

# Data sources regarding the nonmedical use of pharmaceutical opioids in the United States

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## Abstract

**Objective:** Recent increases in the nonmedical use of pharmaceutical opioids and the adverse outcomes associated with them have stimulated a large amount of research and data collection on this public health problem. Systematic organization of the available data sources is needed to facilitate ongoing research, analysis, and evaluation. This work offers a systematic categorization of data sources regarding the nonmedical use of pharmaceutical opioids in the United States.

**Methods:** A list of keywords regarding the nonmedical use of pharmaceutical opioids was used to conduct systematic searches in PubMed®. Filtration of search results generated 92 peer-reviewed academic articles, published between January 1995 and April 2012, as well as a number of primary data sources. Lists of topics were developed independently by two researchers which were later compared and consolidated. All sources were then categorized according to their relevance to each of these topics and according to their capacity for geographical and longitudinal trend analysis.

**Results:** Tables cataloging data sources can be used to identify data relevant to specific topics in diversion, nonmedical use, and adverse outcomes associated with pharmaceutical opioids, and they illustrate global trends in data coverage, identifying several topics that have minimal data. A network diagram illustrates global trends in data coverage, showing variation among sources in the number of topics they cover, as well as variation among topics in the number of sources that cover them.

**Conclusions:** The categorization of data sources is hoped to facilitate ongoing research, analysis, and evaluation of this public health problem by serving as a guide for researchers, policy makers, and others who seek data regarding the nonmedical use of pharmaceutical opioids in the United States.

## Keywords

*Pharmaceutical opioids, Data sources; Nonmedical use*

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## Introduction

A dramatic rise in the nonmedical use of pharmaceutical opioids presents the United States with a substantial public health problem [1]. The 2011 National Survey of Drug Use and Health (NSDUH) estimates that 2.3 percent of the US population used pain relievers nonmedically during the past month, and that at least 1.9 million individuals have initiated nonmedical use each year since 2002 [2]. Such medications are now among the most popular drugs for nonmedical use, second only to marijuana [3], and are associated with a variety of adverse outcomes. The number of overdose deaths involving opioids increased threefold between 1999 and 2006, and fivefold among youth aged 15 to 24 [4]. Use disorders involving pain reliever abuse or dependence were estimated to afflict 1.4 million individuals in 2011, one third of whom were young adults between the ages of 18 and 25 [2]. Many of the pharmaceutical opioids that are used nonmedically are diverted in some way from their legally intended purpose: over half of nonmedical users report acquiring their most recent supply of pain relievers from a friend or relative, and among them, over three quarters report that their friend or relative had acquired the pain relievers from a doctor [2-5].

Considerable research has been conducted on the public health problems surrounding nonmedical use of pharmaceutical opioids. Large scale primary data collection methods, such as the NSDUH, the National Poison Data System (NPDS), and the Drug Abuse Warning Network (DAWN) have enabled a large number of analyses on the prevalence [6-7], characteristics [8-9], and adverse outcomes [10-11] associated with nonmedical opioid use. Smaller, independent studies have measured prevalence among a number of prominent subpopulations, such as physicians [12], anesthesiologists [13], and student pharmacists [14], and have been instrumental in identifying additional factors that are relevant to this public health problem. These factors include polydrug use [15], mental health problems [16], social support [17], and routes of diversion [18].

Because of the large number of data sources available for studying nonmedical opioid use and the wide range of relevant factors, systematic organization of data sources is needed to facilitate ongoing research, analysis, and evaluation of this public health problem. Initial efforts organize data sources according to topic [19] and geographical scale [20]; however a systematic approach has not yet been employed in the search and categorization of existing data sources. This work provides a systematic approach to the collection and categorization of data sources along a set of prominent topics in the field, providing a guide for researchers, policy-makers, and others who seek data on various aspects of the nonmedical use of pharmaceutical opioids in the United States.

## Methods

This work was conducted to advance a larger research project which uses System Dynamics modeling to investigate the nonmedical use of pharmaceutical opioids in the United States. System Dynamics is a computer simulation methodology that describes a system in terms of stocks and flows which are governed by differential equations [21-22]. This methodology is capable of incorporating a large range of available data into a systems-level model that represents the global dynamics of the system of interest [23].

### Keyword searches

To provide empirical support for the specification of a System Dynamics model, data sources were systematically sought out for their relevance to the diversion, nonmedical use, and adverse outcomes associated with pharmaceutical opioids in the United States. This investigation began with a list of keywords which were identified from the project's previously established collection of electronic resources,

including journal articles, government documents, and reports regarding the public health problem of nonmedical opioid use. The list was compiled by scanning through documents for words listed in a “keywords” field, and was then simplified by omitting keywords of non-opioid drugs and substances, specific drug formulation names (e.g., Fentanyl, OxyContin), words pertaining specifically to medical treatment, and other words that were not directly related to the phenomena of interest (e.g., screening instrument, prevention, mental health, triplicates). The final list of keywords was grouped into diversion, nonmedical use, and adverse outcome categories, and used in three PubMed searches for peer-reviewed academic articles published between January 1, 1995, and May 1, 2012. The specific searches, submitted to PubMed® in May of 2012, are included in Table I.

