Development of a Coroner-Based Surveillance System for Drug-Related Deaths in Los Angeles County

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ABSTRACT Existing data sources do not provide comprehensive and timely information to adequately monitor drug-related mortality in Los Angeles County. To fill this gap, a surveillance system using coroner data was developed to examine patterns in drug-related deaths. The coroner provided data on all injury deaths in Los Angeles County. A list of keywords that indicate a death was caused by drug use was developed. The cause of death variables in the coroner data were searched for mentions of one of the keywords; if a keyword was detected, that death was classified as drug related. The effectiveness of the keyword list in classifying drug-related deaths was evaluated by matching records in the coroner death data to records in the state death files. Then, the drug-related deaths identified using the keywords were compared to drug-related deaths in the state mortality files identified using International Classification of Death codes. Toxicological test results were used to categorize drug-related deaths based on the type and legality of the drug(s) ingested. Mortality rates were calculated for each category of drug and legal status and for different demographic groups. Compared to the gold standard state mortality files, the coroner data had a sensitivity of 95.6% for identifying drug-related deaths. Over three quarters of all drug-related deaths tested positive for opiates and/or stimulants. Males, Whites, and 35–54-year-olds each accounted for more than half of all drug-related deaths. The surveillance of drug-related deaths using coroner data has several advantages: data are available in a timely fashion, the data include information about the specific substances each victim ingested, and the data can be broken down to compare mortality among specific subpopulations.

KEYWORDS Surveillance, Mortality, Legal drugs, Illegal drugs

INTRODUCTION

Poisonings are a major source of injury-related morbidity and mortality in the USA, causing more than 37,000 deaths and 900,000 emergency department visits during 2006.¹ Most poisonings are caused by the ingestion of drugs,^{2–6} and drug-related mortality has increased in recent years, most dramatically among 20–29 and 45–54-year-olds.² These increases have largely been attributed to prescription drugs, particularly opioid analgesics.^{4, 7–9} Locally, drug-related mortality is also a serious problem; drug overdoses are consistently among the ten leading causes of premature death in Los Angeles County.¹⁰ Despite the large numbers of deaths, research has shown that treatment and prevention programs can effectively reduce drug-related

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morbidity and mortality.^{11,12} To address this issue and aid in prevention efforts, the Los Angeles County Department of Public Health (DPH) developed a surveillance system using coroner data to monitor trends and demographic changes in drug-related fatalities.

The DPH surveillance system addresses the gap in comprehensive information about drug-related deaths in Los Angeles County. National surveys provide information about the use of specific drugs but do not typically include information about fatal outcomes and do not always provide county-level data.^{13,14} The Community Epidemiology Work Group provides detailed information about drug use in Los Angeles County, but does not focus on fatalities.¹⁵ Official state mortality files provide data on all drug-related deaths at the county level, but suffer from significant reporting delays. Both California mortality files and Los Angeles County's vital statistics system rely on International Classification of Disease, 10th Revision (ICD-10) codes, which are not explicit enough to identify specific drugs involved in a death.^{4,9,16,17} Poison control center data are also inadequate; while providing the specific drugs involved in a fatality, studies show only a fraction of poisoning fatalities are actually captured.¹⁸⁻²⁰ This work provides county-level data on drug-related mortality while contributing a new methodology to the scientific literature: a keyword list of drug use terms for extracting drug-related deaths from coroner data.

Other jurisdictions have successfully used coroner data to examine drug-related deaths. For example, in New Mexico, researchers studied trends in unintentional overdose deaths both for all drugs and for prescription drugs, and looked at racial/ethnic and gender differences in these trends.^{21,22} Studies in New York City looked at deaths caused by certain substances such as heroin, methadone, opiates, cocaine, and alcohol and at differences in drug deaths by racial/ethnic groups.²³⁻²⁵ These studies relied either on the coroner to identify which deaths were drug related or on a manual review of coroner cases to identify drug related deaths.

Data provided by the Los Angeles County Coroner (LACC) include all local drug-related deaths, are available with minimal delay, and include the specific drugs detected in each case. The goals of the new surveillance system are as follows: (1) capture drug-related deaths in a populous, diverse county; (2) analyze, interpret, and report on changing patterns and trends in drug-related mortality in a defined, urban community; and (3) distribute data to local drug treatment and prevention programs. The remainder of this article describes the development of the surveillance system and reports on some of the basic data that the system provides.

