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Patterns of Drug-induced Mortality in Maine, 2015 Update

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Patterns of Drug-induced Mortality in Maine, 2015 Update

by Marcella H. Sorg, Margaret Greenwald, and Jamie A. Wren

Drug addiction and drug-induced mortality have received a good deal of attention nationally and in Maine in recent years. The authors review overall trends in the patterns of drug overdoses that have continued for nearly two decades, including those involving opioid pharmaceuticals, and discuss the recent resurgence of the illicit drugs heroin and non-pharmaceutical fentanyl.

Substance abuse and legitimate drug use in Maine exist along a complex series of continua. Use of illegal drugs by socially marginal people is only one extreme of a large, interrelated set of behavior patterns. Those who die from drug overdose come from all walks of life. They include people of all ages, although they disproportionately affect young and middle age adults.

This marks the nineteenth year for which the authors and Maine's Office of Chief Medical Examiner have tracked and reported on drug death statistics.[1] In this article, we update two previous reports from 2003 and 2010 (Sorg and Greenwald 2003; Sorg et al. 2010). We will review overall trends in drug overdose patterns that have continued for nearly two decades (see Figure 1), including those involving opioid pharmaceuticals, and discuss the recent resurgence of illicit drugs heroin and non-pharmaceutical fentanyl.

BRIEF HISTORY OF OPIOID ABUSE IN MAINE

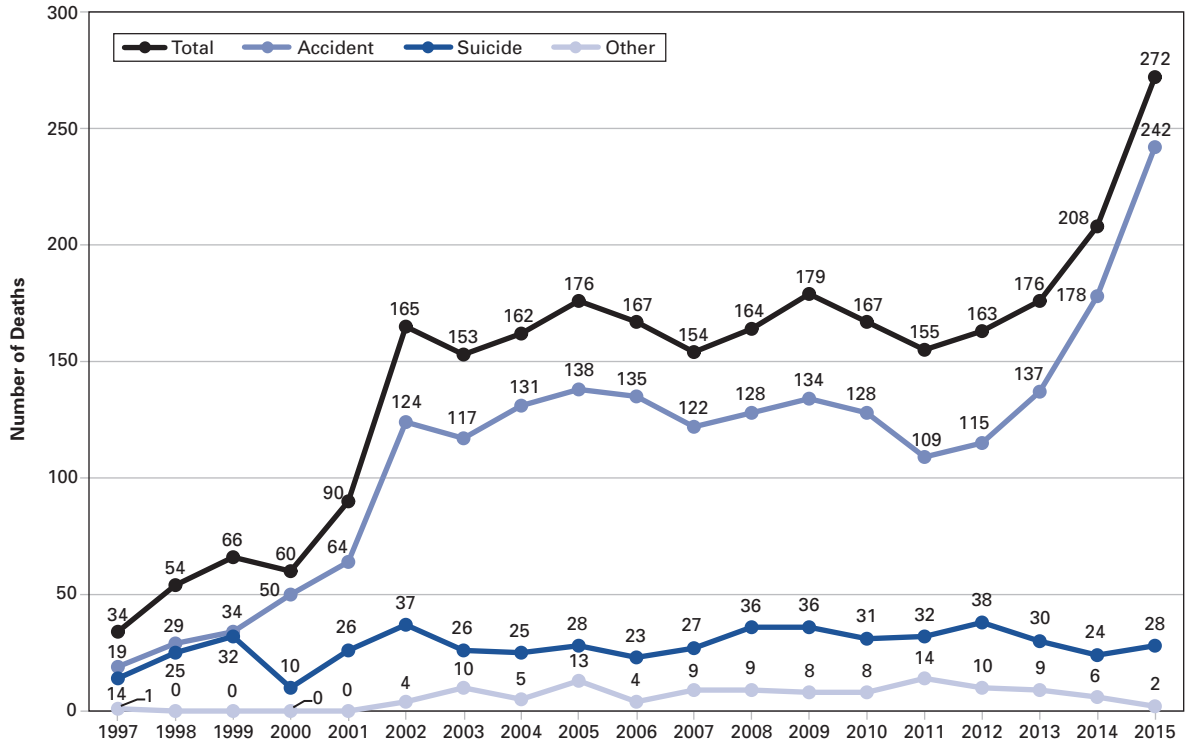
During the 1990s, synthetic and long-acting narcotic pain medications were aggressively marketed and more heavily prescribed, with a resulting increase in patients who developed addictions. Originally marketed with the erroneous belief that patients taking synthetic opioids for pain would not become addicted, these drugs became much more accessible, initially through legitimate prescriptions. They subsequently became more generally available for diversion and misuse by a rapidly expanding number of people.

A small minority of unethical prescribers took advantage of the opportunity to supply drugs to opioid-addicted persons, which exacerbated the problem. By the early 2000s, it became apparent in Maine and elsewhere that addiction to pharmaceutical pain medication was becoming a serious problem that had to be addressed by society and by medical professions. An expansion of medication-assisted treatment using methadone helped many, but also complicated the picture. As these clinics expanded, so did opportunities for diversion. At the same time, because methadone could also be used as an inexpensive drug for long-term pain relief, many providers began to prescribe it for pain. Oxocodone and methadone, both synthetic forms of opium, emerged as prominent addictive substances. The state began to experience the multiple consequences of the rising tide of substance-use disorders, including an increase in drug-induced deaths.

MAINE'S POLICY RESPONSES

Public policy interventions required attention by medical prescribers and the systems supporting them, as well as resources for an unprecedented number of citizens who had become addicted to opioids and who were at increased risk of overdose. Initially the number of treatment slots for drug addiction was expanded, including both traditional inpatient and outpatient treatment, as well as medication-assisted (methadone) outpatient treatment clinics. The Drug Enforcement Agency and the Maine Drug Enforcement Agency began to investigate and prosecute illegal prescribing practices. In 2004, Maine instituted one of the earliest prescription monitoring programs (PMP) in the nation, requiring dispensers to report "Schedule II" prescriptions, including any opioid drug, tranquilizers, and

FIGURE 1: **Number of Drug Deaths Occurring in Maine by Manner of Death, 1997–2015**



certain stimulants. Prescribers could now monitor the prescriptions of their patients to forestall "doctor shopping." In 2011, the Office of Chief Medical Examiner was given access to the PMP to investigate decedent prescriptions.

