Addictive Behaviors 76 (2018) 348–354

Contents lists available at ScienceDirect

Addictive Behaviors

journal homepage: www.elsevier.com/locate/addictbeh

Associations between statewide prescription drug monitoring program (PDMP) requirement and physician patterns of prescribing opioid analgesics for patients with non-cancer chronic pain

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HIGHLIGHTS

- State PDMP implementation was not associated with physician opioid prescribing.
- State PDMP requirement levels was not associated with physician opioid prescribing.
- Medicare patients were more likely to be prescribed opioid analgesics.
- Hispanic patients were less likely to prescribed opioid analgesics.

ARTICLE INFO

Keywords:
Chronic pain
Prescription drug
Drug abuse
Drug policy
Ambulatory care

ABSTRACT

Objective: State-level prescription drug monitoring programs (PDMPs) have been implemented in most states. PDMPs enable registered prescribers to obtain real-time information on patients' prescription history to reduce non-medical use of controlled drugs. This study examined whether PDMP implementation and different levels of PDMP requirements were associated with physicians' patterns of prescribing opioid analgesics for patients with non-cancer chronic pain.

Methods: This is a secondary analysis study using cross-sectional national data. Patients with non-cancer chronic pain from the 2012 National Ambulatory Medical Care Survey were included (weighted N = 81,018,131; unweighted N = 3295). Heckman two-step selection procedure employing two logistic regressions was used to explore the associations between PDMP requirements and physicians' prescribing behaviors, controlling for physician characteristics, patient characteristics, physician-healthcare system interaction, and physician-patient relationship, guided by the Eisenberg's model of physician decision making.

Results: State PDMP implementation status and requirement levels were not associated with physician opioid prescribing for non-cancer chronic pain treatment (p's ranged 0.30–0.32). Patients with Medicare coverage were more likely to be prescribed opioid analgesics than those with private health insurance (OR = 1.55, $p < 0.01$). Hispanic patients were less likely to be prescribed opioid analgesics than non-Hispanic white patients (OR = 0.61, $p < 0.05$).

Conclusions: Findings indicated that the effectiveness of PDMPs on physicians' opioid prescribing tendency for non-cancer chronic pain treatment could not be supported. Policy makers should be aware of the need for redesigning PDMPs regarding requirements and enforcement for prescribers and related stakeholders. Future studies also are needed to identify characteristics contributing to PDMP effectiveness in reducing non-medical use of prescription opioids.

1. Introduction

Non-medical use and misuse of opioid analgesics is a major public health concern in the U.S. (Kolodny et al., 2015; Paulozzi, 2012). There are serious consequences associated with opioid misuse, including traumatic physical and psychological consequences, and increased

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http://dx.doi.org/10.1016/j.addbeh.2017.08.032
Received 7 June 2017; Received in revised form 17 August 2017; Accepted 29 August 2017
Available online 05 September 2017

emergency department visits, hospitalizations, substance treatment admissions, and economic costs (Coben et al., 2010).

Previous studies of non-medical use of prescription opioid analgesics have focused on patient drug seeking behaviors such as doctor or pharmacy shopping or using family's or friends' opioids (Shei et al., 2015; Yang et al., 2015). However, the problem of non-medical use may begin with healthcare providers who fail to adequately play a gatekeeping role when prescribing opioid analgesics (e.g., over-prescribing, providing unnecessary refills, etc.). In fact, prescriptions of opioid analgesics have dramatically increased (Volkow & McLellan, 2011), despite the ongoing controversy of prescribing for non-cancer chronic pain (Chou et al., 2015; Rosenblum, Marsch, Joseph, & Portenoy, 2008). Clinical practice guidelines stipulate that opioid analgesics should never be used as a first-line pharmacological treatment for non-cancer chronic pain, and only be prescribed after other non-opioid pain medications have been shown to be ineffective (Chou et al., 2009; World Health Organization (WHO), 1990). However, these guidelines are often not followed—an estimated 1 out of 5 patients with non-cancer pain are prescribed opioid analgesics in office-based settings (Daubresse et al., 2013). Indeed, prescriber prescribing behaviors may play a crucial role in the epidemic of non-medical use of prescription opioid analgesics.