1	(Opioid OR Opioids) AND (Misuse OR Noncompliance OR “Non-compliance” OR Diversion) AND (“1995/01/01”[Date - Publication] : “2012/05/01”[Date - Publication])
2	(Opioid OR Opioids) AND (Deaths OR “Drug-related harm” OR “Fatal Outcome” OR Mortality OR Overdose OR Poisoning) AND (“1995/01/01”[Date - Publication] : “2012/05/01”[Date - Publication])
3	(Opioid OR Opioids) AND (Abuse OR “Aberrant drug-related behaviors” OR Addiction OR “Abuse Liability” OR “Problem Drug Use” OR “Substance Use Disorders” OR “Substance-Related Disorders” OR “Substance related disorders” OR “Nonmedical Use” OR “Non-medical Use” OR “Non medical Use”) AND (“1995/01/01”[Date - Publication] : “2012/05/01”[Date - Publication])

**Table I.** Opioid Searches Submitted to PubMed® in May 2012

### Source filtration

Literature searches conducted in PubMed® returned a large number of hits regarding diversion (1,506), nonmedical use (15,512), and adverse outcomes (4,508). These studies were filtered by a team of three graduate students with the following search criteria: all journal articles were required to be peer reviewed, to be available in the English language, to contain quantitative data on human subjects, to have a minimum sample size of 30 participants, and to have direct relevance to the US population. Studies on medical treatment with pharmaceutical opioids were excluded, including treatment for opioid or opiate dependence. Articles which analyzed secondary data were also excluded, but the primary data sources used were noted for inclusion in the categorization process described below.

A filtered collection of 92 articles meeting the search criteria were evaluated qualitatively by two graduate students, who independently created lists of the most prominent topics. The two lists were compared, and differences between them were resolved through discussion, resulting in a final list of 20 topics. These topics were grouped for their relevance to diversion, nonmedical use, and adverse outcomes, as they appear in Tables II through IV. At a later time point, two design features were identified as salient, as several articles reported analyses of longitudinal and/or geographic trends. These attributes are included in the Appendix.

### Categorization

A list of sources was created, including the 92 filtered articles and 42 additional primary sources that had been noted during the filtration process. Each source was categorized by the geographical scale at which it was collected, and for its relevance to any of the 20 topics and 2 design attributes. Closer examination of articles during this phase resulted in several more instances of exclusion, for reasons of confounding (e.g., opioids with heroin; nonmedical with medical use), absence of original data (e.g., review articles, secondary analyses), or research on excluded topics (e.g., search algorithms for post-marketing surveillance, healthcare costs among nonmedical users). Several primary sources were also excluded during the categorization phase, for reasons of duplication (e.g., Veterans Affairs and Veterans Health Administration), and measurement of excluded topics (e.g., adverse events, which imply medical use). This resulted in a final list of 35 original research articles as well as 22 primary data

sources, categorized in Tables 2 through IV, and the Appendix. For primary data sources (i.e., those not specific to any journal article), additional references were sought to establish whether they satisfied each scale, topic, and attribute in the tables.

## Results

The following sections describe the data sources that were found to be relevant to various aspects of diversion, nonmedical use, and the adverse outcomes associated with pharmaceutical opioids, as shown in Tables II through IV. Data sources' capacity for geographical and longitudinal trend analysis will not be discussed in detail, but results are available in the Appendix. In all tables, row headings indicate prominent topics, while column headings indicate the highest scale at which the data source is relevant. Sources are arranged by bullets within a table cell to differentiate large scale primary sources from independent studies. Bullets containing the name of a primary source are followed by informational resources and example analyses. Bullets without a source name contain the independent studies that have been conducted for a given topic and scale level. Sources that can be accessed publicly are indicated with bold type font, and sources that do not strictly limit responses to pharmaceutical opioids, but imply them (e.g., listing "pain killers," "pain relievers," or "narcotics other than heroin") are indicated with an asterisk. Key highlights among the predominant data sources for nonmedical use, diversion, and adverse outcomes are provided in the sections below.