METHODS

Data Description

The data for this surveillance system are provided by the LACC. LACC investigates all sudden, violent, and unusual deaths in Los Angeles County; that is, all deaths that are not due to natural causes are investigated. This includes all deaths due to homicides, suicides, and unintentional injuries as well as unexplained natural deaths and cases in which the manner of death is undetermined. For the surveillance of drug-related deaths, the LACC provided data on every non-natural death examined by the coroner. The LACC consists of one nonmedical person in the appointed position of coroner and several medical examiner positions filled by medical doctors. Only the medical examiners determine the cause of death and review toxicology results in all cases investigated by the coroner's office.

LACC data are provided in two files, the main data and the toxicology data. Main data includes victim demographics, circumstance descriptions, injury event and death locations, and the cause (e.g., drowning and motor vehicle collision) and manner (e.g., unintentional and homicide) of death as determined by the coroner. The information included in the main data is the same information that is included on the death certificates, once they become available. Toxicology data include the quantity of each substance that was detected. Since 2005, toxicology data are available for all tests, even if the result was negative, while only positive results are available for earlier years. This toxicology data is unique to the coroner data, and is not provided in the state death certificate files.

Data Collection and Management

LACC provides data electronically to DPH in Microsoft Excel. Since DPH was already receiving data on all homicides, suicides, and undetermined intent deaths in this format for another project, LACC simply added unintentional injury deaths to the data provided. Data collection began in early 2008, and includes retrospective data from 2000 through 2007. Data updates are provided to DPH quarterly and include only deaths finalized by the coroner. Deaths become part of a data update once the investigation is complete. LACC estimates 85% of all cases are closed within 60 days of death (personal communication, Christopher Rogers, LACC, May 8, 2009); however, the average for drug-related deaths may be longer due to the time needed for toxicological analysis.

Once a quarterly update of the main coroner dataset is received, it is imported into SAS version 9.1.3 (SAS Institute, Cary, North Carolina), merged with any earlier updates of data from the same year, and duplicate records are eliminated along with occasional records for stillbirths, fetal deaths, specimens, and non-human remains. These records were removed by searching first and last name variables for terms such as “stillbirth,” “bones,” and “not human.” The main data file is then ready for processing (described below) to identify drug-related deaths.

In the toxicology data, every test performed is entered as a single record, so many deaths have multiple records in the toxicology data. Therefore, before combining toxicology data and the main data, all toxicology results for a decedent are collapsed into one record. These single toxicology files are then merged with the main data using the coroner’s case number as a unique identifier.

Definition of Drug-Related Deaths

For the purposes of this surveillance system, drug-related deaths are defined as those deaths that were caused by the intake of a drug or drugs. This includes both intentional and accidental overdoses of legal and illegal drugs. Deaths from diseases such as AIDS that may be related to drug use and deaths from injuries such as motor vehicle crashes in which drug use may have contributed to the injury event are excluded. Alcohol use alone, in the absence of other drug use, was not sufficient for a death to be considered drug related.

Identifying Drug-Related Deaths

Toxicology results are not used to determine if a death is drug related since deaths with positive toxicology may not always fit the definition of drug-related deaths. Instead, drug-related deaths are identified by examining the four cause of death variables (CauseA, CauseB, CauseC, and CauseD) included in the main coroner data. These variables correspond to the causes of death included in Part 1 of the

death certificate. DPH developed a list of 171 keywords that, if present in one or more of the cause of death variables, indicated a particular death was directly caused by the intake of drugs. This keyword list is available from the authors upon request. Designated keywords range from specific drug names to more general terms such as “opiate” or “substance abuse.”

Validation of Keyword List

The California state mortality dataset, called the Death Statistical Master File (DSMF), was used as the gold standard to measure the accuracy of the keyword list as a screening tool for identifying drug-related deaths in the LACC data. The DSMF was selected as the gold standard since it includes complete county-level data and provides ICD-10 codes to identify drug-related deaths. Currently (February 2010), DSMF files are available only through 2007.

