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Systematic Review

Helpful, Unnecessary, or Harmful: A Systematic Review of the Effects of Prescription Drug Monitoring Program Use on Opioid Prescriptions

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Abstract: Prescription drug misuse is a global problem, especially in the United States (US). Clinician involvement is necessary in this crisis, and prescription drug monitoring programs (PDMPs) are a recommended tool for the prevention, recognition, and management of prescription opioid misuse. However, because of the plethora of differences between different PDMPs, research on their effects is mixed. Yet, despite varied evidence, policy on PDMP use is trending stricter and more comprehensive. We aimed to identify patterns in the research to inform clinicians and policy. Through a systematic review of four literature databases (CINAHL, Cochrane Database, Embase, and Medline/OVID), we found 56 experimental and quasi-experimental studies published between 2016 and 2023 evaluating PDMP effects on clinician behavior. To address study heterogeneity, we categorized studies by type of intervention and study outcome. The review suggests that more comprehensive PDMP legislation is associated with decreases in the number of opioid prescriptions overall and the number of risky prescriptions prescribed or dispensed. However, this review shows that much is still unknown, encourages improvements to PDMPs and policies, and suggests further research.

Keywords: prescription drug monitoring programs; prescription monitoring; controlled substance diversion; prescription drug misuse; inappropriate prescriptions; opioid crisis

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1. Introduction

Opioids are considered the strongest medications for addressing pain but can also result in adverse drug reactions (ADRs). The global pharmacovigilance system, VigiBase, and national systems such as the United Kingdom's Prescription Event Monitoring System (PEMS) have tracked and documented opioid-related ADRs such as constipation; nausea; sedation and respiratory depression; tolerance; and dizziness and falls [1,2]. Opioids are also among the substances at the highest risk for addiction and misuse, leading to unintentional overdose [3,4]. Despite these concerns, opioid prescriptions continue to rise worldwide and have been accompanied by a global increase in prescription opioid misuse [5–7]. Prescription opioid misuse is especially a problem in the United States (US), which has 3.5 times more drug-related deaths than 17 other developed nations, primarily because of opioid misuse [8]. There was a nearly five-fold increase in overdose deaths involving prescription opioids in the US between 1999 to 2020 [9]. The United Nations Office on Drug and Crime (UNODC) and the World Health Organization's International Standards on Drug Use Prevention encourage clinician involvement in the prevention, identification, and treatment of prescription drug misuse [7]. In the US, clinicians are advised to use prescription drug monitoring programs (PDMPs), which are databases that solely track controlled substance prescriptions, such as opioids; they contain data

about the patient to whom the controlled substance is prescribed, the prescribing physician, the dispensing pharmacy, the medication name, and the dose [10]. At the population level, PDMP data are supposed to help identify patterns of inappropriate and/or illegal use of controlled substance prescriptions such as "pill mills" or drug diversion rings that enable large quantities of prescriptions for misuse purposes [11–13]. At the patient level, PDMPs are supposed to assist clinicians in making appropriate prescribing and dispensing decisions by identifying (a) potentially inappropriate prescriptions, such as very high doses or the co-prescribing of medicines that could harm the patient; (b) prescription drug misuse, where the medication is taken for a reason other than the one prescribed; (c) drug-seeking behaviors such as "doctor/pharmacy shopping", where patients seek multiple, overlapping prescriptions for the same or similar medications; and (d) drug diversion, where prescriptions are given to others for whom the prescription was not made [10,14].

In the US, there is no national PDMP. While PDMPs receive federal funding [11,15,16], they are administered and regulated at the state level. In total, 49 out of 50 US states maintain and administer their own PDMPs. State regulations differ in the entity that manages the PDMP (law enforcement department, public health agency, medical or pharmacy board), who can access the PDMP data, how access can be requested, and under what clinical circumstances the database should be used [17–20]. Each state also makes its own decisions on PDMP software, so PDMPs differ in report structures and notification capabilities. PDMP access and policies also differ between healthcare facilities and systems, with each having its own training and organizational policies concerning PDMP use [21–23] and with some clinicians having access to clinical decision support and/or integration of the PDMP into their employers' electronic health record systems (EHRs) [24–27].

