medically dispensed opioid use, are likely to have greater impact due to analogous knowledge of physicians prescribing patterns. Being able to identify processes, such as mandates, that persuade physicians to more proactively consider an opioid prescription plan is critical in controlling the opioid epidemic. Most of states' Department of Health or Pharmacy Board is headed by directors with medical degrees and practicing experience, which often offer first-hand knowledge of physician behavior. Pennsylvania's Department of Health is run by Dr. Rachel Levine, a Fellow of the Society of Adolescent Health and Medicine and accomplished author on the opioid crisis, medical marijuana, and adolescent medicine (Department of Health Executive Leadership 2020). As so, a recommendation to further increase effectiveness of PDMP would be for states should consider allowing a health-facing agency to partner in operating and implementing a PDMP. Consumer-facing agencies such as Law Enforcement or Professional Licensing Agencies likely lack the medical knowledge and general expertise necessary to design procedures and policies that target specific physician prescribing behavior. As a result, these states hence experience an overall less effective PDMP. Missouri, the singular state that has not yet passed legislation to institute a PDMP, would likely benefit most from the MO Department of Health or MO Pharmacy Board implementing and operating its PDMP.

FUTURE CONSIDERATIONS

Future research should focus on further building upon understanding the impact of operational characteristics, which has not yet been studied. Some operational characteristics that differ across states' PDMPs include sources of funding, which vary from state funds, federal

grants, and local funds. Employee headcount is another factor that differs across different PDMPs, including the number of operational employees, technical workers, and epidemiological analysts. Lastly, given the connection between containing illegal opioids and Law Enforcement, another operational characteristic should consider the various requirements of Law Enforcement to view and access PDMP data in curbing physician over-prescribing. Law Enforcement in different PDMPs may need a subpoena, court order, probable cause, search warrant, proper need, or other requirements to access a PDMP, all with varying degrees of accessibility which may impact physician prescribing behaviors.

Given the benefits of PDMPs, which include reduced opioid access through limiting prescription and decreased opioid overdose rates, more attention is needed to maximize their clinical utility to reach their full potential. Because PDMPs are state-run programs, it is essential to determine and understand the impacts of both operational and functional characteristics to best reduce opioid usage and increase patient safety.

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Supplemental Figures & Graphics