To compare drug-related deaths in the DSMF and LACC datasets, it was necessary to merge the two datasets together; however, there is no unique identifier common to both datasets. Instead, matches were based on various demographic characteristics including last name/initial, first name/initial, date of death, year of birth, birth date, last four digits of social security number, and gender. There were 35,914 records in the LACC data between 2000 and 2006. Appropriate matches were found in the state death file for 34,860 (97.1%) of these records. No matching errors were found in a random sample of about 1% ($N=346$) of the matched records.

DSMF records with an underlying cause of death of F11–F16, F19, X40–X44, X60–X64, X85, or Y10–Y14 were considered to be drug related. F-codes include deaths caused by mental and behavioral disorders due to psychoactive substance use. X and Y codes indicated accidents, suicides, homicides, and injuries of undetermined intent caused by acute exposure to drugs.²⁶ Other research used similar ICD codes, adding only F18 (disorders from volatile substances) to the list.²⁷

The total number of drug-related deaths in Los Angeles County was then estimated using capture–recapture methodology. The estimate was calculated by multiplying the number of drug-related deaths identified in the LACC data by the number identified in the DSMF data and dividing that total by the number of drug-related deaths identified by both sources.²⁸

Toxicology Results

The toxicology results were combined with the main coroner data after the identification of drug-related deaths using the cause of death variables. Toxicology results were only used to determine which drugs were present in each victim’s system at the time of death, since deaths with positive toxicology did not always meet the definition of drug-related deaths. Additionally, not all drug-related deaths had positive toxicology results. Frequently, these cases were hospitalized for several days prior to death, allowing any drugs to completely metabolize before death.

Some records included tests for both a drug and a metabolite of that drug; a positive test for either was considered a positive result. Positive results did not necessarily indicate a particular drug was the cause of death, merely that *any* trace of that drug was present at the time of death.

Drug Categories

Overall, there were positive test results for 275 different substances. Forensic staff from the LACC grouped these substances into 15 different categories: antidepressants, antihistamines, antipsychotics, antiseizure drugs, cardiovascular drugs,

hallucinogens, local anesthetics, muscle relaxants, non-opiate analgesics, opiate analgesics, sedatives (also includes hypnotics and tranquilizers), stimulants, other drugs, ethanol, and not drugs (e.g., other volatiles, cyanide, and arsenic). These categories do not correspond with the categories of ICD-10 codes (T36–T50) that indicate the type of drugs involved in a death. The T-code groupings were not used because a CDC report found that more than one quarter of substances with T codes on death certificates were included in a general other/unspecified drug category.³ As a consequence, T-code designations would lack the specificity needed for this surveillance system. Instead, the LACC's categorization for each substance was compared to the drug categorizations in the Drug Abuse Warning Network's (DAWN) Drug Reference Vocabulary,²⁹ which contains more detailed drug categorizations. Any disagreements between the LACC categorization and DAWN were resolved by one of the study authors (PC). Drug categories were not mutually exclusive; many deaths tested positive for multiple drugs within a given category and/or for drugs classified across drug categories. As previously mentioned, several drug-related deaths did not test positive for any substance.

Heroin Classification

Heroin rapidly metabolizes to morphine after use,³⁰ so a death was classified as heroin-positive if the presence of 6-monoacetylmorphine (an intermediate metabolite unique to heroin³¹) was reported, or if the death was morphine-positive *and* the word 'heroin' (along with certain common misspellings) was mentioned in any of the cause of death or circumstance variables in the LACC data. Similar methods of separating heroin from morphine among drug-related deaths were used in New Mexico.²¹ The authors examined a 10% sample of all morphine-positive deaths ($N=306$) to check for potential misclassifications. Only one record in the sample (0.3%) did not appear to be correctly categorized, and that death appeared to be related to methadone rather than heroin.

Legal Status

In addition to classifying each substance into a drug category, every substance was also classified as legal or illegal. Drugs that are currently illegal to buy or possess according to federal law were classified as illegal. These drugs are heroin, cocaine, methamphetamine, marijuana, gamma hydroxybutyrate, ketamine, phencyclidine, methylenedioxyamphetamine, and methylenedioxymethamphetamine. The LACC data do not provide information about the source of any drugs used, so all other substances were classified as legal, even though they may have been obtained and/or used illegally. The legal status of each death was computed based on the legality of all substances found to have a positive toxicology result. Each death was grouped into one of four mutually exclusive categories: Legal drugs only, Illegal drugs only, Both legal and illegal drugs, or No positive toxicology.