During the later 2000s, the opioid buprenorphine became available as an alternative medication-assisted treatment. Along with the help buprenorphine provided to many patients has come increased diversion of this drug also. This drug, however, contains naloxone, which limits its recreational use and reduces its mortality risks.

There have been multiple professional and policy efforts to limit or refine practices for prescribing opioid analgesics. The Maine Medical Association and the Maine Board of Licensure in Medicine have promoted use of the PMP, a single medical home for patients, patient contracts, and enhanced evaluation of pain to document need for prescriptions. Maine has developed similar rules for MaineCare (Medicaid), including limits on how much opioid medication a patient may receive and the length of time they receive such medication without additional approvals. Doctors in the state of Maine who prescribe opioids are required to take an online course on good practices for prescribing opioids in order to renew or obtain a medical license. Finally, prescribers as well as dispensers are now required to participate in the PMP, and the program has become much more efficient and timely. In addition, interstate compacts are being developed to share prescription data across state lines.

First responders in Maine have struggled to address the exploding overdose rate, and law enforcement agencies have likewise struggled to address the increase in heroin trafficking. For every fatal overdose, there are many nonfatal overdoses that require emergency services and medical treatment, increasing both public and private costs. Funding for the Maine Drug Enforcement Agency has been increased. New policy task forces have been formed at both the community and state levels, and funding for outpatient treatment has been increased. Naloxone, an emergency treatment to reverse opioid overdoses, has been made more widely available for first responders, including law enforcement officers. As this article is going to press, the Maine Legislature has just

overturned a veto by the governor to pass a law allowing Naloxone to be sold over the counter.

OVERDOSE DEATH INVESTIGATION IN MAINE

All suspected overdose deaths are referred to Maine's Office of Chief Medical Examiner (OCME). The OCME has statutory authority to investigate all suspicious, accidental, and unintended deaths to certify their cause and manner. Prior to 2008, their investigation usually included a scene visit whenever practicable. An autopsy and full toxicology screen were routine in suspected drug deaths. With the dramatic statewide increase in these cases, the number of autopsies has been reduced, although full toxicology is still done on all suspected cases. The medical examiner has the legal authority to obtain hospital or other medical records upon request. The Maine OCME has two full-time forensic pathologists and two full-time death investigators headquartered in Augusta, as well as a small number of local medical examiner physicians who can investigate cases not brought in for autopsy. In the face of the large recent increase in overdose cases, personnel resources have not been adequate to send an OCME representative to the scenes when someone dies outside the hospital. They do send an investigator to do an external examination at the funeral home and take a toxicology sample. Law enforcement personnel, often the primary investigators at such scenes, use a standard protocol developed jointly by the OCME and Office of Attorney General to collect medical evidence and information from family or other witnesses.

Toxicology Testing

The investigation of potential drug deaths in Maine routinely includes full toxicology testing. Two types of tests are done: screening to detect the presence or absence of drugs; and confirmatory testing to measure the level of drugs that are present. The comprehensive toxicology screen is designed to detect a wide range of drugs, including analgesics, anticonvulsants, antihistamines, antidepressants, hypnotics, narcotics, sedatives, stimulants, and tranquilizers in very small amounts. (See sidebar for list of common drugs and their classes.)

The toxicology report includes a list of all drugs in the victim's system at the time of death, but their presence does not necessarily mean they were a causal or contributing factor. For example, if a cardiac patient also on methadone maintenance had taken over-the-counter drugs for a cold and then died of an accidental overdose of digoxin (a cardiac drug), the toxicology report would include methadone, digoxin, and perhaps drugs taken for a cold such as an antihistamine. However, only the digoxin toxicity would be listed as a cause of death on the death certificate. In some cases, use of a drug must be inferred from the presence of a metabolized form identified by the toxicology test. Some drugs metabolize quickly, even after death. Breakdown of

Common Name and Drug Class for Frequently Occurring Drugs

Drug	Common/ Brand Name	Drug Class
Amitriptyline	Elavil	Antidepressant
Alprazolam	Xanax	Anti-anxiety agent
Buprenorphine	Suboxone (Buprenorphine & Naloxone), Subutex	Narcotic
Diazepam	Valium	Anti-anxiety agent
Diphenhydramine	Benadryl	Antihistamine
Ethanol	Alcohol	Depressant
Fentanyl	Duragesic	Narcotic analgesic
Fluoxetine	Prozac	Antidepressant
Hydrocodone	Vicodin	Narcotic analgesic
Methadone	Methadone	Narcotic analgesic
Morphine	Morphine, MS Contin, Avinza	Narcotic analgesic
Nortriptyline	Aventyl	Antidepressant
Oxycodone	OxyContin, Roxicodone	Narcotic analgesic
Propoxyphene	Darvon	Narcotic analgesic

chemicals may be more extensive if there is a delay in discovering the death.

The relationship between drug levels provided in the toxicology report and the cause of death is not always straightforward. Toxic drug levels sometimes overlap with therapeutic levels. Further, there may be a large range of individual variation in tolerance for a given drug; doses needed in a person with high tolerance may be lethal for a person with low tolerance. This is especially common with opioids. Drugs may also interact with one another in dangerous ways. It is possible for an otherwise benign drug taken at therapeutic levels to be toxic in combination with other drugs.

The toxicology report is an essential component of any drug death investigation, but the interpretation requires knowledge, experience, care, and caution. For this reason, our analysis gives more weight to the medical examiner's determination of cause of death than to the raw data in the toxicology report.

Determining Manner of Death

The manner of death is clasified as *natural, accidental, suicide*, or *homicide*. A small number of deaths classified as natural do involve drugs. These include deaths resulting from known effects of accepted medical treatment, such as digitalis toxicity from treatment of congestive heart failure. It is important to note that when death is due to a consequence of chronic (long-term) substance abuse—such as withdrawal seizures from chronic alcoholism or cardiac inflammation (endocarditis) due to chronic intravenous drug use—the manner is also ruled natural (Hanzlick, Hunsacker, and Davis 2002).