Researching PDMP effects is challenging given the myriad of differences between PDMPs. Another difficulty is accounting for how PDMP functions and legislation constantly change, potentially impacting the applicability of prior PDMP research. PDMP regulations may also be implemented at the same time as other opioid misuse mitigation efforts, such as greater law enforcement efforts; the existence of multiple independent variables confounds findings [28–32]. There have also been consequential initiatives at the professional level that likely confound research findings, such as the 2016 publication of the CDC's Guidelines for Prescribing Opioids for Chronic Pain [33].

Given these complexities in PDMP research, it is not surprising that research results have been mixed about PDMP effects on prescribing and dispensing behavior [34,35]. However, despite the murky picture of PDMP effects, there is a policy trend toward stricter and more comprehensive PDMP mandates [36]. Given this legal pattern, it is important to provide guidance on the effects of these policies to avoid unintended consequences. This literature review provides a synthesis of research on the effect of PDMP use on the prescribing and dispensing decisions of clinicians [37].

2. Results

A PRISMA diagram illustrating the search process is provided below. It is formatted per the latest guidance from Page et al., 2021. In this latest PRISMA 2020 statement, individual citations and databases are jointly referred to as "records" [38]. This is the terminology that is used. In total, 2659 records were identified from the library databases; 30 were identified from other sources; and 1094 duplicates were removed. The remaining 1595 records were screened by title and abstract, and 1418 were excluded because they did not meet review criteria; 177 records were retrieved and assessed for eligibility, and 121 were excluded because of the following: 93 records did not meet inclusion criteria; 23 records did not meet the quality criteria; and 5 were earlier publications about the same research (see Figure 1).

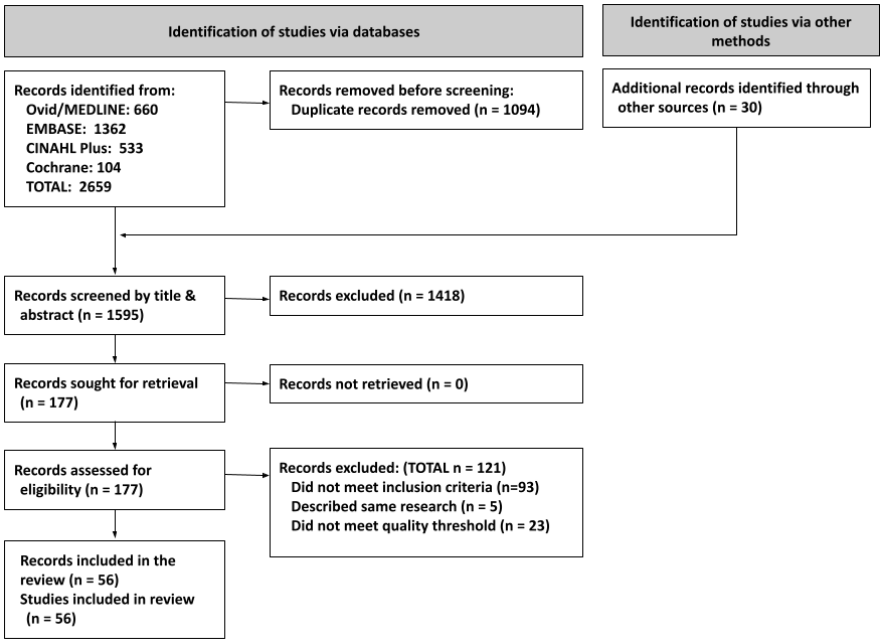

Figure 1. PRISMA diagram for PDMP effects on clinician prescribing and dispensing behavior.