Data Analysis

All analyses were performed using SAS version 9.1.3. The number and rate of drug-related deaths were calculated for each year, by demographic groups, drug category, intent of the death, and overall legal status of drugs taken by each decedent. Population estimates used to calculate rates were provided by the Los Angeles County Office of Urban Research. All rates were calculated per 100,000 population, and rates other than those for specific age groups were age adjusted to the 2000 US population.

RESULTS

Comparison of LACC and DSMF Data, 2000–2006

There were 34,860 deaths between 2000 and 2006 with records that could be matched from both LACC and DSMF data (Table 1). In 98.0% of these records, the keyword list in the LACC data and the ICD-10 codes in the DSMF data agreed on the “drug relatedness” of each death. Among the discordant records, 446 (1.3%) were considered drug-related deaths by the LACC data, but not by the DSMF data, while 244 (0.7%) were considered drug-related deaths by the DSMF data, but not by the LACC data. The LACC data’s keyword list had a sensitivity of 95.6% and a positive predictive value of 92.3% in identifying drug deaths compared to the gold standard of the ICD-10 coded DSMF data.

From these matched records, 5,810 drug-related deaths were identified from the LACC data, while 5,608 were identified from the DSMF data. Of these, 5,364 were identified from both sources. The estimated total number of drug deaths in Los Angeles County is then $(5,810 \times 5,608) / 5,364 = 6,074$. The drug-related deaths identified from the LACC data represent 95.7% of this estimated total. These results gave the authors confidence that the keyword list process could be applied to all of 9 years (2000–2008) of LACC records with accuracy.

LACC Data Analysis, 2000–2008

Since this paper’s primary focus is to describe the development of the coroner-based drug-related surveillance system in Los Angeles County, detailed statistical analyses are not presented here. Instead overall rates of drug-related deaths for various types of drugs and for different populations are reported for the study period of 2000–2008 to provide a general understanding of the type of information available from the surveillance system.

Overall, there were 7,483 drug-related deaths in Los Angeles County between 2000 and 2008, with an average annual mortality rate of 8.5 deaths per 100,000 population. Morphine (including heroin), cocaine, ethanol, codeine, and methamphetamine were the most commonly detected substances (Table 2). When individual drugs were grouped into drug categories, opiate analgesics, and stimulants were the most frequently detected; over three quarters (78.3%) of all drug deaths tested positive for one or both of these categories (Table 3). The use of legal and illegal drugs in combination was more common than using either legal substances or illegal substances alone.

TABLE 1 Comparison of Los Angeles county deaths identified as drug-related by death statistical master file (gold standard) and Los Angeles County Coroner data, 2000–2006

		DSMF data (gold standard)		
		Drug death	Not drug death	Total
Coroner data	Drug death	5,364	446	5,810
	Not drug death	244	28,806	29,050
	Total	5,608	29,252	34,860

Drug-related deaths in DSMF are those with underlying cause of death of: F11–F16, F19, X40–X44, X60–X64, X85, or Y10–Y14; drug-related deaths in LACC data are those with one of several keywords listed in one of four cause-of-death variables. Sensitivity = $5,364 / (5,364 + 244) = 95.6\%$; specificity = $28,806 / (28,806 + 446) = 98.5\%$; positive predictive value = $5,364 / (5,364 + 446) = 92.3\%$; negative predictive value = $28,806 / (28,806 + 244) = 99.2\%$

TABLE 2 List of drugs that were detected in more than 100 drug-related deaths, LACC data 2000–2008