Deaths may be classified as suicide in Maine only if there is a "preponderance of evidence" that the victim intended to cause his own death. Such evidence might include a suicide note or history of previous attempts. Although drug abuse in and of itself carries with it an inherent risk of overdose and death, engaging in risky or reckless behavior is not generally considered sufficient evidence of suicidal intent. Medical examiners are bound by these legal guidelines.

Maine's strict guidelines for what can be judged suicide means that medical examiners classify as accidents all drug deaths directly due to the unintended or unexpected, acute (sudden or short-term) toxic effects of a drug or poison.[2] Accidental deaths thus constitute something of a composite category; deaths under this rubric may be the result of a range of heterogeneous drug uses. In a few cases, the medical examiner may not be able to determine if a case is suicidal or accidental and may classify the case as an undetermined manner of death.

The Certificate of Death

For each death investigated, a medical examiner is responsible for completion of a certificate of death, which includes information about the death event (time, place, how the injury or activity leading to death occurred), the manner of death (natural, accident, suicide, homicide, or undetermined), and the medical cause of death (up to four levels of causation may be specified, as well as significant conditions that contributed to the death). The death certificate information goes electronically from the OCME to the Maine Department of Health, Office of Data, Research and Vital Statistics. State-level mortality information is then forwarded to the Centers for Disease Control and Prevention's National Center for Health Statistics, where the cause of death is coded. Both the state and the federal government use the standardized codes from death certificate data to generate statistics about population mortality.

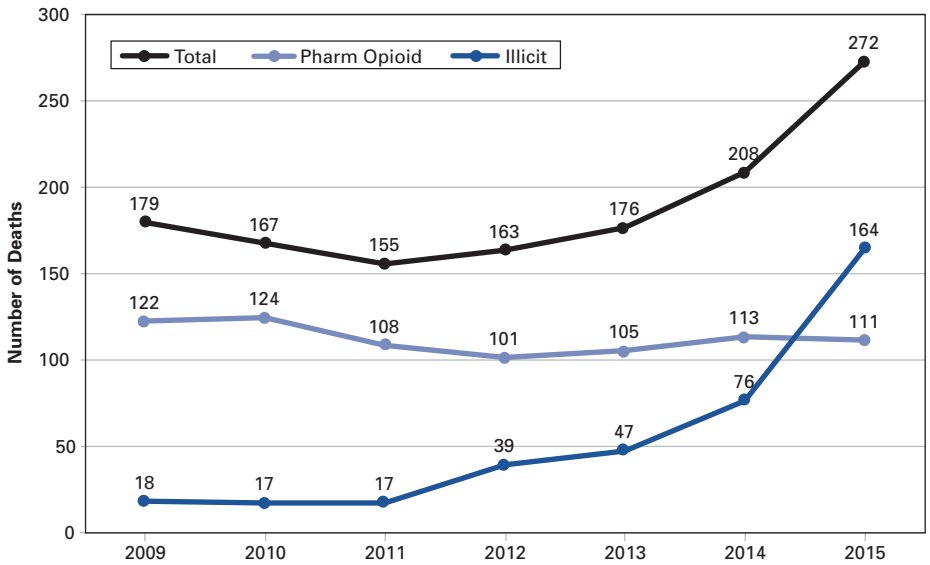
DEFINING "DRUG DEATHS"

In our studies, drug deaths, sometimes labeled "overdose deaths" or "poisoning deaths," include all medical examiner cases in which a drug was determined to be either a cause (primary cause or one of the three underlying causes) of death or a significant contributing factor. The deaths reported in this article are for the period from 2009 through 2015. These are occurrent deaths, that is, deaths that occurred within the state of Maine. Deaths of Maine residents who may have died in other states are not included here.

Deaths caused directly or indirectly by drugs may involve illicit substances (such as heroin or cocaine) or pharmaceutical drugs. Deaths caused by chronic alcohol abuse, in which no other drugs were implicated, were excluded; however, deaths in which both alcohol and drugs were causal or contributing factors have been included.

Drug deaths do not include deaths due to trauma, such as with a motor vehicle fatality, even if the decedent had drugs in her system and may have been impaired. Although there is a legal impairment standard for alcohol impairment and a legal requirement for the

FIGURE 2: **Number of Deaths Due to Pharmaceutical Opioids or Illicit Drugs, 2009–2015***



*Illicit drugs include heroin, non-pharmaceutical fentanyl, and cocaine. Drug categories are combined in some deaths.

OCME to measure alcohol levels in the blood for motor vehicle fatalities, there is no legal standard for impairment from drugs.

Even when drugs are not the primary cause of death, they may be an important component of the overall causal sequence. For example, a medical examiner may determine that lack of oxygen to the brain (brain anoxia) was the immediate cause of death, but that brain anoxia was due to heroin toxicity. In that case, heroin toxicity would be listed as an underlying (secondary) cause on the certificate of death.

MORTALITY RATES

The total annual number of drug-induced deaths occurring in Maine increased dramatically from 34 in 1997 to 272 in 2015, with large increases in 2002 and further increases during the last four years, 2012–2015. As we show, the recent increase is due predominantly to accidental rather than suicidal overdoses and is largely the result of heroin and non-pharmaceutical fentanyl. Figure 1 shows the total number of suicidal and accidental deaths by year. Beginning in 2001, the number of drug-induced suicides has fluctuated, but has remained within the range of 25 to 38 each year; that type of variation is likely random change due to the small number. During the same period, the number of accidental deaths rose sharply from 64 to 124 between 2001 and 2002, with another sharp increase from 2012 to 2015, going from 115 to 272.

Since our last report in 2010 (Sorg et al. 2010), Maine has seen the number of deaths due to pharmaceutical opioids stabilize, with a dramatic increase in illicit drug trafficking and abuse. As shown in Figure 2, in 2009 there were 18 deaths due to heroin, non-pharmaceutical fentanyl, and cocaine, a number that remained about level through 2011. But, beginning in 2012, the number of deaths due to these illicit drugs began to increase sharply, doubling by 2012, doubling again by 2014, and again by 2015, an increase overall of 890 percent. In 2015, the number of illicit drug deaths surpassed the number caused by pharmaceutical opioids (Figure 2).