### Nonmedical use table

Table II categorizes data sources by central topics in the prevalence, frequency, and characteristics of those who use pharmaceutical opioids nonmedically in the United States. Because of the illegal nature of nonmedical opioid use, its prevalence is measured most often through self-report surveys, especially among non-patient populations [24-31]. Among patient populations, prevalence of nonmedical use is measured with either survey [16,24,32] or toxicology methods, such as urine screening [24,33,34]. In addition to prevalence, some surveys ask about the frequency of nonmedical use during a recent period of time [26,35-40], or about the age of initiation [5,41,42], or duration [43] of nonmedical use. Other studies measure prevalence among more specific populations, such as parturients [44], club goers [36], student pharmacists [14], healthcare workers [12,13], and probationers [17].

A great amount of attention is paid to determining the characteristics of nonmedical opioid users [8,45,46]. Not surprisingly, a large number of data sources capture demographic information, which allows nonmedical use of pharmaceutical opioids to be studied in terms of age, gender, and racial/ethnic differences. Additional characteristics include income [42,47], employment status [27,28,42,47,48], housing status [42,48], educational performance [46] and attainment [16], physical health [16,30,31,47], mental health [16,17,30,31,32,34,46], and legal or behavioral problems [34,42,47]. Social characteristics include marital status [16,27,28,49], family structure [27,28,49], social support [17], urbanicity [50] and community size [9], as well as college-level characteristics [51]. Several studies have also measured motivations for nonmedical use, such as pain relief, experimentation, or "getting high" [9,14,24,37,38,52], as well as attitudes about the perceived risk of using pharmaceutical opioids nonmedically [9]. Two additional topics of importance include common routes of administration [9,13,37,38,48,53-57], and polydrug use behaviors [5,13,15,29,35,38,42,43,58,59], which make the potential harm of nonmedical use especially high [43].

### Diversion table

Table III provides categorization of sources based on their relevance to the diversion of pharmaceutical opioids. Diversion is defined as the transfer of pharmaceutical opioids from their lawful purpose to

Topics: nonmedical use	Scale <sup>o</sup>			
	National	State	Multi-center	Single-Center
<b>Prevalence of misuse/ abuse among patients</b>	<input type="checkbox"/> Toxicology [33] <input type="checkbox"/> [88]		<input type="checkbox"/> RADARS <sup>®</sup> [25,75] <input type="checkbox"/> [16,32,34]	
<b>Prevalence of nonmedical use among non-patients</b>	<input type="checkbox"/> <b>DAWN</b> [6,82,89] <input type="checkbox"/> <b>MTF</b> * [9,39] <input type="checkbox"/> NAVIPPRO [57,86,90] <input type="checkbox"/> <b>NESARC</b> * [91-93] <input type="checkbox"/> NLAES* [92] <input type="checkbox"/> <b>NSDUH</b> * [7,41,46,94] <input type="checkbox"/> [51]	<input type="checkbox"/> CDAS* [30,31,95] <input type="checkbox"/> [12]	<input type="checkbox"/> RADARS <sup>®</sup> [25,75] <input type="checkbox"/> [13,36*,37,96]	<input type="checkbox"/> [14,24,26,29,35,38,42]
<b>Frequency of nonmedical use</b>	<input type="checkbox"/> <b>MTF</b> * [39] <input type="checkbox"/> <b>NSDUH</b> * [40,94]		<input type="checkbox"/> [36]*	<input type="checkbox"/> [26,35,38]
<b>Initiation of nonmedical use</b>	<input type="checkbox"/> NAVIPPRO [86,90] <input type="checkbox"/> <b>NSDUH</b> [2,41,94]		<input type="checkbox"/> RADARS <sup>®</sup> [75]	<input type="checkbox"/> [42]
<b>Individual characteristics of those exhibiting nonmedical use</b>	<input type="checkbox"/> <b>DAWN</b> [6,82] <input type="checkbox"/> <b>MTF</b> * [9] <input type="checkbox"/> NAVIPPRO [57,86,90] <input type="checkbox"/> <b>NESARC</b> * [92,93] <input type="checkbox"/> NLAES* [92] <input type="checkbox"/> <b>NSDUH</b> * [7,40,41,46,47,68-70,94] <input type="checkbox"/> <b>NVSS</b> [83,97] <input type="checkbox"/> <b>TEDS</b> [98,99] <input type="checkbox"/> Toxicology [33]	<input type="checkbox"/> CDAS* [30,31,95] <input type="checkbox"/> [12]	<input type="checkbox"/> RADARS <sup>®</sup> [50,75] <input type="checkbox"/> [13,16,32,34,36*,37,48]	<input type="checkbox"/> Treatment Centers [45,100,101] <input type="checkbox"/> [15,17,24,35,38,42,52,58]
<b>Social characteristics of those exhibiting nonmedical use</b>	<input type="checkbox"/> <b>NESARC</b> * [91,92] <input type="checkbox"/> NLAES* [92] <input type="checkbox"/> <b>MTF</b> * [9] <input type="checkbox"/> [51]	<input type="checkbox"/> CDAS* [30,31,95]	<input type="checkbox"/> RADARS <sup>®</sup> [50] <input type="checkbox"/> [36*,48]	<input type="checkbox"/> [17]
<b>Motivations/ attitudes toward nonmedical use</b>	<input type="checkbox"/> <b>MTF</b> * [9]		<input type="checkbox"/> RADARS <sup>®</sup> [102] <input type="checkbox"/> [37]	<input type="checkbox"/> [14,24,38,52,66]
<b>Routes of administration</b>	<input type="checkbox"/> <b>MTF</b> * [39] <input type="checkbox"/> NAVIPPRO [57,86,90] <input type="checkbox"/> NPDS [10,72,84] <input type="checkbox"/> <b>NSDUH</b> * [53,54,94]		<input type="checkbox"/> RADARS <sup>®</sup> [55] <input type="checkbox"/> [13,37,48]	<input type="checkbox"/> [38,42]
<b>Prevalence of polydrug use</b>	<input type="checkbox"/> <b>DAWN</b> [6,82] <input type="checkbox"/> NAVIPPRO [86,90]		<input type="checkbox"/> [13]	<input type="checkbox"/> [15,29,35,38,42,58,59]