Drug name	Drug category	Frequency
Morphine	Opiate analgesics	3,335
Cocaine	Stimulants	2,439
Ethanol	Ethanol	2,260
Codeine	Opiate analgesics	1,852
Methamphetamine	Stimulants	961
Hydrocodone	Opiate analgesics	849
Amphetamine	Stimulants	713
Diphenhydramine	Antihistamines	674
Diazepam	Sedative/hypnotic/tranq	570
Methadone	Opiate analgesics	500
Nortriptyline	Antidepressants	389
Citalopram	Antidepressants	348
Amitriptyline	Antidepressants	339
Fluoxetine	Antidepressants	333
Alprazolam	Sedative/hypnotic/tranq	332
Chlorcyclizine	Antihistamines	314
Propoxyphene	Non-opiate analgesics	301
Meprobamate	Sedative/hypnotic/tranq	277
Oxycodone	Opiate analgesics	249
Phenobarbital	Sedative/hypnotic/tranq	233
Quetiapine	Antipsychotics	229
Carisoprodol	Muscle relaxants	219
Olanzapine	Antipsychotics	213
Trazodone	Antidepressants	211
Acetaminophen	Non-opiate analgesics	207
Sertraline	Antidepressants	202
Hydromorphone	Opiate analgesics	190
Venlafaxine	Antidepressants	186
Lorazepam	Sedative/hypnotic/tranq	184
Paroxetine	Antidepressants	177
Clonazepam	Sedative/hypnotic/tranq	172
Promethazine	Antihistamines	171
Zolpidem	Sedative/hypnotic/tranq	170
Bupropion	Antidepressants	169
Temazepam	Sedative/hypnotic/tranq	163
Dextromethorphan	Other drug	161
Fentanyl	Opiate analgesics	151
Mirtazapine	Antidepressants	136
Cyclobenzaprine	Muscle relaxants	125
Doxylamine	Antihistamines	124
Gabapentin	Antiseizure drugs	120
Lidocaine	Local anesthetics	108
Chlorpheniramine	Antihistamines	107
Tetrahydrocannabinol	Hallucinogens	103
Hydroxyzine	Antihistamines	101
Oxazepam	Sedative/hypnotic/tranq	100

TABLE 3 Drugs detected and legal status of drugs detected among drug-related deaths reported by the Los Angeles County Coroner, 2000–2008

Category		Drug-related deaths		
		Number	Percent	Rate
Drug category ^a	Non-opiate analgesics	667	8.9	0.76
	Opiate analgesics	4,529	60.5	5.14
	Sedatives, hypnotics, and tranquilizers	1,679	22.4	1.92
	Ethanol	2,260	30.2	2.56
	Antidepressants	1,721	23.0	1.97
	Antipsychotic drugs	572	7.6	0.65
	Antiseizure drugs	334	4.5	0.38
	Local anesthetics	123	1.6	0.14
	Stimulants	3,185	42.6	3.57
	Hallucinogens	184	2.5	0.20
	Antihistamines	1,203	16.1	1.37
	Cardiovascular drugs	215	2.9	0.25
	Muscle relaxants	349	4.7	0.40
	Other drugs	343	4.6	0.39
	Non-drug substances	183	2.4	0.21
Legal status	Only legal drugs detected	2,309	30.9	2.65
	Only illegal drugs detected	1,416	18.9	1.60
	Both legal and illegal drugs detected	2,971	39.7	3.33
	No drugs detected	787	10.5	0.90

Rates are per 100,000 population and age adjusted to the 2000 US population

^aThe different drug categories are not mutually exclusive; many deaths tested positive for drugs in more than one category

Table 4 shows demographic characteristics and intent of all drug-related deaths. Over four fifths of deaths were classified as unintentional by the coroner. Males, Whites, and 35–54-year-olds each accounted for more than half of all drug-related deaths. Mortality rates were also highest for males and 35–54-year-olds, but rates for specific racial/ethnic groups were highest for Blacks.

DISCUSSION

As described here, a keyword list can be successfully used to identify drug-related deaths in coroner data. During a 9-year period, DPH detected 7,483 drug-related deaths, an average of 831 each year. Comparison with state mortality statistics suggest that the deaths captured by this surveillance system represent a substantial proportion of all drug-related deaths reported in the official ICD-10 coded mortality statistics. The LACC data include several variables of interest: demographics, circumstances of death, time and location of death, and complete toxicology results. Coroner and medical examiner data have been used to examine various aspects of drug-related mortality in numerous other jurisdictions, including agencies from New Mexico,^{21,22,32} New York City,^{23–25} Georgia,³³ Maine,³⁴ Canada,³⁵ Sweden,³¹ Australia,³⁶ and England.^{37,38} The Centers for Disease Control and Prevention have also issued several reports on drug-related deaths using data from medical examiners in Multnomah County, Oregon;³⁹ King County, Washington;⁴⁰ Utah;⁷ and New

TABLE 4 Characteristics of drug-related deaths reported by the Los Angeles County Coroner, 2000–2008