In total, 56 articles were included in the review. There were 3 articles that described experimental studies and 51 that described quasi-experimental, observational studies [39,40]. The final two articles described mixed methods studies. These final two Underwood et al. studies paired an observational cohort analysis with a document review [41,42]. Data used in the 56 studies spanned the years 2000–2021 (see Figure S1; counts not mutually exclusive). Data from all 50 states were used in the analyses. In total, 11 studies used data from multiple states as they compared outcomes between multiple states (see Figure S2; counts not mutually exclusive); 19 studies involved single-state data analyses; 15 studies studied national trends; and 11 studies looked at changes at the healthcare facility level (see Figure S3). The 56 studies in this review also varied in the data sources used in their analyses; data came from the AHRQ Medical Expenditure Panel Survey (MEPS), the Census National Ambulatory Medical Care Survey (NAMCS), DEA ARCOS (Automation of Reports and Consolidated Order System), facility EHR systems, Medicare, Medicaid, private insurance claims, retail pharmacy sales, state PDMPs, and Veterans Health Administration (VHA) (see Figure S4).

It was not possible to conduct a meta-analysis to determine the size of the effects of PDMP use because of study design heterogeneity. There were variations in measures for studying outcomes, how study variables were defined, covariate adjustments, analytic approaches, study scopes, and data sources. Our analysis instead relied on counts of studies that looked at similar interventions and analyzed similar outcomes (see Table S1). Per the principle of triangulation, the more research with a given outcome, the stronger the evidence. Of the 32 studies that evaluated the effect of more comprehensive PDMP legislation (mandated PDMP use) on the number of opioids dispensed or prescribed overall, 29 studies found that the number of opioids overall decreased after the legislation went into effect, whereas only 3 studies [39,43,44] found no change. Less comprehensive PDMP legislation (allowing clinicians access to electronic PDMP data or mandating PDMP registration but not use) did not have as strong of an effect on the number of opioids prescribed or dispensed overall. Seven studies [45–51] found that less comprehensive PDMP legislation was associated with a decrease in the number of opioids prescribed or dispensed overall, whereas eight found no change [44,52–58].

There were fewer studies on the effect of PDMP use (whether mandated or not) on the number of potentially risky prescriptions. Four studies evaluated the effect of non-mandated PDMP use; two found that non-mandated PDMP use was associated with a de-

crease in the number of risky prescriptions [47,59], and two others found no change [54,60]. However, there appeared to be stronger effects of mandated PDMP use on the number of risky prescriptions. All six studies that evaluated mandated PDMP use found that the legislation was associated with a decrease in the number of risky prescriptions [54,61–65].

Other studies looked at PDMP-use-related interventions. Six studies evaluated outcomes following proactive clinician notification of potentially inappropriate prescriptions. Five of these studies showed a decrease in the number of opioid prescriptions overall [42,66–69] versus one that showed no change [70]. Proactive notification also appeared to have an effect on the number of risky prescriptions. Five studies showed a decrease in the number of risky prescriptions following notification [41,66–69] versus one that showed no change [71].

One study evaluated the effect of PDMP data-sharing between states and found that there was no significant difference in the number of opioids prescribed overall in states that had data-sharing arrangements and those that did not [40]. Another study examined the effect of delegates on the number of risky prescriptions and found that the number of risky prescriptions decreased following legislation allowing clinicians to use delegates to access PDMP data on their behalf [62]. It is important to note, however, that PDMP data-sharing arrangements and permission for delegate access may have been present in other studies, but only these two studies highlighted these interventions. Other studies did not specifically mention these capabilities.

This review also included studies about the association between PDMP and the number of non-opioid medications. The evidence is mixed on whether PDMP use is associated with the number of benzodiazepines, non-opioid analgesics, and stimulants [40,43,44,68,72–75]. Only one study evaluated the effect of mandated PDMP use on the length of chronic opioid treatment and found no change [76].

3. Discussion

Despite the diversity of research on the effect of PDMPs, this review drew insights about the effects of use, clinician experiences, and research gaps.