**Table II.** Categorization of data sources regarding the nonmedical use of pharmaceutical opioids

CDA = Center for Drug and Alcohol Studies; DAWN = Drug Abuse Warning Network; MTF = Monitoring the Future; NAVIPPRO = National Addictions Vigilance Intervention and Prevention Program; NESARC = National Epidemiologic Survey on Alcohol and Related Conditions, NLAES = National Longitudinal Alcohol Epidemiology Survey; NPDS = National Poison Data System; NSDUH = National Survey on Drug Use and Health; NVSS = National Vital Statistics System; RADARS<sup>®</sup> = Researched Abuse, Diversion and Addiction-Related Surveillance; TEDS = Treatment Episode Data Set

\* Source measurement does not strictly limit responses to pharmaceutical opioids, but instead lists “pain killers,” “pain medicine,” “pain relievers,” or “narcotics other than heroin”

<sup>o</sup> Scale categorization indicates the highest geographical scale at which the source is relevant. Many sources also have more detailed information at smaller scales than are listed here

Bold type font indicates a data source that is publicly available

Topics: diversion	SCALE °			
	National	State	Multi-center	Single-center
<b>Controlled substances transactions/tracking</b>	<input type="checkbox"/> ARCOS [62,63,103]			
<b>Prescription drug diversion by healthcare workers</b>			<input type="checkbox"/> RADARS® [65]	<input type="checkbox"/> Police Records [64] <input type="checkbox"/> [18,66]
<b>Sources of prescription drugs</b>	<input type="checkbox"/> MTF* [39,67] <input type="checkbox"/> NAVIPPRO [57,86] <input type="checkbox"/> NSDUH* [68,70,94,104]	<input type="checkbox"/> CDAS* [30,31,95]	<input type="checkbox"/> RADARS® [50,65,75] <input type="checkbox"/> [37,105]	<input type="checkbox"/> [14,29]
<b>Availability of opioids</b>	<input type="checkbox"/> MTF* [9]	<input type="checkbox"/> CDAS* [30,31,95]	<input type="checkbox"/> [71,105,106]	
<b>Prescription drug post-marketing surveillance</b>	<input type="checkbox"/> DAWN [6,82] <input type="checkbox"/> NAVIPPRO [57,86,90] <input type="checkbox"/> NPDS [10,72,84]		<input type="checkbox"/> RADARS® [73-75] <input type="checkbox"/> [71]	

**Table III.** Categorization of data sources regarding diversion of pharmaceutical opioids

ARCOS = Automation of Reports and Consolidated Order System; CDAS = Center for Drug and Alcohol Studies; DAWN = Drug Abuse Warning Network; MTF = Monitoring the Future; NAVIPPRO = National Addictions Vigilance Intervention and Prevention Program; NPDS = National Poison Data System; NSDUH = National Survey on Drug Use and Health; RADARS® = Researched Abuse, Diversion and Addiction-Related Surveillance

\* Source measurement does not strictly limit responses to pharmaceutical opioids, but instead lists “pain killers,” “pain medicine,” “pain relievers,” or “narcotics other than heroin”

° Scale categorization indicates the highest geographical scale at which the source is relevant. Many sources also have more detailed information at smaller scales than are listed here

Bold type font indicates a data source that is publicly available

illicit use [60]. The manufacturing and delivery of pharmaceutical opioids to retail locations is monitored by the Drug Enforcement Agency (DEA) through the Automation of Reports and Consolidated Orders System (ARCOS) [61]. Various routes of diversion can disrupt the supply chain of pharmaceutical opioids between their production and lawful distribution to patients. Large scale thefts are recorded by the DEA [62,63], and diversion by healthcare workers is captured in police records [64], through the RADARS® key informant network [65], and in independent studies [18,66].