In order to improve physician prescribing practices surrounding pain medications and to reduce diversion, all states (except Missouri) and District of Columbia (D.C.) have implemented state-level prescription drug monitoring programs (PDMPs), which enable registered prescribers and pharmacists to obtain real-time information on patients' prescription history and thus, prevent “doctor shopping” with concomitant extra prescriptions. However, PDMPs are statewide programs and vary by design, requirement, and operation across states, which has caused barriers to evaluating the effectiveness (Rutkow, Turner, Lucas, Hwang, & Alexander, 2015). For example, each state has various, and often different, terms of provider engagement. As of 2012 (the year of data in this study), 44 states had implemented PDMPs. Among them, two states mandated physicians to enroll in the PDMP query system, whereby physicians could see a patient's fill/refill records of controlled medications. Seven states mandated physicians to query a patient's fill/refill records of controlled medications before prescribing them. The remaining 35 states did not require prescribers to enroll in or query the PDMP systems (Table 1).

Some studies supported the effectiveness of PDMP mandates including mandatory enrollment and mandatory query (Excellence & America, 2013; Freeman, Goodin, Troske, & Talbert, 2015; Haffajee, Jena, & Weiner, 2015). One study found substantial increases in PDMP queries and reductions in opioid prescriptions following implementation of comprehensive use mandates in Kentucky, Tennessee, New York, and Ohio (Kreiner, Nikitin, & Shields, 2014). In contrast, others have found an insignificant impact of PDMPs on physician prescribing of opioids (Brady et al., 2014; Paulozzi, Kilbourne, & Desai, 2011).

To date, studies evaluating the PDMP effectiveness at reducing physician prescribing of opioids have important limitations. First, existing studies usually included both acute and chronic pain cases in the analyses. However, patients with chronic pain tend to receive prescriptions for pain medication multiple times and for a longer period (Chou et al., 2015; Kuo, Raji, Chen, Hasan, & Goodwin, 2016) and thus are at higher risk for developing opioid dependence (Chou et al., 2014; Dowell, Haegerich, & Chou, 2016) as well as misuse or diversion (Volkow & McLellan, 2016), implying that analysis should focus on patients with chronic pain. Second, there have been few studies of PDMPs using national data. Recently, one study used the National Ambulatory Medical Care Survey (NAMCS) and concluded that PDMP implementation was associated with a 30% reduction in opioid prescribing (Bao et al., 2016). However, this study neither distinguished chronic pain from acute pain nor considered different levels of PDMP requirement. Given the aforementioned literature gaps, it is needed to use national data to re-examine the effectiveness of different state-level PDMPs on physicians' opioid prescribing, considering for differences in treatment for acute and chronic pain as well as different levels of PDMP requirements among different states.

This study fills the literature gaps by analyzing physician-reported data on opioid prescribing for patients with non-cancer chronic pain collected from the 2012 NAMCS. We used the Heckman two-step selection procedure to control potential selection bias between patients who needed pain medications and who did not. The Heckman procedure modeled physicians' decision making in two steps: (1) determine whether a pain medication should be prescribed, and (2) if yes, whether opioid analgesics should be prescribed.

2. Methods

2.1. Conceptual framework

We applied the Eisenberg Model of Physician Decision Making to analyze physicians' prescribing patterns, which describes the sociological factors that influence physician decision making. Physician decision making is influenced by four groups of factors: (1) physician characteristics (e.g., physician specialty); (2) patient characteristics (e.g., age, sex, race/ethnicity); (3) physician's relationship with the healthcare system (e.g., practice setting, ownership); and (4) physician's relationship with the patient (e.g., patient seen before) (Eisenberg, 1979). This model has been widely used to characterize physician decision-making when prescribing treatment (Goldberg & Lin, 2017; Lin, Erickson, & Balkrishnan, 2011).

2.2. Data and study sample

This study used data from the 2012 NAMCS, a national probability sample survey conducted by the National Center for Health Statistics and the Centers for Disease Control and Prevention (CDC, 2016). The NAMCS included ambulatory visits to non-federally employed office-based physicians. A physician or staff member provided information about a patient's sociodemographics, physician specialty, reasons for

Table 1
Statewide PDMP implementation status and requirement in 2012.

