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Spatiotemporal Investigation of Opioid-Involved Fatalities in Connecticut, 2009-2017

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May 1, 2019

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Abstract

Over the past two decades, overdose deaths involving pharmaceuticals, heroin and, more recently, synthetic opioids such as illicitly manufactured fentanyl have increased in the United States. Connecticut has one of the highest opioid-involved mortality rates when compared to other states, and between 2009 and 2017, the incidence of opioid-involved fatal overdoses in Connecticut increased by about 350%. We examined opioid-involved fatality data from the Connecticut Office of the Chief Medical Examiner over a 9-year period, from January 1st, 2009 and December 31st, 2017, to better understand the granular spatiotemporal trends of the crisis within CT with an eye toward informing public health overdose prevention and treatment strategies.

The epidemiology of fatal opioid-involved overdoses in Connecticut exhibits distinct spatial, demographic, and temporal patterns. The recent increase in overdose deaths is driven by fentanyl and fentanyl analogues. Although much of the crisis has impacted white, non-Hispanic people, the burden on black, non-Hispanic and Hispanic, White populations continues to grow and outpace that of the white, non-Hispanic population. Additionally, fatalities among males are outpacing fatalities among females. Thus, future interventions ought to focus on preventing overdose deaths among people of all races and males in particular.
Keywords: Opioid, Overdose, Mortality, Death, Prescription opioid, Fentanyl, Heroin
**Background.** Unintentional opioid-involved overdose fatality rates have increased about 350% in Connecticut from 2009 to 2017, inciting a considerable statewide public health crisis. Several breeds of opioids have given rise to these overdose deaths, including pharmaceutical opioid analgesics, illicit opioids like heroin and fentanyl. The objective of this study is to descriptively assess the temporal and spatial trends in opioid-involved overdose deaths in Connecticut between January 1st, 2009 and December 31st, 2017.

**Methods.** Using data extracted from the Connecticut Office of the Chief Medical Examiner database, rates of opioid-involved overdose death --for which injury occurred in Connecticut between 2009 and 2017-- were calculated. Spatial and temporal trends in opioid-involved fatalities were evaluated, including descriptive statistics on age, race/ethnicity, type(s) of opioids present, the presence of other drugs in the toxicological report, and whether injection was suspected to have been involved in the fatality. Emerging hot spot analysis was used for spatiotemporal analysis.

**Results.** From January 1, 2009 to December 31, 2017, we identified 4,547 victims of fatal opioid-involved overdose which occurred in Connecticut. The rate of deaths involving an opioid of any type increased from 7.62 to 26.86 per 100,000 people from 2009 to 2017 and increased from 0.4 to 18.6 per 100,000 people in the same period for those involving fentanyl. The number of cases that involved fentanyl or a fentanyl analogue as the only opioid present at time of death have increased over time whereas pharmaceutical-only deaths have steadily decreased during the same period. Across all years and after adjusting for population size, victims were consistently more male than female, and more white (non-Hispanic) than any other race when adjusting for population size. Cases were concentrated in the 25 to 44 age group for all years with a bimodal distribution, including peaks near ages 25 and 45. While the majority of fatalities in 2009 and 2010 included only pharmaceuticals, heroin-only deaths dominate from 2011 to 2015. In 2016 and 2017, most deaths were attributed to a combination of opioid types, including fentanyl, heroin, and pharmaceuticals. The crisis has become more fentanyl-driven over time, with an increase from 0.4 to 18.6 per 100,000 population of fentanyl-involved deaths from 2009 to 2017. In Connecticut, cases are most concentrated in urban areas by both raw total and when adjusted for population size. Among only fentanyl-involved deaths, victims were predominantly male (79.1%) with 54.5% of victims aged between 25 and 44 (38.3% aged 34 or under).

**Conclusions.** The recent increase in opioid-involved deaths during the studied 9 years is attributed to the expanded availability of fentanyl and fentanyl analogues. This corresponds to the growing supply and use in the United States of illicitly manufactured fentanyl. Additionally, there are distinct spatial patterns to the crisis; interventions ought to account for the distinct spatial patterns and the demographic profile of the crisis.
1. Introduction

Since 2000, overdose deaths involving pharmaceuticals, heroin and, more recently, synthetic
opioids such as illicitly manufactured fentanyl (IMF) have increased in the United States (Rudd
et al. 2016). Situated in the Northeast, where much of the opioid crisis has taken its toll,
 Connecticut has one of the highest opioid-involved (OI) mortality rates when compared to other
states (CDC, 2018). We examined OI fatality data from the Office of the Chief Medical
Examiner (OCME) over a 9-year period, from January 1st, 2009 and December 31st, 2017, to
better understand the granular spatiotemporal trends of the crisis within CT. The purpose of this
study is to better understand how the opioid crisis is evolving and who ought to be targeted by
future interventions.