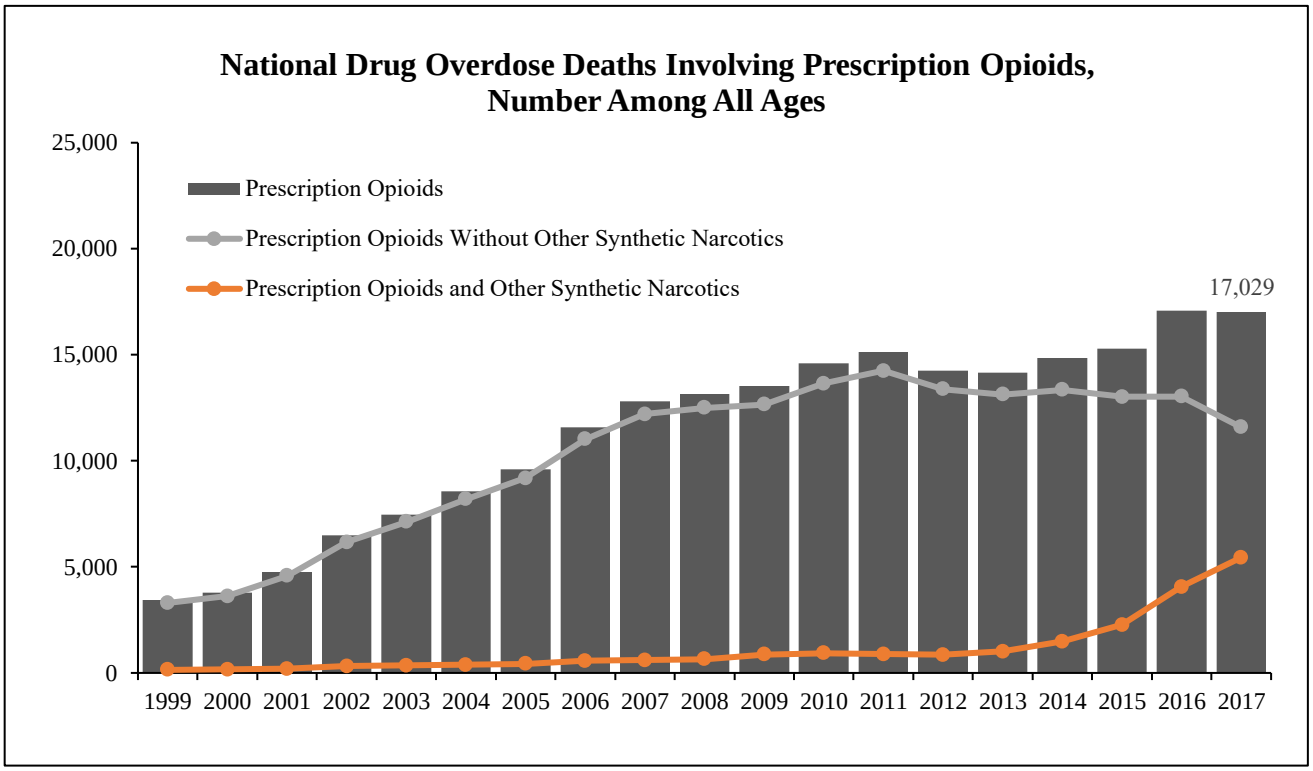

Figure 1: Opioid overdose death rates among all ages from years 1999 to 2017. (CDC Wonder 2017).

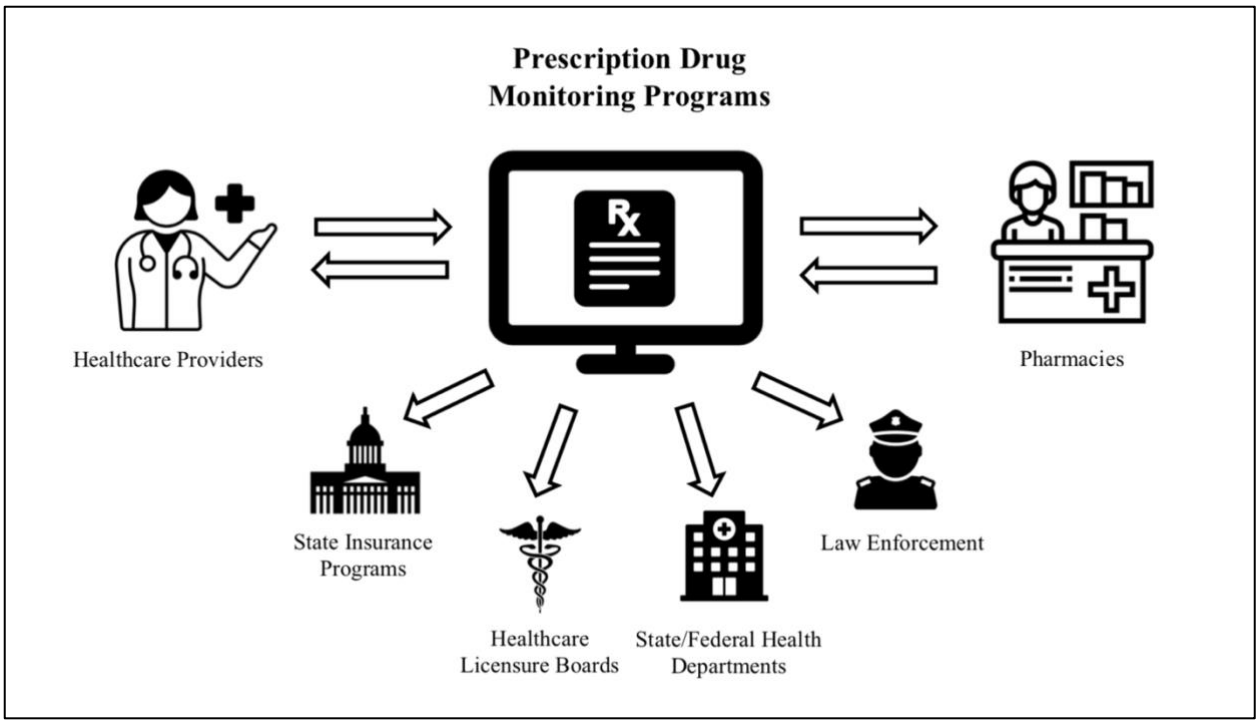

Figure 2: Graphic of PDMP structure and different parties involved. Healthcare providers and prescribers/pharmacies can both input patient information into the PDMP and view patient prescribing history. Such information is commonly shared with state insurance programs, healthcare licensure boards, state and federal health departments, and law enforcement.