In the last few years the rate of drug-induced deaths, particularly those attributable to pharmaceutical and illicit opioids, has risen drastically across the United States. According to a recent analysis by the Centers for Disease Control and Prevention, Maine was one of 14 states nationwide that saw a statistically significant percentage increase in drug-induced deaths from 2013 to 2014, with a 27.3 percent climb (Rudd et al., 2016). Among other New England states, both New Hampshire and Massachusetts also experienced statistically significant increases in drug-induced deaths during this same time period, with Massachusetts witnessing an increase of 18.8 percent, and New Hampshire, an increase of 73.5 percent. Among those 14 states with statistically significant percentage

increases, Maine, New Hampshire, and Massachusetts ranked third, second, and seventh, respectively.

Maine's drug deaths are spread throughout the state and thus are not a strictly urban phenomenon. In Table 1, we summarize the total number and percentage of drug deaths by county, compared to each county's proportion of the 2010 Maine population. Although the proportion of drug deaths is similar to the population in most counties, Cumberland County has 4.4 percent more deaths than would be predicted based on its population, and Oxford County has 2.0 percent less. We calculated the rate per 100,000 for deaths occurring in each county (see Table 2). Mortality rates in larger counties are similar to each other and also more stable over time, largely because they have larger populations (e.g., for 2013–2015, Androscoggin is 21.0; Cumberland is 20.8, and Kennebec is 21.6). In Table 2, we have used three-year rolling averages to smooth out some of the year-to-year random fluctuations that occur in counties with small populations, but this small-number problem persists. Thus, some rate changes over time in the smaller counties are likely due to random fluctuations rather than changes in drug use. Nevertheless, several non-urban counties have experienced the lowest drug mortality rates per 100,000 population (e.g., for 2013–2015, Aroostook is 10.2, Franklin is 9.8, Oxford is 8.1, and Sagadahoc is 7.6). Most counties in Maine, however, have seen an increase over time in the rate of drug deaths. The map (Figure 3) shows the average ratio of drug deaths per 100,000 population in Maine's counties in the 2009 to 2015 period.

TABLE 1: **Total Number and Percentage of Drug Deaths by County, 2009–2015***

County	Number of Drug Deaths 2009–2015	Percentage of Total Drug Deaths 2009–2015	Percentage of 2010 Maine Census Population	Percentage Deviation from Census
Androscoggin	129	9.8	8.1	1.7
Aroostook	47	3.6	5.4	-1.8
Cumberland	338	25.6	21.2	4.4
Franklin	22	1.7	2.3	-0.6
Hancock	44	3.3	4.1	-0.8
Kennebec	141	10.7	9.2	1.5
Knox	33	2.5	3.0	-0.5
Lincoln	31	2.3	2.6	-0.3
Oxford	31	2.3	4.3	-2.0
Penobscot	150	11.4	11.6	-0.2
Piscataquis	20	1.5	1.3	0.2
Sagadahoc	15	1.1	2.7	-1.6
Somerset	50	3.8	3.9	-0.1
Waldo	36	2.7	2.9	-0.2
Washington	38	2.9	2.5	0.4
York	195	14.8	14.8	0.0
Total	1,320	100	100	—

*Compared to county population (U.S. 2010 Census).

DECEDENT CHARACTERISTICS

Some victims of drug-induced overdose in Maine are people most Mainers would characterize as marginal: without a stable place to live or a stable work history, perhaps with histories of mental illness or serious substance abuse problems. Others, however, are well-educated homeowners, employed at responsible jobs in a variety of skilled occupations. Aside from being (like most Mainers) overwhelmingly Caucasian, the population of those who die of drug-related causes is surprisingly diverse.

Both men and women are included among overdoses, but their distribution does not mirror the general population. Table 3 compares the age and sex structure of Maine drug deaths from 2009 to 2015 to that of the U.S. 2010 census for Maine. The drug death population is clustered in the age categories from 25 to 54. Males disproportionately occupy younger, and females older, age categories, whereas the Maine general population is more evenly distributed among age and sex categories.

Men outnumber women approximately two to one among accidents (703 men vs 341 women), and women outnumber men by about 50 percent among suicides (130 women vs 90 men). During the 2009–2015 period, there were 1,320 deaths; decedent ages range from 17 to

TABLE 2: **Rate of Drug Deaths per 100,000 Population by County, Three-year Rolling Averages, 2009–2015***

County	2009–2011	2010–2012	2011–2013	2012–2014	2013–2015
Androscoggin	13.6	13.6	13.3	18.0	21.0
Aroostook	9.3	9.3	11.6	9.7	10.2
Cumberland	13.4	13.8	14.7	16.4	20.8
Franklin	11.9	11.9	9.8	7.6	9.8
Hancock	12.9	8.0	6.1	8.6	11.6
Kennebec	13.6	14.5	15.3	15.8	21.6
Knox	10.1	10.9	10.9	12.6	15.1
Lincoln	9.7	9.7	12.6	13.5	16.4
Oxford	8.1	5.2	6.3	5.8	8.1
Penobscot	14.1	12.6	13.0	12.8	14.5
Piscataquis	24.7	20.9	5.7	5.7	13.3
Sagadahoc	3.8	5.7	6.6	8.5	7.6
Somerset	12.1	12.8	13.4	14.7	14.0
Waldo	13.8	14.6	15.5	13.8	12.0
Washington	14.2	18.3	19.3	19.3	18.3
York	12.7	11.0	10.5	13.9	16.6
Statewide	12.6	12.2	12.4	13.7	16.5

*This occurrent ratio excludes deaths of Maine residents that occurred in other states.

92, with the exception of two children age 2 and one age 7. The average age of all decedents for the period from 2009 to 2015 is 43. More than half (53 percent) of these decedents were aged 35 to 55. Accident victims are on average slightly younger (average age 41with sexes combined, males 40, females 43) than those who commit suicide (average age 51 with sexes combined, males 49, females 52), and twice as likely to be male.

Compared to averages for Maine's population as a whole, overdose victims are less educated and less likely to have been born in Maine. Table 4 compares the 2015 drug deaths by manner of death to the Maine 2010 census population. The 2015 accidental death victims are about twice as likely (16 percent) as the general population (9 percent) to have less than a high school education and approximately one-third as likely (8 percent) as the general population (28 percent) to have a bachelor's degree or higher. Accidental overdose victims are less likely (57 percent) than members of the general population (66 percent) to have been born in Maine; suicidal overdose victims are even less likely (43 percent) to have been born in the state. Racial make-up is similar across categories.