2. Background

2.1 Opioid Crisis in the United States

Fatal overdose has become a significant public health issue in the United States (US), where
between 1999 and 2017, over 700,000 individuals died from a drug overdose (CDC, 2019). The
proportion of fatal overdoses which involve an opioid has increased during this time period, with
approximately 6 times greater OI deaths in 2017 than in 1999 (CDC, 2019). On average, 130
Americans die from an OI overdose per day (WONDER, 2017).

The emergence of the current overdose crisis is often attributed an increase in opioid prescribing
beginning in the 1990s (Kolodny et al. 2015). The Centers for Disease and Prevention (CDC)
considers the early increase in pharmaceutical-involved fatal overdoses a “first wave” in a series
of three waves in the crisis.

Prescription opioid abuse is a significant risk factor for initiating heroin use (Rudd et al., 2016a),
as studies have shown that heroin initiation is often preceded by prescription opioid use, up to
75% of the time (Cicero et al., 2014; Mars et al., 2014). The transition from pharmaceuticals to
heroin is often due to the cheaper price and greater availability of heroin when compared to
prescriptions, particularly after over-prescribing was recognized as a problem (McGreal, 2016).
Additionally, abuse-deterrent reformulations of pharmaceutical opioids began to appear around
2010 at the instigation of the FDA (Evans, 2018).

The opioid crisis accelerated in 2010 with an increase in heroin-involved deaths, which has been
termed the “second wave” of the epidemic by the CDC. Between 2011 and 2013, the rate of
heroin-involved overdose deaths in the US increased by almost 200%, from 1.4 per 100,000 to
2.7 per 100,000 population (Jones et al., 2015).
The most recent and most deadly wave of the opioid crisis commenced in 2013 and has been attributed to synthetic opioids like IMF (CDC, 2018; Hedegaard et al., 2017; Rudd et al., 2016b). It is worth distinguishing between pharmaceutical fentanyl and IMF at this juncture; both are extremely powerful analgesics, but pharmaceutical fentanyl is produced legitimately in the US, while IMF is often produced in and shipped from China. It is often pressed into pill form or mixed into the heroin supply. In 2016, approximately 35 times more fentanyl was seized compared to 2013 (Knierim, 2018).

National agencies have endeavored to reduce morbidity and mortality associated with the opioid crisis. These efforts have included placing limits on opioid prescriptions (Chua, 2019), improving awareness of and access to opioid antagonists like naloxone, and improving access to various types of treatment. In 2016, the Obama administration committed to address the crisis and Congress provided $1 billion in grants to states for these efforts (White House, 2016). In October 2017, President Trump declared that the opioid epidemic had become a national emergency, and two funding bills were subsequently passed (White House, 2018). The Trump Administration has stated that as of late 2018, they had secured $6 billion in funding to fight opioid abuse; these efforts have been focused on a “Safer Prescribing Plan” to reduce opioid prescribing, as well as securing the borders against smuggling (White House, 2018).

### 2.2 Opioid Crisis in Connecticut

Connecticut has not been spared from this US public health crisis, experiencing one of the highest rates of increase in synthetic opioid deaths (125.9% from 2014 to 2015) when compared to other states; during this same time period, neighboring New York saw an increase of 135.7%, and Illinois had the next highest with an increase of 120% (Rudd et al. 2016).

The age-adjusted death rate opioid overdose in Connecticut increased from 3.9 to 23.3 from 1999 to 2016 per 100,000 population in Connecticut (CDC, 2017). In fact, Connecticut had the eighth highest age-adjusted opioid overdose death rate in the US in 2016 (CDC, 2017).

Although it seems the opioid crisis is “leveling off” in Connecticut according to the Chief Medical Examiner, (O’Neill, 2010), it is still recognized as a serious issue in the state. In early April 2019, Governor Ned Lamont announced a new statewide awareness campaign and a new application supported by the Connecticut Department of Health to support access to the opioid antagonist naloxone (State of Connecticut, 2019).
Although there is some talk of the crisis ebbing (Alonso-Zaldivar, 2018), it seems fentanyl is still on the upswing and there is plenty of room for more insight. More research is required to understand the granular spatiotemporal details of the crisis, as much of the research by the CDC is aggregated to large regions.

With that in mind, the purpose of this paper is to describe the epidemiology of fatal opioid overdoses in Connecticut from 2009 to 2017 by identifying demographic factors, spatial and temporal patterns, opioid type detected in toxicology, as well as concomitant identified in toxicology. Results will shed light on how the crisis unfolded in Connecticut during the study period.