Characteristic		Drug-related deaths		
		Number	Percent	Rate
Intent	Unintentional	6,296	84.1	7.12
	Suicide	940	12.6	1.08
	Homicide	32	0.4	0.04
	Undetermined	215	2.9	0.24
Year	2000	779	10.4	8.48
	2001	778	10.4	8.30
	2002	896	12.0	9.36
	2003	896	12.0	9.23
	2004	862	11.5	8.71
	2005	854	11.4	8.54
	2006	852	11.4	8.46
	2007	804	10.7	7.90
	2008	762	10.2	7.40
Sex	Male	5,057	67.6	11.69
	Female	2,426	32.4	5.41
Race/ethnicity	Black	1,229	16.4	14.80
	Hispanic	2,001	26.7	5.72
	White	4,008	53.6	13.26
	Other/unknown	245	3.3	1.93
Age group	0–24 years	441	5.9	1.30
	25–34 years	1,087	14.5	7.83
	35–44 years	2,223	29.7	15.56
	45–54 years	2,530	33.8	21.46
	Above 55 years	1,202	16.1	7.21

Rates are per 100,000 population and, except for age-specific rates, are age adjusted to the 2000 US population

Mexico.⁴¹ On a national level, in the USA, the Drug Abuse Warning Network includes coroner and medical examiner data as part of its surveillance of drug use.⁴²

While coroner data have frequently been used to track drug-related mortality, the use of a keyword list to identify drug-related deaths, as described here, is far less common. The use of the keyword list allows drug-related deaths to be identified with minimal effort. It eliminates the need for a time-consuming manual review of each potential drug-related death. Using the keyword list also requires no additional effort on the part of the coroner; the coroner provides the data they already generate and coroner staff are not involved in determining which deaths are drug related.

In Los Angeles, DPH found that using coroner data to monitor drug-related deaths had several advantages. Compared to the data available from standard state mortality files, the data provided by the coroner is available with minimal delays and includes toxicology information about the specific drugs involved in each death. State mortality files are subject to significant delays and the ICD-10 coding used in the data obscures information about the drugs involved in each death. A CDC report found that using data coded with multiple causes of death (ICD-10 codes for poisoning; T36–50), no specific drug could be identified in about half of the cases.³

Despite the benefits of coroner data, it does not provide enough information to address several key issues: determining which drug or drugs caused death, assessing

the impact of local prevention and treatment efforts, and evaluating drug use among non-drug-related deaths. The coroner's toxicology data include all drugs detected in a decedent's system at the time of death, but do not indicate which drug or drugs actually caused the death. While the coroner's cause of death variables may be useful in determining which drugs in a victim's system were responsible for death, the cause of death variables are frequently non-specific, especially in the case of multiple drug intoxication. The inability to determine the actual drug or drugs causing death is not necessarily a problem, since the complete toxicology results provide detailed information about polydrug use among decedents; however, it might limit the usefulness of comparisons to studies that examine only the drug or drugs responsible for death.

Information about enrollment in treatment and prevention programs is not routinely included in the data, and therefore cannot be used to monitor program effectiveness. However, the system may be able to test generally whether prevention or treatment services led to a change in the rate of overdose-related fatalities in geographical areas that benefitted from those services, in comparison to areas that did not benefit from the services.

Finally, toxicology testing is not routinely performed among non-drug-related deaths, so comparisons of drug-related deaths and other injuries are not possible. While only 10.7% of drug-related deaths had no positive toxicology results, 68.6% of other injury deaths had no positive toxicology screens.

While DPH is unable to evaluate the specific outcomes described above, the coroner-based surveillance does have several important uses. The LACC investigates all non-natural deaths in Los Angeles County, so the system provides unbiased data on the impact of drug-related mortality in the county. In addition to reporting the total number of drug-related deaths, DPH can also monitor drug-related mortality in specific demographic groups and geographic locations in Los Angeles County. The data also provide information about what drug or drugs each victim had in their system at the time of death. This allows DPH to capture information about new and emerging trends in mortality related to the use of specific drugs.