3.1. More Comprehensive PDMP Legislation Can Reduce the Number of Opioid Prescriptions Overall and the Number of Risky Opioid Prescriptions

This review suggests that more comprehensive PDMP legislation is associated with decreases in the number of opioid prescriptions prescribed or dispensed overall. More importantly, PDMPs are associated with decreases in the number of risky prescriptions—those prescriptions that may result in patient harm or point to drug misuse, doctor/pharmacy shopping, or diversion. Studies in this review also suggest that decreases in risky prescriptions and opioid prescriptions overall may be aided by proactive clinician notifications. However, it also shows that less comprehensive PDMP legislation has—at best—a weak association with the number of opioid prescriptions overall and risky prescriptions. One potential reason for the mixed results is that studies have found that registering to use the PDMP did not always translate to using the PDMP [77–79]. Not surprisingly, clinicians were more likely to use the PDMP if it was mandated by their state [80,81].

Also of note is that studies have found that there are differences in how PDMP mandates affect distinct groups of providers [53,72,82–84]. For example, a review conducted by Alogaili, Ghani, and Shah (2020) noted that PDMP implementation barriers were particularly pronounced among rural clinicians [85]. Ultimately, any of the outcomes in these studies are made up of the behaviors of individual clinicians. Researchers have noted a need for more research on how and why clinicians act or do not act following PDMP use [34]. Studies have found that, after viewing patient data on the PDMP, while some physicians reported reducing or eliminating controlled substance prescriptions or changing from a controlled substance prescription to a non-opioid or non-pharmacological treatment [86,87], PDMP use was not always associated with behavior change [59,80,88,89].

This suggests the need for more targeted interventions such as mandatory education and guidance through provider groups and professional organizations [90–92].

3.2. Clinicians Desire Improvements to PDMPs

Even if clinicians already use PDMPs, they desire changes with these PDMPs. They desire more user-friendly navigation and data formats and improvements to login processes such as fewer required password changes and delayed timing out [93–95]. There were also concerns about the timeliness, correctness, and/or completeness of patients' PDMP profiles (e.g., misspelled patient names) and data [96–98]. Clinicians also desired more clinical decision support tools [99] and EHR-embedded alert systems for patient risk factors [100]. A recent survey study also found that pharmacists desired greater access to patient health information like patient diagnosis, prior treatments, past medical history, and previous treatment trials with opioids [101]. Clinicians were also interested in inter-state data to monitor patients who cross state lines to obtain their prescriptions [62,83,102], even though there is currently a mechanism through which US states share PDMP data. The National Association of Boards of Pharmacy (NABP) developed and administers a platform, PMP InterConnect, through which PDMP data can be securely transferred across state lines [103]. However, clinicians may not know how to access PMP InterConnect or about its existence entirely. This may explain the results of Lin et al. (2019)'s study which found that the presence of an inter-state data-sharing agreement was not associated with reductions in the number of opioids and other pain medications prescribed [40].

Besides noting technical and data-related issues, clinicians have criticized how PDMP use impacts their workload and workflow. Studies and reviews have noted clinician dissatisfaction with the amount of time it takes to use PDMPs [77,87,99,104–107]. Alpert et al. (2020) suggested that this "hassle factor" discourages some clinicians from prescribing controlled substances because they think that they do not have or want to take the extra time and energy to check the PDMP [108]. In the literature, PDMP integration with facility electronic health records (EHRs) is recommended as a way to better include PDMP use in clinicians' workflows [31,83,96,104,109,110]. Furthermore, there is clinician interest in allowing non-clinician delegates access to PDMP data on behalf of providers [62,97,102,109]. This review included one study that found that states that allowed delegates experienced a greater decrease in the number of risky prescriptions [62]. A final policy recommendation is the enactment of exemptions for mandated PDMP use.