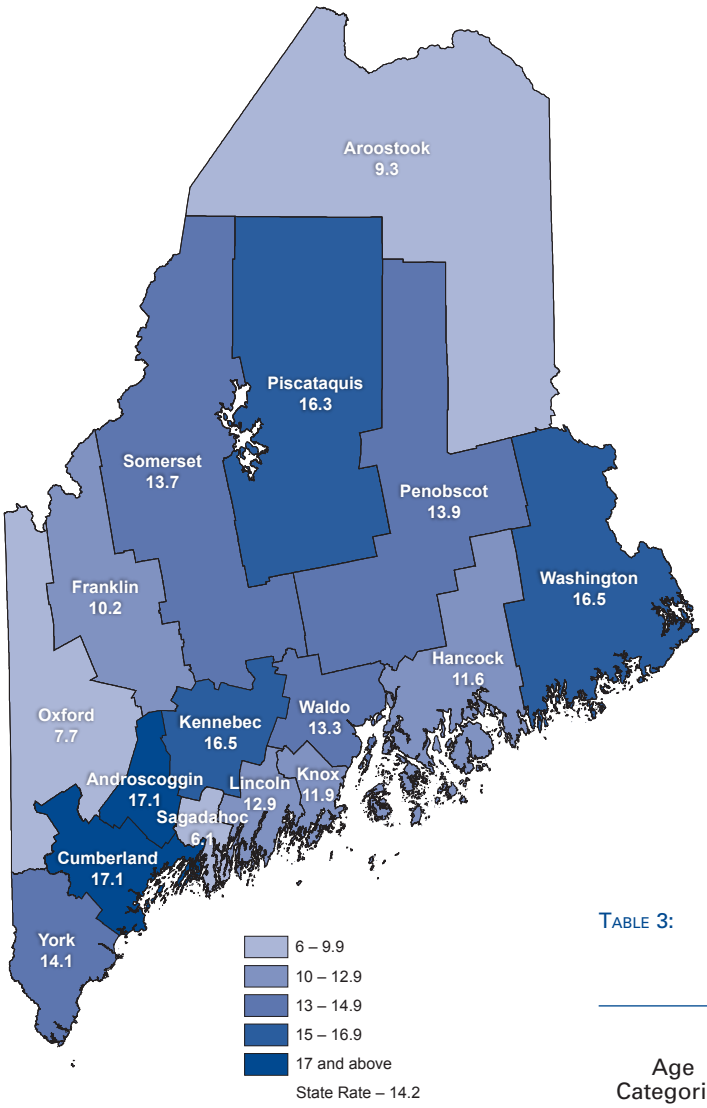
As is true for many middle-aged Mainers, these drug death victims had chronic medical problems, including heart, lung, and liver diseases, as well as obesity. Conditions such as these can play a role in drug-related deaths by reducing physical capacity. For instance, liver diseases such as hepatitis or cirrhosis can reduce the ability of the liver to detoxify blood. This reduced ability helps keep blood drug levels dangerously high. Chronic obstructive pulmonary disease (COPD) reduces lung capacity, which can enhance the respiratory depression produced by high levels of opiates. Obesity can obstruct the airway, particularly in some body positions, thus potentially increasing the risk from respiratory depression caused by opiates. Cardiovascular disease further increases risks from respiratory depression by reducing the capacity of the heart and lungs to process oxygen. Witnesses to the circumstances of overdose deaths often describe the victim as "sleeping" and "snoring" heavily just before death, an unrecognized sign of respiratory distress.

Decedents may have been taking medications prescribed legitimately for conditions such as pain, depression, or anxiety. These medications sometimes have dangerous side effects if taken incorrectly or combined with other drugs. They may interact dangerously with other drugs of abuse. Alcohol, as well as some medications prescribed for anxiety or depression, if taken in conjunction with opioids, can boost the blood levels—hence the toxic effects (Davis et al. 2012; Sorg et al. n.d.).

KEY DRUGS INVOLVED

Of the pharmaceutical drugs specifically listed on death certificates as either cause or contributing factor, three classes predominate: opioid analgesics (including for example methadone, oxycodone

FIGURE 3: **Average Rate of Drug Deaths per 100,000 Population by County, 2009–2015***



*This occurrent ratio excludes deaths of Maine residents that occurred in other states.

and hydrocodone), antidepressants (most frequently SSRIs [selective serotonin reuptake inhibitors] such as fluoxetine or tricyclic antidepressants such as amitriptyline), and benzodiazepines (especially anti-anxiety agents such as diazepam and alprazolam). Alcohol (a depressant) and cocaine (a stimulant) are also frequently listed. Heroin, which is a non-pharmaceutical opioid, has emerged as one of the most frequent causes, along with non-pharmaceutical fentanyl (and acetyl-fentanyl). Heroin, cocaine, and non-pharmaceutical fentanyl are the most prominent of the illicit drugs in Maine deaths.

Of all overdoses between 2009 and 2015, 67 percent had at least one pharmaceutical drug mentioned as a cause of death (82 percent for accidents and 98 percent for suicides). This is much greater than the 63 percent for accidents and about the same as the 94 percent for suicides noted in our 2003 article (Sorg and Greenwald 2003). However, it is important to note a change in how medical examiners certify deaths with multiple drugs; they are much more likely to mention all potential co-intoxicants on the death certificate.

An overwhelming majority of pharmaceutical opioids and benzodiazepines implicated as causing or contributing to overdose deaths since 2009 lack any evidence of a prescription. For example, of the 96 cases in 2015 in which a pharmaceutical opioid was implicated as a cause of death (35 percent of cases overall), only 7 percent had a prescription.