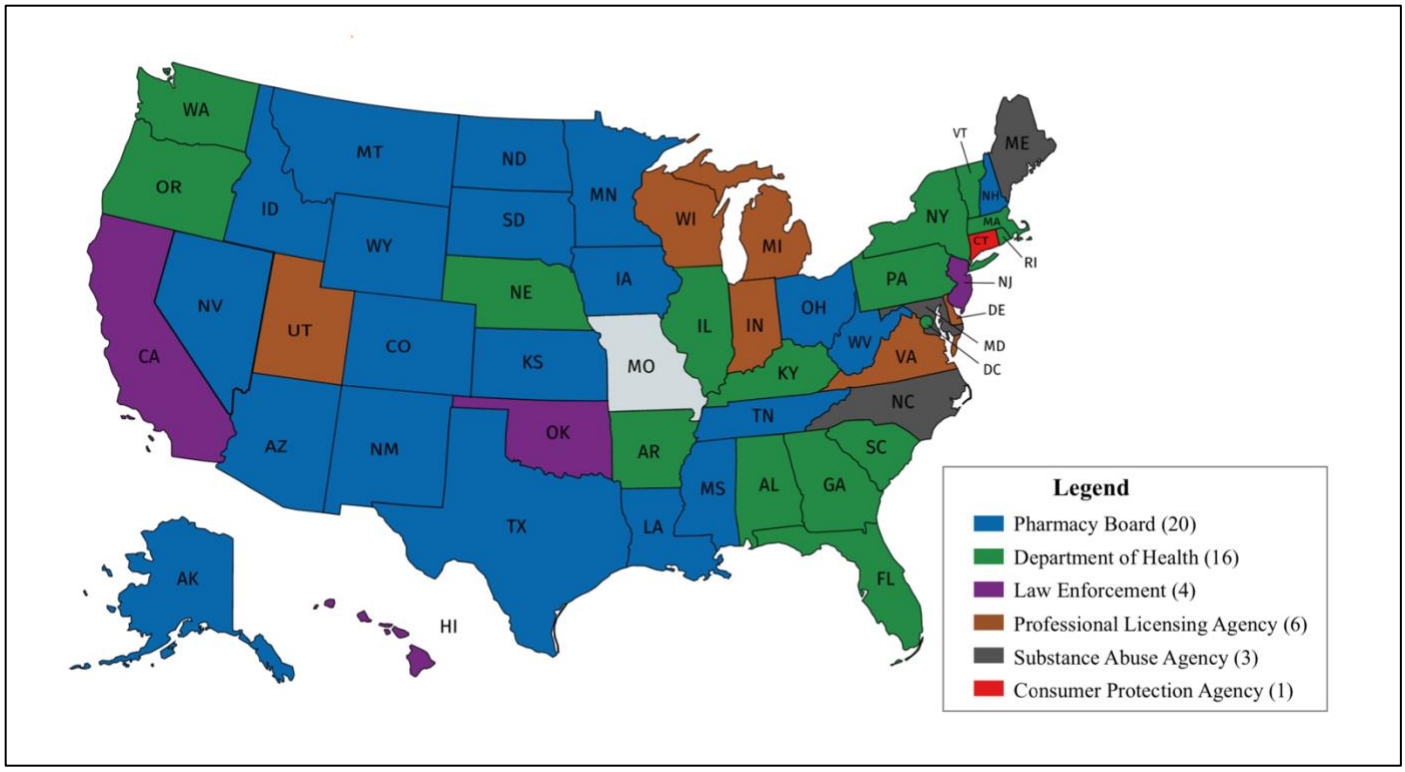

Figure 3: Graphic of the operating agency that runs the PDMP in each state and D.C.
Note: Missouri does not have PDMP and therefore is not shaded in the map.

Table 1: State Prescription Drug Monitoring Program and correlated operating agency type.