3.3. More Research Is Needed on PDMP Effects on Patients

When asked about how PDMPs have been used in their practices, clinicians mentioned how using a PDMP has challenged their biases on the types of patients with multiple prescriptions [97,111], helped them communicate with and educate patients [95,112], identified potential instances of misuse [106,113–115], and assisted with prescription verification and proper prescribing [77,99]. However, there were also perceptions of PDMP use leading to patient harm. In interviews, PDMP stakeholders mentioned the possibility of PDMPs causing a "chilling effect." This term refers to patients facing barriers to appropriate opioid analgesic treatment because physicians are hesitant to prescribe opioids; discontinue ongoing treatment; or drop/refuse to see patients whose health history includes an opioid prescription. Several studies have noted a belief that PDMPs are associated with decreases in clinically appropriate opioid prescriptions [96,105,116,117]. Other articles have noted that PDMP data are used to refuse care to patients [111,114,116]. Clinicians are also concerned that their prescribing controlled substances could potentially result in them losing their licenses [10]. This review could not find clear evidence of potential chilling effects, nor could it discount the possibility of its existence. Worryingly, some studies have found associations between PDMP use and decreases in clinically appropriate opioid treatment, like treatments for cancer- or sickle cell-related pain [48,118,119]. Rhodes et al. (2019) conducted a review of studies on PDMPs and population-level patient opioid-related mortality, morbidity, and societal issues. The authors concluded that there was not enough

evidence to determine an association between PDMPs and opioid-related harms and consequences to patients [120]. Moride et al. (2019) likewise concluded that there was not enough evidence of associations between PDMP use, levels of appropriate prescribing, and decreases in patient harm [121]. Some studies have found that must-access PDMPs might actually be associated with negative outcomes. Wetzel et al. (2021) evaluated data from the National Health Interview Survey from 2006 to 2015 and found that, for respondents with a recent injury or surgery, PDMP use (whether mandatory or not) was associated with more bedridden days [122].

Furthermore, while the primary focus of PDMP research has been on opioid misuse, this review found research on the associations of PDMP use with prescriptions for non-opioid medications: non-opioid analgesics, benzodiazepines, and stimulants. However, the results are mixed, and more research needs to be conducted to more clearly determine any effect [123]. This may point to PDMPs leading to a "substitution effect" where clinicians transition from prescriptions of monitored medications such as opioid analgesics to prescriptions of unmonitored medications or off-label prescriptions, such as sedatives [96,124–128]. This review echoes the call for more research on the potential effects of PDMPs on patients and especially on negative unintended consequences [29,120,129–131].

3.4. PDMP Policy Must Be Considered in the Larger Discussion of Opioid Risk Mitigation and Patient Safety

Two studies in this review found associations between PDMPs and opioid prescriptions but only if paired with another opioid misuse risk mitigation effort [42,55]. Furthermore, studies have tracked rising opioid overdose deaths despite changes in prescribing behavior [132–136]. This supports the prevalent view among clinical and policy experts that PDMPs are just one of the opioid misuse mitigation efforts necessary to address the opioid crisis. In the updated (2022) CDC clinical practice guidelines for the prescribing of opioids for pain management, PDMP use is encouraged along with other recommendations to help improve patient–provider communication and the safety and effectiveness of opioid pain treatment [137]. Clinicians have also noted the importance of access to pain management specialists and substance abuse treatment [95,138] and greater communication and collaboration between clinicians and different disciplines to proactively monitor and address prescription drug misuse [31,96,112,117,139]. As explained by Fink et al. (2018), more research is needed on how the combination of PDMPs and complementary drug prevention programs can improve population health [129].

3.5. Limitations

Because this review only includes PDMP policies enacted through administrative action or legislation, it does not include information on likely consequential interventions at the organizational level or through professional organizations. These interventions could provide more evidence of potential PDMP effects and information about aspects of PDMPs that are more impactful. Machine learning studies, which methodologically were not included in this review, have been conducted to explore this area, and we encourage and look forward to more research [140,141].

Furthermore, while we used the Johns Hopkins Evidence-Based Practice for Nurses and Healthcare Professionals Toolkit [142] to assess the quality of publications in this review, we are aware of potential publication bias for studies showing positive effects. However, we surmised that the robust amount of research conducted on PDMP effects would lower this effect. Bias could also have been introduced by the inclusion/exclusion of articles and the abstraction and analysis of article content primarily being conducted by one researcher. The research team sought to counter this potential with guidance and oversight by three other researchers.