Most drug-induced fatalities involve more than one drug. In our 2003 article, for about a quarter of the deaths that occurred in the 1997–2002 period, the toxicology was so complex that the cause of death was listed simply as "polydrug" or "mixed drug." Practice guidelines for medical examiners have changed since then, however (see Davis et al. 2012), and it is now more

TABLE 3: **Age and Sex Distribution for Drug Deaths from 2009 to 2015 Compared with Maine 2010 Census Population**

Age Categories	2010 Maine Population			2009–2015 Deaths		
	Male	Female	Both Sexes	Male	Female	Both Sexes
	%			%		
<18	22	20	21	0	1	1
18-24	9	8	9	7	6	6
25-34	11	11	11	27	15	22
35-44	13	13	13	24	24	24
45-54	16	16	16	27	33	29
55-64	14	14	14	12	16	13
65+	14	17	16	3	6	4
Total	100	100	100	100	100	100

common to list any potentially interacting or synergistic substances on the death certificate.

Oxycodone and Methadone

Oxycodone is a synthetic opioid often prescribed for pain. Since 1995, it has been marketed in the long-lasting form OxyContin, but is also prescribed in lower dose, shorter-acting products. Once metabolized, however, OxyContin and other commercial forms of oxycodone are indistinguishable. Oxycodone has been one of the key intoxicants found in Maine decedent toxicology since the late 1990s and is often the most commonly identified opioid across all overdose decedents in Maine.

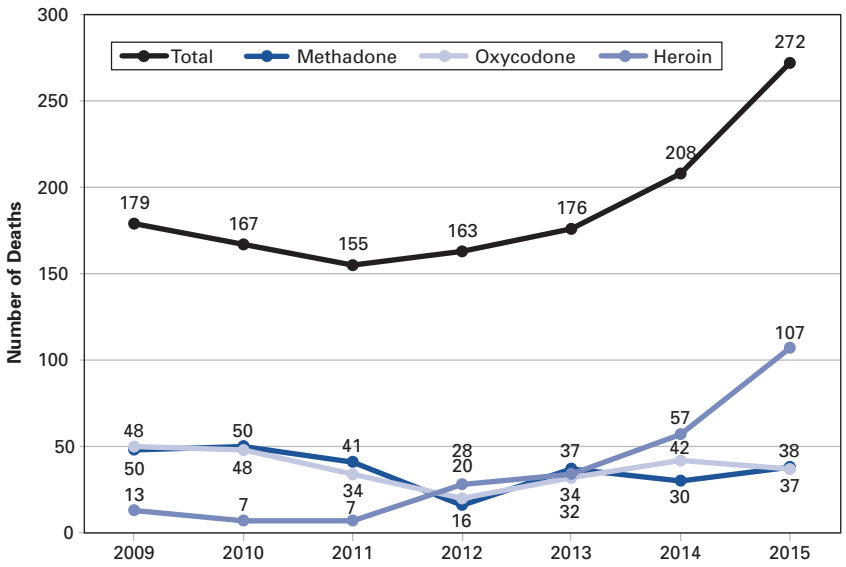
Methadone is a synthetic opioid with two distinct primary uses. Because it is long-acting, without the same euphoric high as heroin, it has long been used in the treatment of opioid addiction, prescribed in liquid, powder, or wafer form. Methadone is also frequently used in pill form for chronic pain. Toxicology screenings cannot discriminate between these various forms. Methadone pharmacology is particularly complex. Tolerances vary widely from one individual to another. The range of blood levels seen with therapeutic doses may overlap with the toxic range. As with other opioids, people can die of fairly low, theoretically safe, doses, often when alcohol or other drugs are present or if the individual has low tolerance. An individual's tolerance can also change with circumstance. Tolerance is reduced for regular users who, for one reason or another, stop receiving regular doses, e.g., those who are in jail. When they resume taking dosages to which they had been accustomed, they are at greater risk for fatal overdose. The slow onset of methadone's effects may prompt some users to take more methadone, with fatal effect. This can increase the risk of respiratory depression, the most common adverse effect of all opioids and the one most likely to prove fatal.

Figure 4 illustrates the trends in the frequencies of deaths due to key opioids methadone and oxycodone, contrasted with heroin trends. The rates of oxycodone and methadone have been similar during the 2009–2015 study period, temporarily dropping during 2012,

TABLE 4: **Demographic Characteristics of Decedents in 2015 by Manner of Death, Compared with Maine 2010 Census Population**

2015 Deaths, Category	All Deaths	Accidents	Suicides	Maine 2010 Population
	%			
Race				
Caucasian	95	97	100	95
Education (ages 25+)				
Less than high school	14	16	4	9
High School	85	84	96	91
Bachelors or Higher	9	8	19	28
Nativity				
Born in Maine	56	57	43	66

FIGURE 4: **Number of Deaths Caused by Methadone, Oxycodone, and/or Heroin, Alone or in Combination with Other Drugs, 2009–2015**



but stablizing since 2013. These drugs are sometimes found together.

Heroin and Non-pharmaceutical Fentanyl

Heroin is an illicit opioid associated with intravenous drug use. Heroin is sometimes difficult to identify in toxicology. Because it metabolizes quickly in the body to morphine, the toxicology reports morphine, not heroin. Morphine could be pharmaceutical morphine sulfate, an opioid analgesic, or metabolized heroin. If they lack clear evidence of heroin from the scene investigation, medical examiners are likely to name the drug causing death as "morphine" on the death certificate, even though many of these cases are in fact due to heroin. To avoid undercounting heroin, our method has been to cast a wider net. We examine the scene investigation data to rule out that the death is due to morphine sulfate pills and rule out that the decedent has a prescription for pharmaceutical morphine; we then count any remaining cases of morphine toxicity as heroin.

Fentanyl is likewise a substance found in toxicology that may be pharmaceutical or, since 2011, non-pharmaceutical. This substance is being manufactured in Asia and has been widely distributed as both powder and pills by drug traffickers in the United States. Maine began seeing non-pharmaceutical fentanyl deaths in 2012. Similar to our approach with heroin, we rule out the presence of known pharmaceutical fentanyl products such as fentanyl patches or known prescriptions for the decedent; we then count any remaining cases of fentanyl toxicity as non-pharmaceutical fentanyl.

Deaths caused by heroin had declined during the mid-2000s. They began to rise in 2011, along with non-pharmaceutical fentanyl. Fentanyl and its analogue acetyl-fentanyl are sometimes found alone, sometimes in combination with each other, and often combined with heroin in decedent toxicology (see Figure 5). Illicit drug dealers often combine these drugs and sell the product as heroin. Fentanyl is many times more potent than heroin and often fatal.