Status and requirement	States
No PDMP implemented	• Arkansas, District of Columbia, Georgia, Maryland, Missouri, New Hampshire[a,b], Wisconsin[b]
No Requirement	• Alaska, California, Colorado, Connecticut, Delaware[a], Florida, Hawaii, Idaho[a], Illinois, Iowa, Louisiana, Maine[a], Massachusetts, Michigan, Mississippi, Montana[a], Nebraska, New Jersey, New Mexico[a], New York, North Carolina, North Dakota, Ohio, Oregon, Pennsylvania, Rhode Island[a], South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont[a], Virginia, West Virginia[a], Wyoming[a]
Mandatory enrollment	• Alabama, Arizona
Mandatory query	• Indiana, Kansas, Kentucky, Minnesota, Nevada[a], Oklahoma, Washington

Data source: compiled by this study.

[a] Not included in this study due to lack of state identifiers in NAMCS or inability to identify state PDMP status based on NAMCS census division identifiers.

[b] PDMPs that were enacted but not yet implemented in 2012.

the visit, source of payment for the visit, diagnoses, and prescribed medications (CDC, 2016). We used data from the 2012 NAMCS because they have been released in the latest year with state identifiers for us to match each study participant with his/her state.

Notably the 2012 NAMCS did not provide the state identifier for 16 states that were less populous in order to avoid confidentiality breaches of patients. For these 16 states, we used the NAMCS census division identifier to identify a state's PDMP requirement if the state is within a census division where all of the included states had the same PDMP requirement, and consequently five states' PDMP requirement was further identified. Finally, we were able to identify 39 states' PDMP requirement (Table 1).

Due to our focus on high risk populations, we only included patients diagnosed with non-cancer chronic pain that included general chronic pain, back pain, arthritis/joint pain, as suggested by previous studies (Edlund et al., 2010; Martin et al., 2011). These patients were extracted based on the ICD-9-CM codes shown in Appendix A. Cancer patients were excluded because prescribing opioid analgesics to this population is more accepted (Portenoy, Mehta, & Ahmed, 2017). We excluded children due to the heterogeneity of pain treatment. This study was classified as a non-human subjects study by the institutional review board of Indiana University.

2.3. Measurement

2.3.1. Outcome variables

Two outcome variables were constructed to characterize the two-step process of physicians' decision making: (1) prescribing pain medications (both opioid and non-opioid agents); and (2) prescribing opioids (including opioids, opioid combinations, and opioid equivalents) when any pain medication to be prescribed. Table 2 lists the pain medications that were included in this study as clinical practice guidelines suggest them as pharmacological treatment for non-cancer chronic pain (ASA, 2012; Chou et al., 2009). The two outcome variables were both coded as binary (ever prescribed in 2012).

2.3.2. Primary independent variable

We classified the PDMP requirement for each state as no PDMP implemented, no requirement, mandatory enrollment, and mandatory query (see Table 1). Mandatory enrollment mandated physicians to enroll in the PDMP query system where physicians could see a patient's fill/refill records of controlled drugs. Mandatory query mandated physicians to query a patient's fill/refill records of controlled drugs before they prescribed such drugs. No requirement indicated that the states had implemented PDMPs but had no requirement regarding PDMP enrollment and query.

2.3.3. Covariates

Based on the Eisenberg Model, we included the following covariates: primary care physician or specialist, the patient's sex, age, race, primary source of payment (private insurance, Medicare, Medicaid, or others), physician as full owner of practice setting or not, owner of practice settings (physician or physician group, medical center or hospital, or health insurance plans), practice region (northeast, midwest, south, or west), metropolitan status, adoption of electronic medical record (EMR) system (all electronic, partial paper and partial electronic, or all paper), and new patient status. All variables were coded as categorical variables.