There are several limitations to keep in mind. Many problems arise from the way toxicological tests are performed. Testing is expensive, and there is no consistent panel of substances for which each decedent is tested. The coroner tests for drugs suspected to be present, and with several different medical examiners performing autopsies, there may be variation in testing based on who is performing the examination. Additionally, 10.7% of drug-related deaths had no positive toxicology results; discussion with the coroner suggests that these decedents may have been hospitalized prior to death, allowing any drugs in their systems to completely metabolize (written communication, Dan Anderson, LACC, October 2008). Of the deaths with no positive toxicology results, 83.3% had a hospital listed as the place of death, compared to 28.9% of deaths with any positive toxicology screen. Other research has found a similar proportion of drug-related deaths with no positive toxicology results²⁷ (oral communication, Bruce Goldberger, University of Florida, October 2008).

The misclassification of heroin also introduces error. Two thirds of the 3,022 morphine-positive deaths were classified as heroin-related based on a mention of heroin in one of the cause of death variables. It is likely that the surveillance system underestimates the true number of heroin-related deaths, and at the same time overestimates morphine-related deaths, since the system is reliant on descriptive information provided by the coroner to determine if heroin was involved. Research

conducted during the 1990s found that morphine accounted for just 1.9% of all heroin/morphine deaths,⁴³ as opposed to the 33.7% of heroin/morphine deaths in this study. While checking a sample of all morphine-positive deaths suggested that few non-heroin deaths were misclassified as heroin-positive, based on the information provided by the coroner, it was not possible to determine if additional morphine-positive deaths should have been classified as heroin-positive.

Defining legal status based on toxicological results is problematic for other reasons; in particular, all prescription drug use is categorized as legal, despite the prevalence of prescription drug misuse. Numerous studies have highlighted the increasing burden of prescription drug abuse,^{7-9,44-46} and in many cases decedents testing positive for legal drugs may have obtained the drugs illegally. Legal drug use may also be misclassified as illegal; medical marijuana use is permitted in California,⁴⁷ yet all marijuana use is classified as illegal.

While the keyword list is an efficient method to identify which coroner's deaths are drug related, it also clearly introduces error. Between 2000 and 2006, there were 244 drug-related deaths in the state death files not captured from the coroner's data. Examining the cause of death variables in the LACC data did not show any obvious patterns; many deaths were described as undetermined, but alcohol, hemorrhages, and pneumonia were also frequently mentioned. Looking at the state death files, X44 (35.7%) and X42 (23.8%) were the most frequently mentioned ICD-10 codes for these records. Among the 5,364 records coded as drug related in both the LACC and state death data, X44 (26.0%) and X42 (38.7%) were again the most common ICD-10 codes, but the distribution of these codes is quite different.

There were also 446 drug-related deaths found in the coroner's data that were not coded as drug-related deaths in the state death files. Examining the cause of death variables in the LACC data for these records found that for 237 (53%), only drug-related causes were mentioned. Most of the remaining records also mentioned drug use, usually in combination with disease and/or injury. Liver disease, sepsis, cardiomyopathy, and drowning were some of the causes of disease and injury often found in combination with drug use. In the state death files, one third of these deaths had an ICD-10 code of R99 (other ill-defined and unspecified causes of mortality).

Despite these limitations, the data provided by DPH's coroner-based surveillance can be of enormous benefit to Los Angeles County. The population of Los Angeles County is extremely large, greater than the population of 42 states, and very diverse; however, this surveillance system can identify geographic and demographic variation in drug-related mortality. This will allow local treatment and prevention organizations to target their programs appropriately. For example, Los Angeles County recently implemented a naloxone distribution program to reduce mortality associated with heroin overdoses; data from the surveillance system can be used to ensure that participants are drawn from neighborhoods with the highest rate of heroin overdose mortality. Since research has shown that targeted programs are more effective (i.e., naloxone distribution will not be useful in minimizing cocaine-related mortality),^{11,12} using this data to guide such programs in Los Angeles County will improve outcomes.

Since implementing the surveillance system, DPH has been working to ensure that the system's goals are met. The results described here show how drug-related mortality can be monitored and touch on the breadth of data available from the system. Current plans for the data involve examining trends in drug-related death, comparing differences in drug-related mortality among specific geographic and demographic subpopulations, and breaking down the general drug categories to

monitor drug-related mortality associated with specific substances. This future work with the system will broaden our understanding of drug-related mortality in Los Angeles County and provide useful information to guide efforts to minimize the harmful effects of drug use in our communities.

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