State Name	Abbreviation	Operating Agency	Mandate
Alabama	AL	Department of Health	Mandate
Alaska	AK	Pharmacy Boards	Mandate
Arizona	AZ	Pharmacy Boards	Mandate
Arkansas	AR	Department of Health	Mandate
California	CA	Law Enforcement	Mandate
Colorado	CO	Pharmacy Boards	Mandate
Connecticut	CT	Consumer Protection Agency	Mandate
Delaware	DW	Professional Licensing Agency	Mandate
District of Columbia	DC	Department of Health	No mandate
Florida	FL	Department of Health	Mandate
Georgia	GA	Department of Health	Mandate
Hawaii	HI	Law Enforcement	Mandate
Idaho	ID	Pharmacy Boards	No mandate
Illinois	IL	Department of Health	Mandate
Indiana	IN	Professional Licensing Agency	Mandate
Iowa	IA	Pharmacy Boards	Mandate
Kansas	KS	Pharmacy Boards	No mandate
Kentucky	KY	Department of Health	Mandate
Louisiana	LA	Pharmacy Boards	Mandate
Maine	ME	Substance Abuse Agency	Mandate
Maryland	MD	Substance Abuse Agency	Mandate
Massachusetts	MA	Department of Health	Mandate
Michigan	MI	Professional Licensing Agency	Mandate
Minnesota	MN	Pharmacy Boards	Mandate
Mississippi	MS	Pharmacy Boards	Mandate
Missouri	MO		
Montana	MT	Pharmacy Boards	No mandate
Nebraska	NE	Department of Health	No mandate
Nevada	NV	Pharmacy Boards	Mandate
New Hampshire	NH	Pharmacy Boards	Mandate
New Jersey	NJ	Law Enforcement	Mandate
New Mexico	NM	Pharmacy Boards	Mandate
New York	NY	Department of Health	Mandate
North Carolina	NC	Substance Abuse Agency	Mandate
North Dakota	ND	Pharmacy Boards	Mandate
Ohio	OH	Pharmacy Boards	Mandate
Oklahoma	OK	Law Enforcement	No mandate
Oregon	OR	Department of Health	Mandate
Pennsylvania	PA	Department of Health	Mandate
Rhode Island	RI	Department of Health	Mandate
South Carolina	SC	Department of Health	No mandate
South Dakota	SD	Pharmacy Boards	Mandate
Tennessee	TN	Pharmacy Boards	Mandate
Texas	TX	Pharmacy Boards	Mandate
Utah	UT	Professional Licensing Agency	Mandate
Vermont	VT	Department of Health	Mandate
Virginia	VA	Professional Licensing Agency	Mandate
Washington	WA	Department of Health	Mandate
West Virginia	WV	Pharmacy Boards	Mandate
Wisconsin	WI	Professional Licensing Agency	No mandate
Wyoming	WY	Pharmacy Boards	No mandate

Note: Data was sourced from Prescription Drug Monitoring Program Training and Technical Assistance Center

Table 2: Regression output for impact of health-facing agency vs. consumer-facing agency for opioid prescription rates.

Coefficients	Estimated Std.	Error	t-value	Pr(>|t|)	
(Intercept)	78.521	6.256	12.551	< 2e-16	***
year2016	9.384	4.530	2.071	0.038867	*
year2015	14.167	4.554	3.111	0.001978	**
year2014	19.208	4.554	4.218	2.96E-05	***
year2013	21.706	4.577	4.742	2.82E-06	***
year2012	25.116	4.683	5.363	1.29E-07	***
year2011	24.097	4.742	5.081	5.44E-07	***
year2010	26.434	5.038	5.246	2.36E-07	***
year2009	25.534	5.083	5.023	7.26E-07	***
year2008	26.437	5.181	5.103	4.88E-07	***
year2007	23.274	5.414	4.299	2.09E-05	***
year2006	21.225	5.630	3.770	0.000184	***
mandate	-25.721	5.970	-4.308	2.01E-05	***
health agency	-15.229	6.278	-2.426	0.015647	*
mandate*health agency	-25.902	6.815	-3.801	0.000163	***

Note: This table reports results using the regression equation found on page 13 using opioid prescription rates reported by the CDC as the variable of measurement. Fixed effects for years are always included. Robust p-values are as follows: *** $p<0.001$, ** $p<0.01$, * $p<0.05$.