2.3 Previous Findings

There is a wealth of literature regarding the recent opioid crisis, including a 2011 analysis of OI deaths in Connecticut (1997-2007) using Connecticut OCME data, which found that total heroin-involved deaths were relatively stable across the study period and total OI deaths (including pharmaceuticals) were increasing over time (Green et al. 2011). Since even the newest data included in that analysis is over a decade old, it is prudent to take another look at fatal opioid intoxications in Connecticut, as the number of overdoses annually has increased significantly since that time and the ratio of opioid types has shifted.

A more recent publication using data from the Connecticut OCME, focused on 2016, established that targeting by opioid type is needed (Clinton et al. 2019). Clinton et al showed that the younger population tends towards illicit opioids (under 44), while those aged 45 and older are more likely to overdose as a result of pharmaceutical opioids; thus, specialized approaches are needed. However, their analysis is limited in scope to one calendar year.

To our knowledge, there has not yet been an effort to spatiotemporally evaluate Connecticut’s OI fatality data in recent years to this level of detail and over a several-year timespan. This paper will fill that gap.

3. Methods

3.1 Data Source

All physicians, funeral directors, law enforcement officers, and other officials are required by law to notify the OCME of any reportable death (OCME, 2009). A reportable death is defined as a death which is subject to investigation by the Chief Medical Examiner, which includes accidents, homicides, suicides, and other deaths which are sudden or unexpected. Approximately half of all deaths which occur in Connecticut are reportable, as the criteria are designed to be
“broad, overlapping, and inclusive” (OCME, 2006). Therefore, we expect that the OCME database includes all OI deaths which have occurred in Connecticut and does not underestimate the reach of this crisis (Grau, personal communication).

After the investigation is finalized by the medical examiner, several variables are available to be extracted from the OCME database, including dates of birth and death, addresses for injury location, residence, and death location, toxicological results, narrative and investigation records, a post-mortem report (autopsy), photographic evidence, and a death certificate which lists the manner of death (MOD) and the cause of death (COD).

Both MOD and COD are listed on a death certificate and they are not interchangeable. MOD is a way to categorize all deaths into general categories; the options are: natural, accidental, suicide, homicide and undetermined. For some cases, MOD is temporarily listed as “Pending” while evidence is collected. COD is a more specific way to describe the injury that caused death, and in the case of drug overdose, they often list the drugs which were present in the toxicology results.

3.2 Data Collection & Case Selection

These data were collected at the OCME in Farmington, Connecticut. The January 1st, 2017 to December 31st, 2017 data were collected by Natalee Desotell and Dr. Lauretta Grau in 2018 and 2019, while earlier data were collected either by Dr. Lauretta Grau or individuals under her supervision.

There are several salient differences between our gathered data and those released by the Connecticut Department of Health (DPH) and available online. The latter report accidental death data only and begin in 2012 (CT Open Data, 2019). Our data includes both accidental and undetermined deaths (70 additional cases) and thereby provides a possible upper and lower bound to the actual number of OI deaths (Grau, personal communication).

Cases with a MOD of either undetermined or accidental were kept in the dataset. Of these accidental and undetermined cases, we selected all which were likely to be OI based on review of the COD.

All available toxicology reports were reviewed for the presence of opioids and other substances, including only those with quantifiable results (i.e., we do not include screening data unless the ME chose to use those data in identifying the COD). There is no toxicological test specific for heroin, and the presence of this opioid was based upon either the presence of 6-monoacetylmorphine (a heroin metabolite) or medical examiner’s determination of the COD.
For rare cases with no toxicology report (55 cases, 1.2%) or post-mortem report (35 cases, <1.0%), we relied on the COD as diagnosed by the medical examiner to confirm that an opioid was involved. A common reason for the absence of a toxicology report was when the deceased had been hospitalized, no biological samples were available from the time of admission, and an extended period of time then elapsed between time of injury and death. Occasionally, no post-mortem report was performed for religious reasons. In such cases, we deferred to the medical examiners’ decisions concerning the COD when they based it upon hospital screening tests, history at admission, and their clinical expertise. In all, no more than 5% of any variable had missing or unknown data.

Most cases had three associated addresses (residence, injury, and death). A “best” address of the three was selected for purposes of geospatial analysis. The injury location was used when available (4329, 95.2%). If injury was not available, the residence address was used (194, 4.2%). As a last resort, the death location (often a hospital) was used (24, 0.5%). The rationale for using the death address as a last resort was that, although it is likely within driving distance of the injury site, the location where a person was pronounced dead may have no bearing on where they used drugs.

For the purpose of this study, we classified race/ethnicity as white, non-Hispanic (W-NH); black, non-Hispanic (B-NH); white, Hispanic (W-H); and other/unknown (O-U). The other/unknown category was made up of victims whose race was unknown or who was part of a racial/ethnic group which had under 25 total cases.