2.4. Statistical analysis

Descriptive statistics were provided for each variable. Chi-square tests were conducted to examine the differences between patients who were and were not prescribed pain medications on each of the variables. The primary analysis of the 2012 NAMCS data involves applying the Heckman two-step selection procedure to characterize the two-step process of physicians' decision making on prescribing pain medications and opioid analgesics. The first step of the Heckman procedure used a logistic regression to examine the factors which may influence whether a patient was prescribed any pain medication. The second step of the procedure used another logistic regression to examine factors which may influence whether opioid analgesics were prescribed among those who were prescribed a pain medication. Specifically, a term named Mill's ratio was generated in the first-step model, and its inverse was then included as an additional covariate in the second-step model to correct for the selection bias associated with physicians' prescribing patterns (Heckman, 1979). All statistical analyses were conducted using Stata® 14 and were weighted based on the NAMCS sampling scheme in order to obtain national estimates.

3. Results

Table 3 depicts descriptive statistics of the variables used in the Heckman two-step selection procedure. Among the study sample, 52.1% were prescribed pain medications. In this national sample, 40.2% of the patients with non-cancer chronic pain were male, approximately 70% aged older than 50 years, 78.4% were non-Hispanic white, 46.2% were treated by primary care physicians, 84.7% were prior patients of the physician, and 45.8% used private insurance as the primary source of payment. In terms of physician-healthcare system interaction, 42.7% patients were treated by physicians who were full owners of practice settings, 42.7% of the practices were in the south, 88.5% of the practices were in metropolitan areas, and 59.9% of the physicians adopted full electronic medical record system. Concerning PDMP status, 70.4% resided in the states with a PDMP but no requirement, 3.96% with mandatory enrollment, and 14.7% with mandatory query. Moreover, among the patients who were prescribed pain medications, 55.9% were prescribed opioids.

The results of Chi-square tests indicate that patients who were and were not prescribed pain medications had significant differences in

Table 2
Pain medications included in this study.

Type of pain medication	Medications included
Opioid medications	• Drugs containing alfentanil, buprenorphine, butorphanol, codeine, dihydrocodeine, fentanyl, hydrocodone, hydromorphone, levorphanol, meperidine, methadone, morphine, nalbuphine, oxycodone, oxymorphone, pentazocine, remifentanil, tapentadol, and tramadol
Non-opioid medications	• Antidepressants: SNRIs (duloxetine, milnacipran, and venlafaxine) and TCAs (amitriptyline, imipramine, and maprotiline) • NSAID agents: aspirin, diflunisal, choline magnesium trisalicylate, salsalate, naproxen, ibuprofen, ketoprofen, flurbiprofen, oxaprozin, diclofenac, etodolac, indomenthacin, tolmetin, sulindac, meloxicam, piroxicam, meclofenamate, mefenamic, and nabumetone • COX-2 inhibitor: celecoxib • Salicylates • Pregabalin and gabapentin

SNRI: serotonin-norepinephrine reuptake inhibitor (that have indications for pain treatment).
TCA: tricyclic antidepressants (that have indications for pain treatment).
NSAID: nonsteroidal anti-inflammatory drug agents.

Table 3
Descriptive statistics of study sample (patients with non-cancer chronic pain).