Table 3: Regression output for impact each operating agency type for opioid prescription rates.

Coefficients	Estimated Std.	Error	t-value	Pr(>|t|)	
(Intercept)	64.840	4.485	14.456	< 2e-16	***
year2016	9.384	4.236	2.215	0.027216	*
year2015	14.130	4.258	3.318	0.000978	***
year2014	19.171	4.258	4.502	8.54E-06	***
year2013	21.720	4.281	5.074	5.66E-07	***
year2012	24.384	4.383	5.563	4.52E-08	***
year2011	23.709	4.438	5.342	1.45E-07	***
year2010	25.299	4.717	5.363	1.30E-07	***
year2009	24.440	4.758	5.136	4.15E-07	***
year2008	25.290	4.850	5.214	2.80E-07	***
year2007	21.807	5.076	4.297	2.12E-05	***
year2006	19.783	5.280	3.747	0.000202	***
mandate	1.138	3.865	0.294	0.768560	
consumerprotection	-20.391	6.911	-2.951	0.003333	**
deptofhealth	-3.372	5.990	-0.563	0.573774	
lawenforcement	26.334	7.043	3.739	0.000208	***
professionallicensing	-15.181	10.131	-1.498	0.134696	
substanceabuse	-2.537	4.339	-0.585	0.559007	
mandate*consumerprotection	--	--	--	--	
mandate*deptofhealth	-1.234	6.505	-0.174	0.861716	
mandate*lawenforcement	-40.592	4.597	-3.500	0.024714	*
mandate*professionallicensing	-15.341	10.671	-1.531	0.126366	
mandate*substanceabuse	--	--	--	--	

Note: This table reports results using the regression equation found on page 13 using opioid prescription rates reported by the CDC as the variable of measurement. Fixed effects for years are always included. Robust p-values are as follows: *** p<0.001, ** p<0.01, * p<0.05.

Table 4: Regression output for impact of health-facing agency vs. consumer-facing agency for opioid overdose deaths.

Coefficients	Estimated Std.	Error	t-value	Pr(>|t|)	
(Intercept)	4.545	1.827	2.488	0.013187	*
year2017	14.779	1.696	8.716	< 2e-16	***
year2016	12.942	1.696	7.633	1.18E-13	***
year2015	9.599	1.701	5.642	2.82E-08	***
year2014	7.954	1.701	4.675	3.79E-06	***
year2013	6.279	1.707	3.678	0.000261	***
year2012	5.754	1.736	3.315	0.000982	***
year2011	5.549	1.744	3.182	0.001553	**
year2010	4.857	1.791	2.712	0.006918	**
year2009	4.485	1.802	2.489	0.013143	*
year2008	4.725	1.802	2.622	0.009021	**
year2007	4.498	1.856	2.423	0.015733	*
year2006	4.232	1.8891	2.24	0.025525	*
year2005	3.599	1.9505	1.845	0.065647	
year2004	2.900	1.9751	1.468	0.142699	
year2003	2.719	2.0023	1.358	0.175143	
year2002	1.813	2.0323	0.892	0.372905	
year2001	1.181	2.0323	0.581	0.561342	
year2000	0.306	2.032	0.151	0.880280	
mandate	-2.464	1.276	-1.931	0.054046	
health agency	-4.413	1.501	-2.939	0.003446	**
mandate*health agency	-6.456	1.613	-4.003	7.21E-05	***

Note: This table reports results using the regression equation found on page 14 using opioid overdose deaths reported by the Kaiser Family Foundation as the variable of measurement. Fixed effects for years are always included. Robust p-values are as follows: *** p<0.001, ** p<0.01, * p<0.05.

Table 5: Regression output for impact each operating agency type for opioid overdose deaths.