Other routes of diversion can be measured through self-reports of individuals who have acquired pharmaceutical opioids through illicit means. Monitoring the Future [39,67] the National Survey of Drug Use and Health (NSDUH) [68-70], the National Addictions Vigilance Intervention and Prevention Program (NAVIPPRO) [57], and the Delaware School Survey [30,31] all ask respondents questions regarding the source of nonmedically used pharmaceutical opioids. Diversion can also be measured indirectly by asking respondents whether they believe pharmaceutical opioids could be easily acquired for nonmedical use [9,30,31], and through post-marketing surveillance techniques such as monitoring online forums [71] and measuring the prevalence of accidental poisonings [5,10,72-74] and substance abuse treatment [43,57,75].

### Adverse outcomes table

Table IV categorizes data on a variety of adverse outcomes associated with pharmaceutical opioids. Topics included in this table are not meant to imply causal relationships, but indicate a variety of nega-



tive outcomes that have been found to be associated with nonmedical opioid use, such as fatal and nonfatal opioid poisonings, substance use disorders, addiction relapse, violence and suicide. A common measurement for many of these adverse outcomes is the International Classification of Diseases (ICD-10) [76], which contains medical codes for opioid dependence, opioid abuse, and unintentional poisonings due to methadone, heroin, or “other opioids.” These codes are the basis for much of the data collected through hospital medical records [77-79], insurance claims [79], and death certificates which indicate instances where unintentional opioid poisoning was recorded as the primary cause of death [80,81]. Data regarding emergency department visits for nonfatal opioid poisonings can be accessed through the Drug Abuse Warning Network (DAWN) [82], and data regarding fatal opioid poisonings are available through the CDC’s National Vital Statistics System (NVSS) [83]. Other common measurements of adverse outcomes include those gathered by poison call centers, treatment centers, and surveys. The National Poison Data System (NPDS) [84] is a prominent national

Topics: adverse outcomes	SCALE °			
	National	State	Multi-center	Single-center
<b>Prevalence of fatal opioid poisoning</b>	<input type="checkbox"/> NPDS [10,72,84] <input type="checkbox"/> <b>NVSS</b> [83,97,107]	<input type="checkbox"/> Medical Examiners [80,81]		<input type="checkbox"/> Medical Records [108]
<b>Prevalence of opioid poisoning (nonfatal or fatality unspecified)</b>	<input type="checkbox"/> <b>DAWN</b> [6,82,109] <input type="checkbox"/> NIS [78,110] <input type="checkbox"/> NPDS [10,72,84,111]	<input type="checkbox"/> CDAS* [30,31,95] <input type="checkbox"/> Insurance Claims Data [79]	<input type="checkbox"/> ACMT [77]	<input type="checkbox"/> Medical Records [108] <input type="checkbox"/> [17]
<b>Prevalence of substance use disorders</b>	<input type="checkbox"/> <b>DAWN</b> [6,82] <input type="checkbox"/> NAVIPPRO [57,86,90] <input type="checkbox"/> <b>NESARC*</b> [91,92,93] <input type="checkbox"/> NLAES* [92] <input type="checkbox"/> <b>NSDUH*</b> [40,47,68,94] <input type="checkbox"/> VA Medical Records [112]	<input type="checkbox"/> Treatment Centers [85] <input type="checkbox"/> CDAS* [30,[31,95] <input type="checkbox"/> Insurance Claims Data [79]		<input type="checkbox"/> [26,35,38]
<b>Addiction relapse</b>	<input type="checkbox"/> NAVIPPRO [57,86]	<input type="checkbox"/> [12]		
<b>Suicide, violence, violent suicide</b>	<input type="checkbox"/> <b>DAWN</b> [6,82] <input type="checkbox"/> NVDRS [113] <input type="checkbox"/> <b>NVSS</b> [83,112]			
<b>Domestic impact</b>	<input type="checkbox"/> NPDS [84,114]			

**Table IV.** Categorization of data sources regarding adverse outcomes associated with pharmaceutical opioids

ACMT = American College of Medical Toxicology; CDAS = Center for Drug and Alcohol Studies; DAWN = Drug Abuse Warning Network; NAVIPPRO = National Addictions Vigilance Intervention and Prevention Program; NESARC = National Epidemiologic Survey on Alcohol and Related Conditions; NIS = Nationwide Inpatient Sample; NLAES = National Longitudinal Alcohol Epidemiology Survey; NPDS = National Poison Data System; NSDUH = National Survey on Drug Use and Health; NVDRS = National Violent Death Reporting System; NVSS = National Vital Statistics System; VA = Veterans Affairs)