Finally, we opted to include only studies about US-based PDMPs because the literature is heavily US-centric [123], and given the uniqueness of the US healthcare system, we

surmised that this geographic limit would allow for more apt triangulation of research results. As such, there is a need for more PDMP research outside the US [35,121].

4. Materials and Methods

A Systematic Search and Review was conducted to answer the question, "What are the effects on prescribers and pharmacists of PDMP use?" We have registered the review with Open Science Framework Registries (osf.io/q62jz). A Systematic Search and Review is a literature review method for comprehensively exploring the literature to ascertain what is known on a topic and provide policy recommendations [143]. This review only included English-language publications that described research on PDMP use within the US. This was decided because the literature is heavily US-centric [123], and given the uniqueness of the American healthcare environment, research findings may not be applicable outside of the US. Because of this review's interest in providing policy recommendations, it only includes research on legislative or public administrative actions surrounding PDMP use. As such, we excluded studies about PDMP policies and tools that were not implemented through government authorities, like internal/organizational or insurer policies or guidelines issued by professional organizations. However, taking into account the consequential nature of such policies, this literature search only includes articles published between January 2016 and June 2023. We chose 2016 as the initial cut-off date because this was when the CDC published its National Guidelines for Prescribing Opioids for Chronic Pain [33]. Furthermore, given the intertwined nature of opioid misuse mitigation efforts, it was decided that the literature search would include research where the independent variable was PDMP use paired with/"bundled" with another opioid risk mitigation effort, such as mandated continuing medical education. It was also decided that research on inpatient or veterinary treatment with controlled substances would be excluded because PDMP use mandates generally focus on outpatient prescribing and dispensing to human patients.

The literature search was conducted in four online biomedical literature databases, CINAHL, Cochrane Database, Embase, and Medline/OVID, in consultation with a Texas Medical Center librarian. The librarian helped develop detailed and exhaustive search terms derived from the indexing of related Cochrane reviews (topics: "pharmacist", "controlled substance", "database") and by creating search logic that would be inclusive of the names of all US PDMPs. Search terms are provided in Supplementary Material S1. Furthermore, this research only includes the most recent publication on a research project, as sometimes, articles describe the same project but at different points in the research. Only experimental and quasi-experimental studies or mixed-method studies that included an experimental or quasi-experimental component were considered for this review. Once articles were determined to meet inclusion criteria, their citations were reviewed to see if there were any other relevant peer-reviewed articles that had not been previously identified. This was also performed for citations in reviews evaluated by Tay et al. (2023) [123].

The Johns Hopkins Evidence-Based Practice for Nurses and Healthcare Professionals Toolkit (the Toolkit) was used to assess the quality and rigor of the literature and to abstract evidence. The Toolkit's Research Evidence Appraisal Tool is provided in Supplementary Material S3. Only those publications assessed as "high" or "good" quality were retained. If in doubt, the publication was included in the review. The Toolkit's template for abstracting information from the literature was used to compile the evidence [142]. The Rayyan QCRI tool was used to organize the literature review. The tool assisted the research team in cataloging and de-duplicating citations and annotating and tracking decisions to include or exclude records [144]. One researcher (NZYS) worked with a medical librarian to develop the search strategy and conduct the preliminary search for articles. NZYS screened the titles and abstracts; retrieved full articles; evaluated the articles for inclusion; and consulted with a panel of three other investigators (JDT, SHF, DS, TCL) for questions about whether to include or exclude certain articles. NZYS also extracted information from the articles and synthesized the findings from the review. All data abstracted from the articles is

provided in Supplementary Material S2. No automation tools were used in the selection or data collection processes. Quality criteria applied to included articles resulted in no study investigators needing to be contacted to clarify or provide study information. It was hypothesized that, despite the diversity of the research conducted on PDMPs, findings in common between studies could be triangulated to determine PDMP effects on clinician prescribing and dispensing behavior [145].