Variable	Prescribed pain medication	Not prescribed pain medication	Overall	*P*-value
	N = 42,244,145 (52.1%)	N = 38,773,986 (47.9%)	N = 81,018,131 (100%)	
1. Physician characteristics				
Primary care physician	22,493,110 (27.8%)	149,326,635 (18.4%)	37,425,745 (46.2%)	< 0.0001**
Specialist	19,751,035 (24.4%)	23,841,350 (29.4%)	43,592,385 (53.8%)	
2. Patient characteristics				
Sex				0.6896
Male	17,107,158 (21.1%)	15,422,492 (19.0%)	32,529,651 (40.2%)	
Female	25,136,987 (31.0%)	23,351,493 (28.8%)	48,488,480 (59.8%)	
Age				0.0156*
18–25	1,007,869 (1.24%)	1,335,042 (1.65%)	2,342,912 (2.89%)	
26–49	12,609,815 (15.6%)	10,143,546 (12.5%)	22,753,361 (2.81%)	
50–64	15,121,599 (18.7%)	13,258,021 (16.4%)	28,379,619 (35.0%)	
65 and above	13,504,863 (16.7%)	14,037,376 (17.3%)	27,542,239 (34.0%)	
Race/ethnicity				0.8945
Non-Hispanic white	33,223,686 (41.0%)	30,321,410 (37.4%)	63,545,096 (78.4%)	
Non-Hispanic black	4,243,673 (5.24%)	3,839,284(4.74%)	8,082,957 (9.98%)	
Hispanic	3,239,017 (4.0%)	2,986,622 (3.69%)	6,225,639 (7.68%)	
Other	1,537,769 (1.9%)	1,626,669 (2.01%)	3,164,438 (3.91%)	
Primary source of payment:				0.0051**
Private insurance	18,733,245 (23.1%)	18,371,024 (22.7%)	37,104,270 (45.8%)	
Medicare	13,181,035 (16.3%)	13,420,332 (16.6%)	26,601,418 (32.8%)	
Medicaid	3,118,387 (3.85%)	1,821,840 (2.25%)	4,940,227 (6.1%)	
All others	4,272,884 (5.27%)	3,658,810 (4.52%)	7,931,694 (9.79%)	
3. Physician-healthcare system interaction				
Physician as full owner of practice setting	16,397,591 (20.2%)	18,228,282 (22.5%)	34,625,873 (42.7%)	0.0442*
Owner of practice settings:				0.2875
Physician or physician group	33,662,227 (41.5%)	32,141,895 (39.7%)	65,804,122 (81.2%)	
Medical center or hospital	2,728,183 (3.37%)	2,246,223 (2.77%)	4,974,406 (6.14%)	
Health insurance plans	4,537,921(5.6%)	3,008,342 (3.71%)	7,546,263 (9.31%)	
Practice region				0.0007**
Northeast	5,016,857 (6.19%)	8,188,312 (10.1%)	13,205,168 (16.3%)	
Midwest	7,083,140 (8.74%)	6,996,519 (8.64%)	14,079,658 (17.4%)	
South	19,650,872 (24.3%)	14,978,301 (18.5%)	34,629,173 (42.7%)	
West	10,493,277 (13.0%)	8,610,854 (10.6%)	19,104,131 (23.6%)	
Metropolitan status	36,679,034 (45.3%)	35,042,656 (43.3%)	71,721,691 (88.5%)	0.0129*
Adoption of electronic medical record system				0.7987
Full adoption	25,927,731 (32.0%)	22,617,159 (27.9%)	48,544,890 (59.9%)	
Partial adoption	5,343,494 (6.6%)	5,270,775 (6.51%)	10,614,270 (13.1%)	
No adoption	10,897,684 (13.5%)	10,796,493 (13.3%)	21,694,177 (26.8%)	
4. Physician-patient relationship				
Patient seen before	36,609,617 (45.2%)	31,976,065 (39.5%)	68,585,682 (84.7%)	0.0022*
5. PDMP status				
			0.5683	
No implemented PDMP	4,764,185 (5.88%)	4,122,017 (5.09%)	8,886,202 (11%)	
No requirement	29,199,321 (36.0%)	27,844,990 (34.4%)	57,044,312 (70.4%)	
Mandatory enrollment	1,821,920 (2.25%)	1,383,948 (1.71%)	3,205,868 (3.96%)	
Mandatory query	6,458,719 (7.97%)	5,423,030 (6.69%)	11,881,747 (14.7%)	
6. Opioid prescription				
Yes	23,593,533 (55.9%)[a]	–	–	–
No	18,650,612 (44.1%)[a]	–	–	

Data source: 2012 National Ambulatory Medical Care Survey.
* $p < 0.05$.
** $p < 0.01$.
[a] Only among those who were prescribed pain medications.

whether seen by a primary care physician, patient age, primary source of payment, whether the physician was an owner of practice setting, practice region, metropolitan status, and whether a patient was seen before (all p's < 0.05).

Note that a Chi-square test was conducted to test the difference between the two groups on each categorical variable. The degree of freedom for each variable is the number of categories − 1 (e.g., the df. for age = 3). These bivariate analyses were conducted independently.