\* Source measurement does not strictly limit responses to pharmaceutical opioids, but instead lists “pain killers,” “pain medicine,” “pain relievers,” or “narcotics other than heroin”

° Scale categorization indicates the highest geographical scale at which the source is relevant. Many sources also have more detailed information at smaller scales than are listed here

Bold type font indicates a data source that is publicly available

data source for nonfatal opioid poisonings, collecting data from 57 poison call centers throughout the United States. Information regarding the prevalence of opioid use disorders [43,57,85] as well as addiction relapse [12,57] are captured by substance abuse treatment centers, such as those monitored by the National Addictions Vigilance Intervention and Prevention Program (NAVIPPRO®) [86]. Several questions on the NSDUH can also be used to determine whether participants have opioid dependence [40,47,68], and independent studies have used surveys to measure outcomes such as dependence and withdrawal symptoms [26,30,35,38], and witnessing or experiencing an overdose [17].

## Discussion

The categorization of data sources in Tables II through IV can serve as a guide for those who seek data sources regarding the diversion, nonmedical use, and adverse outcomes associated with pharmaceutical opioids in the United States. Global trends in data source coverage are illustrated as a bi-partite network in Figure 1. Topics from Tables II through IV are listed on the left, and primary data sources are listed on the right. Connections indicate coverage of topics by data sources, illustrating (1) variety among sources in the number of topics they cover, as well as (2) variety among topics in the number of

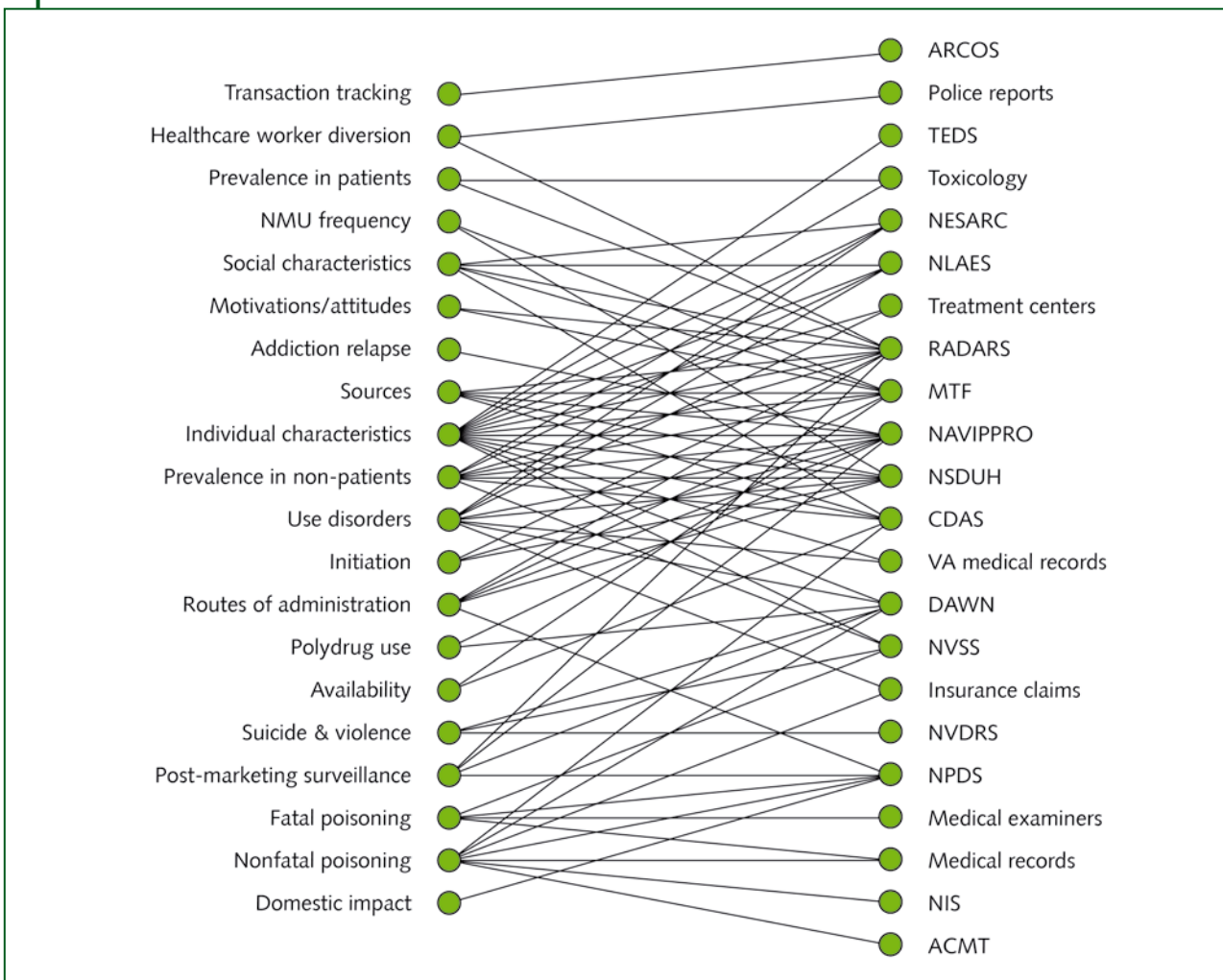


Figure 1. Bi-partite network depicting connections between large scale sources and topics