Drug deaths caused by heroin or non-pharmaceutical fentanyl and its analogues were unevenly distributed around the state. The southernmost counties of Cumberland and York have had a disproportionate share of the heroin/fentanyl deaths. Cumberland County has 21percent of Maine's 2010 population, but has had 34 percent of the heroin/fentanyl deaths, 13 percent more than expected. York, with 15 percent of the population, had 19 percent of the heroin/fentanyl deaths. Many other counties have had fewer than expected heroin/fentanyl deaths through 2015, based on their poulations; for example, Penobscot, with 12 percent of Maine's population, had 9 percent of the heroin/fentanyl deaths, 3 percent less than would be expected. The map (Figure 6) displays the average rate of deaths per 100,000 due to heroin and non-pharmaceutical fentanyl by county over the 2009–2015 period. The four most southern, contiguous counties along the Interstate-95 corridor, along with Washington County, have experienced the highest rates overall during this period.

Those who died due to pharmaceutical opioids are much older on average (males 43; females 46) than those who died due to heroin and/or non-pharmaceutical fentanyl (males 38; females 36). But the distribution is skewed, as shown in Figure 7. For heroin and non-pharmaceutical fentanyl deaths, males far outnumber females, and they cluster largely in the 25- to

FIGURE 5: **Number of Maine Drug Deaths in Which Heroin or Fentanyl (and Its Analogues) Were Listed as the Cause of Death, Alone or in Combination, 2009–2015**

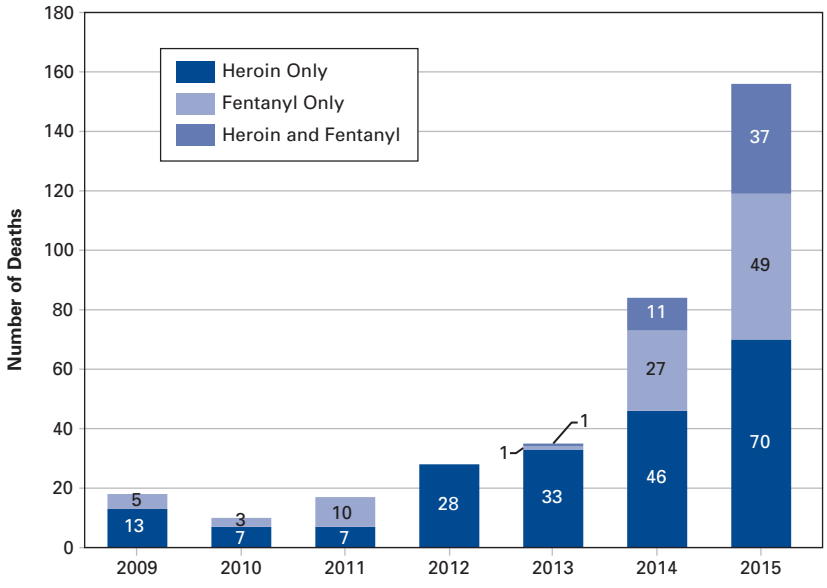
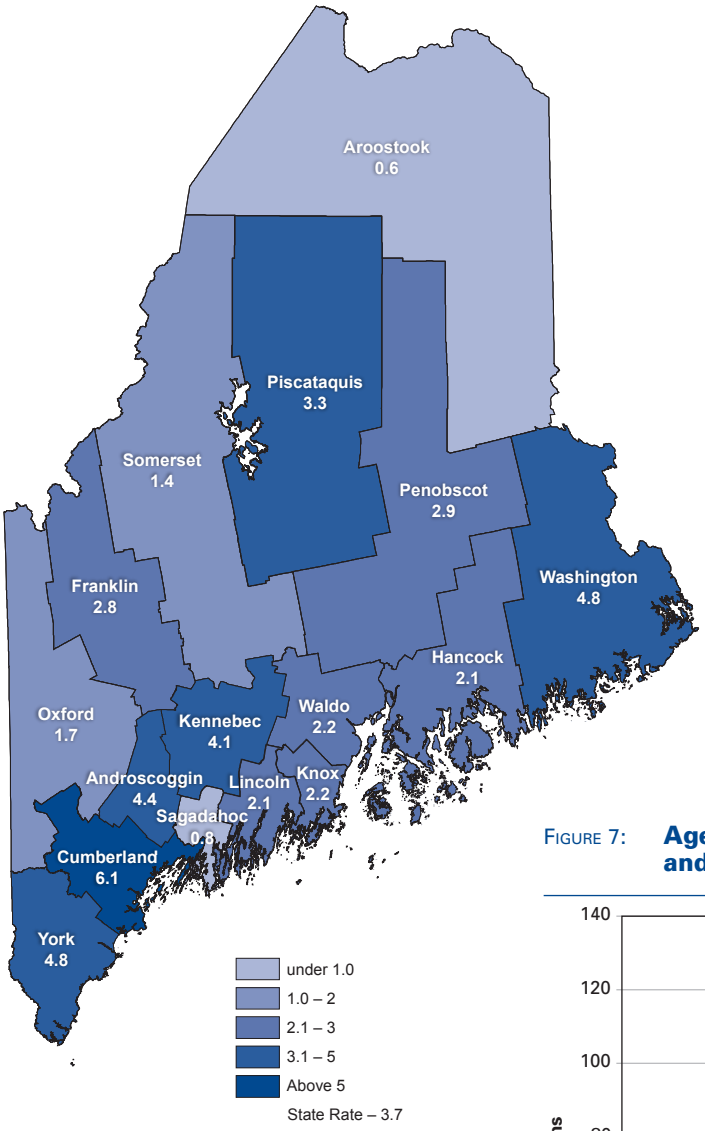


FIGURE 6: **Average Drug Deaths Due to Heroin and Non-pharmaceutical Fentanyl per 100,000 Population by County, 2009–2015***



*This occurrent ratio excludes deaths of Maine residents that occurred in other states.