Coefficients	Estimated Std.	Error	t-value	Pr(>|t|)	
(Intercept)	-0.977	1.740	-0.562	0.574664	
year2017	14.150	1.642	8.615	< 2e-16	***
year2016	12.314	1.642	7.497	3.07E-13	***
year2015	9.056	1.647	5.499	6.14E-08	***
year2014	7.411	1.647	4.501	8.47E-06	***
year2013	5.769	1.653	3.491	0.000525	***
year2012	5.159	1.678	3.075	0.002223	**
year2011	4.982	1.686	2.955	0.003278	**
year2010	3.985	1.734	2.298	0.022000	*
year2009	3.646	1.745	2.090	0.037142	*
year2008	3.885	1.745	2.227	0.026397	*
year2007	3.999	1.793	2.230	0.026192	*
year2006	3.863	1.823	2.119	0.034581	*
year2005	3.314	1.882	1.761	0.078927	
year2004	2.700	1.906	1.416	0.157264	
year2003	2.629	1.931	1.361	0.174083	
year2002	1.813	1.960	0.925	0.355534	
year2001	1.181	1.960	0.603	0.546985	
year2000	0.306	1.960	0.156	0.875895	
mandate	6.909	1.189	5.813	1.11E-08	***
consumerprotection	-0.008	1.821	-0.004	0.996517	
deptofhealth	5.167	1.946	2.655	0.008183	**
lawenforcement	6.400	1.675	3.820	0.000150	***
professionallicensing	4.357	2.725	1.599	0.110537	
substanceabuse	0.261	1.121	0.233	0.815628	
mandate*consumerprotection	--	--	--	--	
mandate*deptofhealth	-7.897	2.058	-3.837	0.000141	***
mandate*lawenforcement	-12.380	1.927	-6.424	3.14E-10	***
mandate*professionallicensing	-6.676	2.843	-2.348	0.019256	*
mandate*substanceabuse	--	--	--	--	

Note: This table reports results using the regression equation found on page 14 using opioid overdose deaths reported by the Kaiser Family Foundation as the variable of measurement. Fixed effects for years are always included. Robust p-values are as follows: *** p<0.001, ** p<0.01, * p<0.05.

Table 6: Questions included in the survey sent to emergency medicine, pain management, and primary care physicians.

Survey Questions
Q1. *Do you know what the Prescription Drug Monitoring Program (PDMP) is?*
Select: Yes
No
Q2. *Do you know the operating agency responsible for managing and implementing Pennsylvania's PDMP?*
Select: Yes
No
Q3. *[IF SELECTED "YES" TO Q2"] Please select the operating agency responsible for managing and implementing Pennsylvania's PDMP.*
Select: PA Department of Health
PA Pharmacy Board
PA Substance Abuse Agency
PA Law Enforcement
PA Consumer Protection Agency
PA Professional Licensing Agency
Q4. *[IF SELECTED "NO" TO Q2"] If you were to guess the operating agency responsible for managing and implementing Pennsylvania's PDMP, which of the following would you pick?*
Select: PA Department of Health
PA Pharmacy Board
PA Substance Abuse Agency
PA Law Enforcement
PA Consumer Protection Agency
PA Professional Licensing Agency
Q5. *How often do you check and refer to PDMP data before prescribing controlled medications for patients (such as opioids or benzodiazepines)?*
Select: Always
Most of the time
About half the time
Sometimes
Never
Q6. *Have you ever made any mental health or substance abuse referrals, or discharged a patient from a prescription after viewing the PDMP?*
Select: Yes
No
Q7. *How familiar do you perceive you are in understanding the functionalities of the PDMP? (1 being NOT familiar, 10 being VERY familiar).*
Slide option: 1 to 10

Note: This survey was sent out to participants via Qualtrics survey.

Table 7: Survey responses for question one through four regarding general PDMP knowledge and operating agency knowledge.

General PDMP Knowledge	**Answer Choices**					
	Yes	**No**				
Q1. Do you know what the Prescription Drug Monitoring Program (PDMP) is?	*94 (100%)*	*0 (0%)*				
Operating Agency Knowledge						
	Yes	**No**				
Q2. Do you know the operating agency responsible for managing and implementing Pennsylvania's PDMP?	*46 (48.9%)*	*48 (51.1%)*				
	Department of Health	**Pharmacy Board**	**Substance Abuse Agency**	**Law Enforcement**	**Consumer Protection Agency**	**Professional Licensing Agency**
Q3. [IF SELECTED "YES" TO Q2"] Please select the operating agency responsible for managing and implementing Pennsylvania's PDMP.	*41(89.13%)*	*2 (4.35%)*	*0 (0%)*	*2 (4.35%)*	*1 (2.17%)*	*0 (0%)*
Q4. [IF SELECTED "NO" TO Q2"] If you were to guess the operating agency responsible for managing and implementing Pennsylvania's PDMP, which of the following would you pick?	*35 (72.92%*	*2 (4.17%)*	*7 (14.58%)*	*1 (2.08%)*	*1 (2.08%)*	*2 (4.17%)*

Table 8: Survey responses for question five through six regarding physicians' PDMP prescription and usage patterns.