Table 4 shows the results of the first-step Heckman selection procedure. The logistic regression examined the factors that were associated with whether a physician prescribed any pain medication for patients with non-cancer chronic pain. Specifically, the odds of being prescribed a pain medication from primary care physicians were higher than that from specialists (OR = 1.74, $p < 0.01$), after adjusting for the effects of all the other covariates. Patients with Medicaid coverage were more likely to be prescribed pain medications than those who had private insurance coverage (OR = 1.66, $p < 0.01$). The odds of being prescribed a pain medication for patients who were treated in practice settings owned by the physician were 0.64 times the odds of those treated in those not owned by physicians (OR = 0.64, $p < 0.01$). Moreover, patients in south and west regions were more likely to be prescribed pain medications than those in northeast region (OR = 2.04 and 2.03, respectively; both p's < 0.01). Nevertheless, we did not find significant associations of PDMP implementation and requirements

Table 4
Pain medication prescription by logistic regression (Heckman 1st step).

	Odds ratio	95% confidence interval
1. Physician characteristics		
Primary care physician	1.74**	(1.27, 2.38)
2. Patient characteristics		
Sex: male	1.02	(0.87, 1.18)
Age		
18–25	–	–
26–49	1.80*	(1.12, 2.87)
50–64	1.68*	(1.05, 2.70)
65 and above	1.52	(0.92, 2.51)
Race/ethnicity:		
Non-Hispanic white	–	–
Non-Hispanic black	0.85	(0.63, 1.16)
Hispanic	0.94	(0.65, 1.37)
Other	0.79	(0.55, 1.13)
Primary source of payment:		
Private insurance	–	–
Medicare	1.03	(0.81, 1.31)
Medicaid	1.66**	(1.17, 2.37)
All others	1.24	(0.85, 1.81)
3. Physician-healthcare system interaction		
Physician as full owner of practice setting	0.64**	(0.48, 0.85)
Owner of practice settings:		
Physician or physician group	1.05	(0.63, 1.76)
Medical center or hospital	–	–
Health insurance plans	1.02	(0.55, 1.90)
Practice region:		
Northeast	–	–
Midwest	1.43	(0.91, 2.23)
South	2.04**	(1.27, 3.26)
West	2.03**	(1.31, 3.16)
Metropolitan status	0.93	(0.64, 1.35)
Adoption of electronic medical record system:		
Full adoption	1.00	(0.70, 1.42)
Partial adoption	1.17	(0.68, 2.00)
No adoption	–	–
4. Physician-patient relationship		
Patient seen before	1.24	(1.00, 1.55)
5. PDMP status:		
No implemented PDMP	–	–
No requirement	1.00	(0.62, 1.61)
Mandatory enrollment	0.98	(0.53, 1.81)
Mandatory query	0.95	(0.56, 1.62)
Intercept	0.30*	(0.11, 0.80)

Data source: 2012 National Ambulatory Medical Care Survey.
Weighted N = 70,844,113; unweighted N = 4937.
* $p < 0.05$
** $p < 0.01$.

Table 5
Opioid prescription by logistic regression (Heckman 2nd step).