To account for the variation in studying PDMPs, some research teams have developed their own PDMP categories based on the comprehensiveness of their capabilities and mandates [39,146,147]. Following this precedent, we categorized studies by type of intervention and outcome. Interventions were categorized into the following categories: (1) less comprehensive PDMP mandates, which capture regulations opening PDMP electronic access to clinicians and mandated registration but not use; (2) more comprehensive PDMP mandates, where prescribers are required to check PDMP data and the PDMP is administered by a health agency, updated at least weekly, and/or includes Schedule II-IV data; (3) permission for a non-clinician delegate to check PDMP data; (4) ability to share PDMP data with other states; and (5) proactive notification of risky prescriptions. The first two categories (less and more comprehensive PDMP mandates) follow definitions from Haffajee et al. (2018) [146] (see Table 1).

Table 1. Outcome categories.

Outcome	Definition
Number of opioids	Rate of prescribing/dispensing or average, total amount, or volume of the following for new patients or patients overall: • Number of opioid prescriptions; • Number of opioid prescription refills; • MEDs/MMEs of opioids; • Number of days supplied through prescription; • Overall spending on opioid prescriptions.
Number of risky prescriptions	Total number or % of patients with any combination of the following elements in their prescription history: • ≥Number of prescription days; • Overlapping opioid prescriptions; • Co-prescriptions of opioids and benzodiazepines; • ≥Number of prescribers; • ≥Number of pharmacies; • Cash payment for opioid prescriptions; • ≥Number of new patient visits resulting in opioid prescriptions.
Other outcomes	• Number of benzodiazepine prescriptions; • Number of non-opioid analgesics (e.g., NSAIDs); • Length of chronic opioid therapy; • Number of stimulant prescriptions.

The remaining three categories (delegate access, data sharing, and notifications) were created to capture the remaining research that did not fit into the first two categories. Study outcomes were divided into (A) the number of opioid prescriptions overall; (B) the number of risky opioid prescriptions where "risky prescriptions" were defined as any combination of the following: large number of prescription days, overlapping opioid prescriptions, co-prescriptions of opioids and benzodiazepines, several different controlled substance prescribers and/or dispensers, cash payment for opioid prescriptions, and number of new patient visits resulting in opioid prescriptions; and (C) other outcomes. We defined "risky opioid prescriptions" as per Bachhuber et al. (2019) and Bao et al. (2018) [61,62]. Outcomes

were then categorized by "direction" (increase/decrease/no change); this categorization emulated the review methodology of Picco, et al. (2021) [34]. If an outcome was measured through several study measures, a significant change in one measure would be noted even if there were no significant results in the other outcome measures (see Table 2).

Table 2. Intervention categories.

Intervention	Definition
PDMP implementation and mandated registration	• Prescriber obtained electronic access to the PDMP; • Prescribers were required to register to use the PDMP or were automatically registered for use but were not mandated to use it.
Mandated PDMP use and stronger PDMP laws	Prescribers are required to check PDMP data under certain conditions and the following PDMP characteristics: • Administered by a health agency; • Data updated at least weekly; • Includes Schedule II-IV data; • No prescriber immunity for failure to check the PDMP.
Proactive notification of risky prescriptions	PDMPs produce proactive reports of potentially risky prescribing or dispensing.
Delegate access	PDMP reports can be accessed by delegates on behalf of clinicians.
Data sharing	Patient-controlled substance prescription information is shared between bordering states to identify patients who cross state borders for drug-seeking behavior.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/pharma2040030/s1, Table S1: Summary of study results. Figure S1: Years of data used by number of studies. Figure S2: Number of studies that utilized data from that state. Figure S3: Data sources used by number of studies. Figure S4: Scope of the study by number of studies. Supplementary Material S1: Systematic search and review search terms. Supplementary Material S2: Systematic search and review abstraction [148–161]. Supplementary Material S3: Johns Hopkins Evidence-based Practice Model for Nursing and Healthcare Professionals Toolkit's Research Appraisal Tool.

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