sources that cover them. The topical coverage of each source is shown by the number of connections that stem from it. Large scale sources such as NAVIPPRO, RADARS, MTF, and DAWN collect data that is relevant for many topics within the pharmaceutical opioid public health problem. Other sources in this review, such as the National Inpatient Survey (NIS), Automation of Reports and Consolidated Orders System (ARCOS), the American College of Medical Toxicology (ACMT), and Veterans Affairs (VA) Medical records, are relevant to only one topic.

In a similar manner, the source coverage of each topic is shown by the number of connections that lead to it. Some topics are covered by more data sources than others. More than half of the primary sources contain data regarding individual characteristics of those exhibiting behaviors of nonmedical use of pharmaceutical opioids. Many sources also cover prevalence, opioid use disorders, illicit sources, social characteristics, and routes of administration. By contrast, addiction relapse, domestic impact, and transaction tracking were each covered by only one primary data source. The scarcity of sources covering some topical areas may be due to sufficiency of a single source, such as the Drug Enforcement Agency's ARCOS tracking system, or mortality data from National Vital Statistics System (NVSS). However, scarcity of sources covering other topical areas may indicate a need for additional data collection, such as addiction relapse or polydrug use, both of which have been found to be pertinent to this public health problem [12,15].

## Limitations

Much effort was made to conduct an exhaustive search for data sources and a comprehensive examination of their relevance to prominent topics in the field. However, the current work is subject to several limitations. First, the original list of keywords stemmed from an existing library that was not created for the purpose of this project. Second, although PubMed® is updated daily and has been identified as an optimal tool for electronic searches [87], this search engine focuses primarily on medicine and biomedical sciences, and may have excluded some relevant sources. Data sources may also have been inadvertently excluded if their direct relevance to nonmedical opioid use was not discussed in peer-reviewed academic literature. Third, the identification of prominent topics was conducted subjectively by members of a larger research project which uses System Dynamics to investigate the nonmedical use of pharmaceutical opioids in the United States. Filtration and categorization of sources may also have been subject to human error.

Additional limitations to this work stem from its boundaries of inclusion. A specific focus on nonmedical use of pharmaceutical opioids led to the exclusion of data sources regarding medical use of pharmaceutical opioids for pain treatment as well as for treatment of individuals exhibiting opioid or opiate abuse. These boundaries made the project much more feasible, but preclude its usefulness for these related topics. Searches in PubMed were also limited to the time period between January 1995 and April 2012.

## Conclusions

This work offers a systematic categorization of data sources pertaining to the nonmedical use of pharmaceutical opioids in the United States. Data sources are categorized according to their relevance to a number of prominent topics in the areas of diversion, nonmedical use, and adverse outcomes associated with pharmaceutical opioids. Sources are also organized according to their capacity for geographical and longitudinal trend analysis. This categorization, provided in Tables II through IV, and the Appendix, can be used as a guide for researchers, policy makers, and others who seek data regarding various aspects of this public health problem. In addition, these tables show the distribution of data coverage across topics, indicating which topics are covered by more and fewer sources. This work serves to increase awareness of data sources that exist, suggests topics that may require additional data collection, and is hoped to facilitate ongoing research, analysis, and evaluation of this public health problem.

### Directions for further research

Researchers, policymakers, and other professionals in the health care field are encouraged to refer to the tables in this article when identifying data sources for ongoing research, analysis, and evaluation of this public health problem. In addition, data collection efforts are needed to address several topics that appear to have few data sources covering them, including nonmedical use frequency, addiction relapse, polydrug use, availability of pharmaceutical opioids for nonmedical use, domestic impact, and transaction tracking. With relatively few data sources identified, measurement of these topics would likely be beneficial for understanding and ameliorating the diversion, nonmedical use, and adverse outcomes associated with pharmaceutical opioids in the United States.