	Odds ratio	95% confidence interval
1. Physician characteristics		
Primary care physician	0.70	(0.18, 2.83)
2. Patient characteristics		
Sex: Male	1.06	(0.85, 1.33)
Age		
18–25	–	–
26–49	2.09	(0.41, 10.61)
50–64	1.88	(0.42, 8.38)
65 and above	1.33	(0.36, 4.89)
Race/ethnicity:		
Non-Hispanic white	–	–
Non-Hispanic black	0.96	(0.54, 1.71)
Hispanic	0.61*	(0.38, 0.99)
Other	0.57	(0.25, 1.33)
Primary source of payment:		
Private insurance	–	–
Medicare	1.55**	(1.14, 2.11)
Medicaid	2.07	(0.59, 7.23)
All others	2.35*	(1.20, 4.61)
3. Physician-healthcare system interaction		
Physician as full owner of practice setting	1.57	(0.45, 5.50)
Owner of practice settings:		
Physician or physician group	0.73	(0.41, 1.31)
Medical center or hospital	–	–
Health insurance plans	1.07	(0.56, 2.06)
Practice region:		
Northeast	–	–
Midwest	1.07	(0.33, 3.49)
South	1.74	(0.25, 12.12)
West	1.34	(0.19, 9.62)
Metropolitan status	0.89	(0.53, 1.47)
Adoption of electronic medical record system:		
Full adoption	0.84	(0.53, 1.33)
Partial adoption	0.90	(0.40, 2.02)
No adoption	–	–
4. Physician-patient relationship		
Patient seen before	1.47	(0.75, 2.86)
5. PDMP status		
No implemented PDMP	–	–
No requirement	0.73	(0.40, 1.34)
Mandatory enrollment	0.69	(0.32, 1.45)
Mandatory query	0.72	(0.38, 1.34)
Inverse Mill's ratio	0.42	(0.006, 29.48)
Intercept	1.14	(0.001, 1149.14)

Data source: 2012 National Ambulatory Medical Care Survey.
Weighted N = 36,799,187; unweighted N = 2468.
* $p < 0.05$.
** $p < 0.01$.

with likelihood of being prescribed pain medications (p's ranged from 0.86–0.99).

Table 5 reveals the results of the second-step Heckman selection procedure. The logistic regression examined factors associated with whether physicians prescribed opioid analgesics for patients with non-cancer chronic pain, under the condition that a pain medication was prescribed. The odds of being prescribed opioids for Hispanic patients were 0.61 times the odds for non-Hispanic white patients, after adjusting for the effects of all the other covariates (OR = 0.61, $p < 0.05$). The odds of being prescribed an opioid for Medicare patients were 1.55 times the odds for those with private insurances (OR = 1.55, $p < 0.01$). Nevertheless, we did not find significant associations of PDMP implementation and requirements with likelihood of being prescribed opioid analgesics for non-cancer chronic pain treatment, under the condition that a pain medication was prescribed (p's ranged from 0.30–0.32).

4. Discussion

This study analyzed physician-reported data on opioid prescription for patients with non-cancer chronic pain from a nationally representative sample. After adjusting for the covariates based on the Eisenberg model, PDMP implementation and different levels of requirements did not have significant associations with pain medication or opioid prescribing for patients with non-cancer chronic pain.

These results indicate that even when PDMPs were implemented, they could hardly reach the goal of reducing physicians' prescribing of controlled medications. Furthermore, even when PDMPs required mandatory enrollment to the program or mandatory query before prescribing, they still failed to reach the goal of reducing prescribing of opioids. It could be surprising that the likelihood of physicians' prescribing opioid analgesics for non-cancer chronic pain patients in states with a PDMP was not significantly different from that in states without

a PDMP. However, the ineffectiveness of PDMPs could be attributable to the following reasons.

This study did not show an association between a PDMP without any requirement for physicians (i.e., mandatory enrollment or mandatory query) and physicians' opioid prescribing. This implied that PDMPs may not reach their ultimate goal of reducing non-medical use of opioids if no requirements are given to prescribers. Additionally, this study neither find an association between a PDMP with the mandatory enrollment requirement and physicians' opioid prescribing. Previous report has indicated that physicians are mandated to enroll in the PDMP query system primarily for meeting the criteria for relicensing (Haffajee et al., 2015), implying that mandatory enrollment does not guarantee that a physician would query the system before prescribing opioids. In sum, PDMPs' mandatory enrollment requirement or lack of any requirement may be unsuccessful when trying to reduce physicians' opioid prescribing.

The insignificant result associated with mandatory query may be surprising as mandatory query mandates physicians to query patients' fill/refill records of controlled drugs before they prescribe such drugs, whereas mandatory enrollment only mandates physicians' enrollment in the PDMP query system. In reality, physicians' busy practice schedules may make mandatory query an unachievable standard (Haffajee et al., 2015). Another possible explanation is that under existing PDMPs, physicians are unlikely to be penalized or punished even when the mandatory query requirement is not met (NAMSDL, 2014). That is, if physicians do not follow the requirement, there will likely be no consequence, implying that the apparent program ineffectiveness may stem from suboptimal execution. Further studies are needed to explore factors that may contribute to physicians' compliance (or non-compliance) to program requirements.