PDMP Prescription Patterns	**Answer Choices**				
	Always	**Most of the time**	**About half the time**	**Sometimes**	**Never**
Q5. How often do you check and refer to PDMP data before prescribing controlled medications for patients (such as opioids or benzodiazepines)?	*62 (65.96%)*	*22 (23.40%)*	*3 (3.19%)*	*6 (6.38%)*	*1 (1.06%)*
	Yes	**No**			
Q6. Have you ever made any mental health or substance abuse referrals, or discharged a patient from a prescription after viewing the PDMP?	*71 (75.53%)*	*23 (24.47%)*			
	Sliding Scale from 1 to 10				
Q7. How familiar do you perceive you are in understanding the functionalities of the PDMP? (1 being NOT familiar, 10 being VERY familiar).	*average: 8.085*				

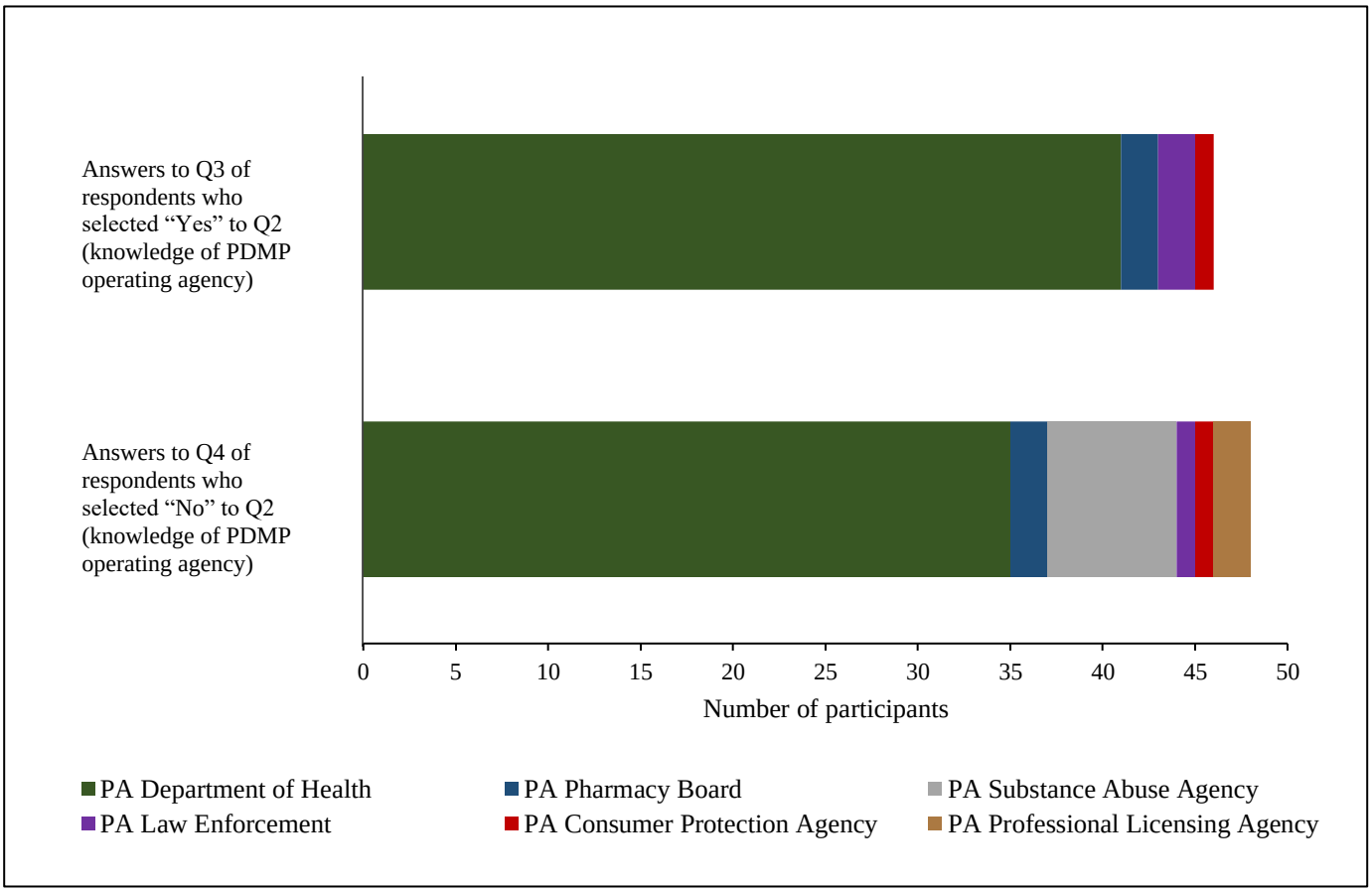

Figure 3: Comparison of response answers to Q3 (answered by respondents who stated they are aware of PA's PDMP operating agency in Q2) and Q4 (answered by respondents who stated they are unaware of PA's PDMP operating agency in Q2).

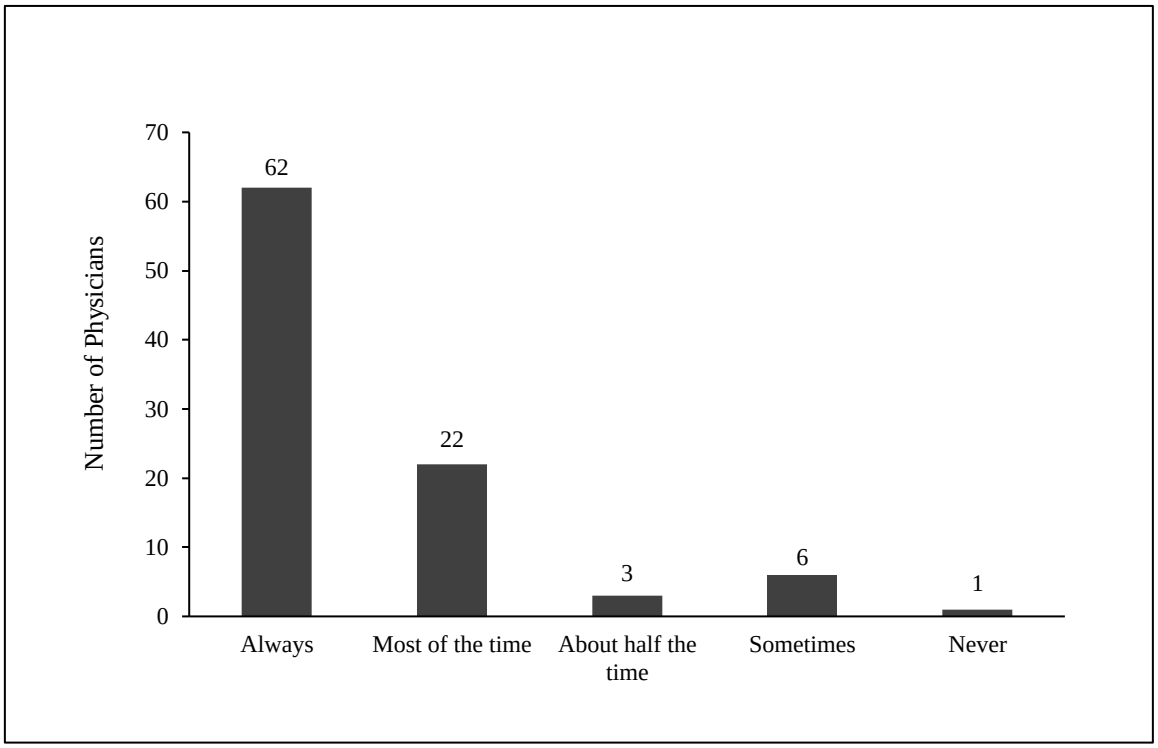

Figure 4: Breakdown of Q5 responses that indicate how often participants check and refer to the PDMP data before prescribing controlled medications.