### The review in brief

Clinical question	This work offers a systematic categorization of data sources regarding the diversion, nonmedical use, and adverse outcomes associated with pharmaceutical opioids in the United States.
Type of review	Systematic
Search of the literature	<p>Searches were conducted using PubMed®, with three sets of keywords:</p> <ul style="list-style-type: none"> <li>• Opioid/Opioids, Misuse/Noncompliance/Non-Compliance/Diversion</li> <li>• Opioid/Opioids, Deaths/Drug-Related Harm/Fatal Outcome/Mortality/Overdose/Poisoning</li> <li>• Opioid/Opioids, Abuse/Aberrant Drug-Related Behaviors/Addiction/Abuse Liability/Problem Drug Use/ Substance Use Disorders/ Substance-Related Disorders/Substance Related Disorders/ Nonmedical Use/ Non-Medical Use/ Non-Medical Use</li> </ul> <p>All sources were categorized according to their relevance to each of 20 topics and 2 design features.</p>
Conclusions	Tables cataloging data sources can be used to identify data relevant to specific topics in diversion, nonmedical use, and adverse outcomes, and for their capacity for geographical and longitudinal trend analysis. Global trends in coverage suggest that some topics have been measured plentifully, while others only minimally. The importance of some topics may warrant further data collection, including nonmedical use frequency, addiction relapse, polydrug use, availability of pharmaceutical opioids for nonmedical use, domestic impact, and transaction tracking.
Limitations	Searches were conducted solely in PubMed®, and were restricted to peer-reviewed academic journals. Keywords were identified through an existing collection of resources from a separate research project which uses computer simulation to investigate the public health problem of nonmedical opioid use. Identification of prominent topics was conducted subjectively by members of this simulation research project. Filtration and categorization of sources may also have been subject to human error.

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## Appendix

Categorization of data sources by geographical and longitudinal design attributes

Topics: data sources by geographical and longitudinal design attributes	SCALE <sup>°</sup>			
	National	State	Multi-center	Single-center
<b>Geographical trends in opioid abuse</b>	<input type="checkbox"/> ARCOS [62] <input type="checkbox"/> <b>DAWN</b> [6,82] <input type="checkbox"/> <b>MTF</b> * [9] <input type="checkbox"/> NAVIPPRO [57,86,90] <input type="checkbox"/> NIS [78,110] <input type="checkbox"/> NPDS [10,84,111,115] <input type="checkbox"/> <b>NSDUH</b> * [116] <input type="checkbox"/> <b>NVSS</b> [83,97] <input type="checkbox"/> <b>TEDS</b> [98,99] <input type="checkbox"/> VA Medical Records [112]	<input type="checkbox"/> CDAS* [30,31,95] <input type="checkbox"/> Insurance Claims Data [117]	<input type="checkbox"/> [96]	
<b>Longitudinal<sup>†</sup> trends in opioid abuse</b>	<input type="checkbox"/> ARCOS [62] <input type="checkbox"/> <b>DAWN</b> [6,82,89] <input type="checkbox"/> <b>MTF</b> * [9] <input type="checkbox"/> NAVIPPRO [57,86] <input type="checkbox"/> <b>NESARC</b> [91,92] <input type="checkbox"/> NIS [78,110] <input type="checkbox"/> NLAES [92] <input type="checkbox"/> <b>NSDUH</b> * [3,94] <input type="checkbox"/> <b>NVSS</b> [83,118] <input type="checkbox"/> <b>TEDS</b> [98,99] <input type="checkbox"/> VA Medical Records [112] <input type="checkbox"/> [51]	<input type="checkbox"/> CDAS* [30,31,95] <input type="checkbox"/> Insurance Claims [79,119] <input type="checkbox"/> Medical Examiners [80] <input type="checkbox"/> [12]	<input type="checkbox"/> RADARS <sup>®</sup> [120] <input type="checkbox"/> [13]	<input type="checkbox"/> [121]

ARCOS = Automation of Reports and Consolidated Order System; CDAS = Center for Drug and Alcohol Studies; DAWN = Drug Abuse Warning Network; MTF = Monitoring the Future; NAVIPPRO = National Addictions Vigilance Intervention and Prevention Program; NESARC = National Epidemiologic Survey on Alcohol and Related Conditions; NIS = Nationwide Inpatient Sample; NLAES = National Longitudinal Alcohol Epidemiology Survey; NPDS = National Poison Data System; NSDUH = National Survey on Drug Use and Health; NVSS = National Vital Statistics System; RADARS<sup>®</sup> = Researched Abuse, Diversion and Addiction-Related Surveillance; TEDS = Treatment Episode Data Set; VA = Veterans Affairs

\* Source measurement does not strictly limit responses to pharmaceutical opioids, but instead lists "pain killers," "pain medicine," "pain relievers," or "narcotics other than heroin"

<sup>°</sup> Scale categorization indicates the highest geographical scale at which the source is relevant. Many sources also have more detailed information at smaller scales than are listed here

**Bold type** font indicates a data source that is publicly available

<sup>†</sup> Longitudinal data sources include cohort or panel studies as well as 'repeated cross sectional' studies