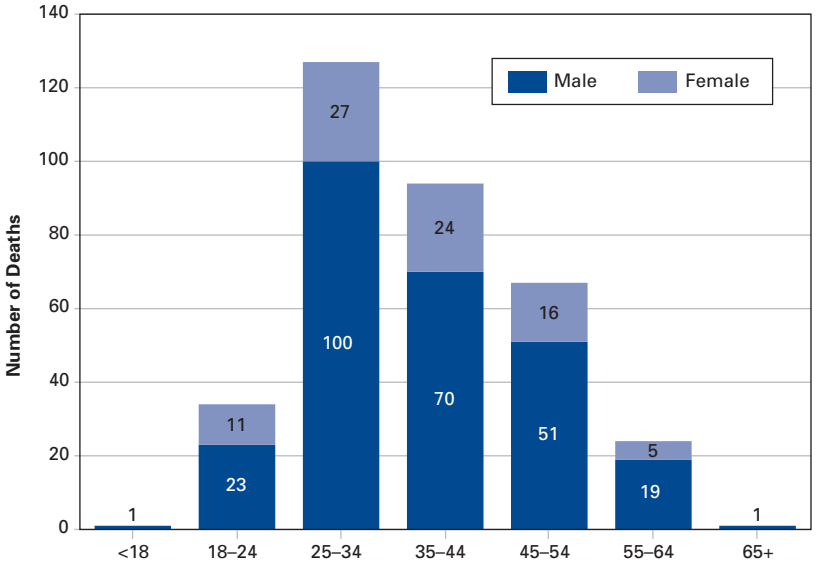
34-age category (100 male decedents). The age distribution for females is similar to the pattern for pharmaceutical opiods.

CONCLUSION

Substance abuse is a critical problem that continues to plague Maine state and local governments and the communities they serve. Death is only the most dramatic consequence of a behavior pattern associated with crime, increased accidents, lost time at work, serious health problems, and untold anguish for family and loved ones.

A 2010 analysis of the impact of substance abuse on the state of Maine revealed that the total economic burdern resulting from drug and or alcohol abuse was over $1.4 billion in 2010 dollars, or $1,057 for every Maine resident (Rogers, Sorg, and Wren 2013). The 175 drug-induced deaths in 2010 represent a $168.7 million in loss in potential lifetime earnings for those decedents. Among individuals in the labor force who had a drug problem in 2010, there was an approximatey $36.1 million loss of productivity. Concerned members of the public often focus on the most exotic elements—illegal drugs such as heroin or cocaine or legal drugs such as methadone that seem to be used primarily by a definable population. Yet the problem is much more complex.

FIGURE 7: **Age-Sex Distribution for Deaths Caused by Heroin and Non-pharmaceutical Fentanyl, 2009–2015**



Study of Maine's medical examiner files indicates that to reduce the risk of drug-related fatalities, policy initiatives must address this complexity of drug use. Here we make a few points on substance abuse issues coming from our study:

- At least one pharmaceutical drug is named as a cause of death (alone or in combination with other drugs) in the overwhelming majority (85 percent) of drug deaths in Maine, 2009–2015. Most of these drugs have been diverted. A minority are prescribed, but misused.
- Within the past three years, illicit drugs including heroin, non-pharmaceutical fentanyl formulations, and cocaine are involved in over half (51 percent) of Maine drug deaths, frequently combined with pharmaceuticals or alcohol. This emergent pattern is worsening: the proportion of illicit drugs identified in drug death cases has increased from 27 percent in 2013 to 60 percent in 2015.
- Alcohol has been a prominent part of the substances listed on death certificates as either cause of death or contributing factor, named in 20 percent of cases in the 2009–2015 period. Maine's substance abuse problem is still frequently an alcohol abuse problem.
- Better public education on signs of respiratory distress might save lives. Unwitting witnesses to drug deaths frequently mistake respiratory distress for snoring and fail to summon medical assistance.

Our study of the forensic epidemiology of drug mortality continues. We hope our findings will provide a more nuanced understanding of the circumstances and risks of drug abuse and drug abusers and will prompt improved public policy initiatives that effectively address the full range of Maine's problems with drug use and abuse.

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ENDNOTES

1 The first report, funded by the U.S. Department of Justice Byrne Fund, covered the period 1997 to the end of June 2002. Funding from the U.S. Department of Justice allowed us to continue tracking through 2005. A second comprehensive report in 2010 was funded by the Offices of United States Attorneys. More recent tracking and funding for the current study have been supported by the Maine Office of Attorney General.

2 This designation is consistent with guidelines recently published by the National Association of Medical Examiners (Hanzlick, Hunsacker, and Davis 2002) for determining the manner of death when drugs are involved. Jurisdictions outside Maine may use different criteria.

REFERENCES

Davis, Gregory G. 2014. "Complete Republication: National Association of Medical Examiners Position Paper: Recommendations for the Investigation, Diagnosis, and Certification of Deaths Related to Opioid Drugs." Journal of Medical Toxicology 10:100–106.

Hanzlick, Randy, John C. Hunsacker III, and Gregory J. Davis. 2002. A Guide for Manner of Death Classiifcation. National Association of Medical Examiners, Atlanta.

Rogers Ann, Marcella Sorg, and Jamie Wren. 2013. The Cost of Alcohol and Drug Abuse in Maine, 2010. Maine Office of Substance Abuse and Mental Health Services, Department of Health and Human Services, Augusta.

Rudd, Rose A., Noah Aleshire, Jon E. Zibbell, and R. Matthew Gladden. 2016. "Increase in Drug and Opioid Overdose Deaths—United States, 2000–2014." Morbidity and Mortality Weekly Report 64(50): 1378–1382.

Sorg, Marcella H., and Margaret Greenwald. 2003. "Patterns of Drug-Related Mortality in Maine, 1997–2002." Maine Policy Review 12(1): 84–96.

Sorg, Marcella H., William Parker, and Sharon Labrie. 2010. Drug-Induced Deaths in Maine 1997–2008, with Estimates for 2009. Maine Substance Abuse and Mental Health Services, Department of Health and Human Services, Augusta. https://www1.maine.gov/dhhs/samhs/osa/pubs/data/2011/DrugInducedDeathsReport%2097-08%20Final%202%5b1%5d.pdf

Sorg, Marcella H., Leann L. Long, Marie Abate, et al. n.d. "Variability Among Opioids in Apparent Co-Intoxicant Additive Effects in Opioid-Related Deaths." Academic Forensic Pathology, submitted for review.

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