Patient characteristics, including race/ethnicity and health insurance coverage, also were found to be associated with physicians' likelihood to prescribe opioids. Our finding indicated that Medicare patients, compared with patients with private insurance, were more likely to be prescribed opioids. This may demonstrate the documented abuse of government funded health insurance programs (Daly, 2009; Sparrow, 2009). Private insurance companies, on the other hand, may have made efforts to implement systems to monitor potential abuse for the purpose of controlling costs, including restrictive drug formularies, tiered medication programs, and drug utilization review. Another notable finding is that Hispanic patients were less likely to be prescribed opioids compared to non-Hispanic white patients. Previous studies have documented racial/ethnic disparities in pain treatment (Anderson, Green, & Payne, 2009; Drwecki, Moore, Ward, & Prkachin, 2011), with minorities less likely to receive pain medications (Bonham, 2001; Pletcher, Kertesz, Kohn, & Gonzales, 2008; Tamayo-Sarver, Hinze, Cydulka, & Baker, 2003), which warrants further investigations on PDMPs' impact on racial/ethnic disparities in pain treatment.

This study has some limitations that should be addressed. First, state PDMPs are diverse in terms of design and implementation. Such diversity cannot be adequately characterized by simply classifying them into mandatory enrollment, mandatory query, and no requirement. The need for more sophisticated classification system is warranted. Second, this was a cross-sectional study so the associations found in this study should not be considered as causal relationships. A longitudinal study with a quasi-experimental design is better suited for making causal inference. Third, NAMCS is a physician-reported survey that is subject to recall and response biases. Fourth, our analysis unavoidably excluded records from eleven less populous states and D.C. without their state identifies. Finally, this study examined the associations of PDMP implementation and requirements on opioid prescribing rather than excessive prescribing. However, the finding of this study is still meaningful as this study focused on non-cancer chronic pain patients whose first-line treatments are recommended to be non-opioid agents. Future studies could further define excessive opioid prescribing and examine how it could be influenced by PDMP implementation.

Statewide PDMPs have been implemented to reduce non-medical use of opioid analgesics which is a major public health concern in the U.S. This study analyzing physician-reported data on opioid prescribing for patients with non-cancer chronic pain found that the effectiveness of PDMPs was not supported even when controlling for the level of requirements for physicians. Policy makers should be aware of the need for redesigning current PDMPs regarding requirements and enforcement for prescribers and related stakeholders. Future studies are also needed to identify detailed characteristics contributing to PDMP effectiveness at reducing non-medical use of prescription opioids.

Role of funding sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Contributors

Lin designed the study and conducted the statistical analysis. Lin and Wang conducted literature searches and provided summaries of previous research studies. Wang and Buu helped with conceptualization of the study and interpretation of findings. Lin and Buu drafted the manuscript. Buu, Boyd and Simoni-Wastila critically revised the manuscript. All authors contributed to and have approved the final manuscript.

Conflict of interests

The authors have no competing interests or conflicts to declare.

Appendix A. ICD-9-CM Codes for Patient Identification

Condition	ICD-9-CM codes
General chronic pain	338.0, 338.2, 338.21, 338.22, 338.28, 338.29, and 338.4
Back pain	724.1, 724.2, 724.5, and 307.89
Arthritis/joint pain	95.6, 95.7, 98.5, 99.3, 136.1, 274, 277.2,287.0, 344.6,353.0, 354.0, 355.5, 357.1, 390, 391, 437.4, 443.0, 446, 447.6, 696.0, 710, 711, 712, 713, 714, 715, 716.0, 716.2, 716.8, 716.1, 716.3–0.9, 719.0, 719.4–0.9, 719.2–0.3, 720, 721, 725, 726, 727, 728.0–0.3, 728.6–0.9, 729.0, 729.1, and 729.4
Cancer	140.x-172.9, 174.x-215.9, 217–229.10, 235–239.9, and 338.3

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