Each of our cases was categorized into one of four categories: “fentanyl only”, “heroin only”, “pharmaceutical only”, or “combination”. A case was regarded as “fentanyl only” if toxicology indicated the presence of fentanyl or a fentanyl analogue, but no heroin or pharmaceuticals. “Heroin only” cases included heroin metabolites, but no pharmaceuticals or fentanyl. A case was considered “pharmaceutical only” if pharmaceutical drugs alone were detected. In a case when any combination of heroin, fentanyl, and pharmaceuticals was indicated, the case was considered a combination.
Total OCME cases and accidental and undetermined totals were collected from OCME Calendar Year Statistics (OCME, 2018), available publicly online; *From 2009 to 2016, some selection was performed by the OCME Information Technology Analyst by querying specific terms, including 6-monoacetylmorphine, heroin, oxycodone and words such as toxicity, poisoning, and overdose. From that comprehensive list, cases which did not involve opioids or were ruled to be the result of a motor vehicle accident or fall were eliminated. For 2017, we were given the full list of all deaths and performed all case selection. We believe the possibility of bias is minimal because of the over-inclusiveness of the queries in the earlier years.; †Cases were omitted if the injury address was outside Connecticut (n = 21). For unknown injury addresses, injury was assumed to be within Connecticut if the residential location was in Connecticut.

The final sample of 4,547 cases included all accidental and undetermined OI deaths between January 1, 2009 and December 31, 2017. All data for the final sample were verified against the source documents which included the final death certificate, external exam section of the post-mortem report, a case narrative consisting of the report and investigation completed when the case was initially reported to the OCME, photographs, and toxicological test reports.
3.3 Analysis

A space-time cube and emerging hot spot analysis was applied to the data in ArcGIS to evaluate the spatiotemporal trends. A space-time cube is a data structure that divides space into equal sections which can be visualized as a 3D cube. The x-y direction of the cube represents physical space, and that geographic area is then separated into equally sized “bins”. The z (or vertical height) direction of the cube represents time. Time is also separated into equally sized “bins”, such as weeks, months, or years (Kang et al, 2018). After applying an emerging hot spot analysis to the space-time cube data structure, it’s possible to visualize how trends vary across both space and time.

Specific incidence rates were computed by sex, age, and race/ethnicity by dividing the raw total of OI deaths by the total population at risk (CT DPH, 2019).

Descriptive figures were created in RStudio version 1.0.143, and spatial visualizations were created in ArcGIS version 10.4.1 with a little assistance from Adobe Illustrator. Location data were geocoded using Texas A&M University’s batch geocoder, which returned a match score representing the confidence in the result (TAMU GeoServices, 2019). For all match scores below 95 (under 10% of all addresses, typically due to a misspelling), a coordinate search was performed using Google Maps.

4. Results

Between 2009 and 2017, 4,547 OI deaths occurred in Connecticut. Of those, 55% occurred between 2015 and 2017 as the epidemic has accelerated (Figure 2).
Figure 2. Bi-weekly Incidence and Cumulative Incidence of All Opioid-Involved Deaths.

Table 1. Demographics and Characteristics, Opioid-Involved Fatalities Per 100,000 Population, Connecticut, 2009-2017 (N = 4547).

<table>
<thead>
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<th>2009</th>
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<th>Rate</th>
<th>2011</th>
<th>Rate</th>
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<th>Rate</th>
<th>2016</th>
<th>Rate</th>
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<th>Rate</th>
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<td>7.2</td>
<td>268 (100.0)</td>
<td>7.5</td>
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<td>178 (26.3)</td>
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<td>White, Non-Hispanic</td>
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<td>233 (26.6)</td>
<td>52.7</td>
<td>264 (27.5)</td>
<td>59.4</td>
</tr>
<tr>
<td>35-44</td>
<td>81 (30.2)</td>
<td>16.6</td>
<td>71 (28.3)</td>
<td>14.9</td>
<td>85 (31.6)</td>
<td>12.4</td>
<td>60 (20.1)</td>
<td>13.1</td>
<td>91 (22.1)</td>
<td>21.2</td>
<td>140 (27.3)</td>
<td>31.9</td>
<td>146 (21.6)</td>
<td>33.9</td>
<td>200 (22.7)</td>
<td>47.3</td>
<td>239 (24.9)</td>
<td>56.5</td>
</tr>
<tr>
<td>45-54</td>
<td>64 (23.9)</td>
<td>11.5</td>
<td>91 (35.8)</td>
<td>15.8</td>
<td>62 (23.9)</td>
<td>11.2</td>
<td>87 (28.9)</td>
<td>15.4</td>
<td>113 (26.3)</td>
<td>28.3</td>
<td>196 (26.7)</td>
<td>24.9</td>
<td>173 (25.6)</td>
<td>32.2</td>
<td>225 (25.5)</td>
<td>42.9</td>
<td>213 (22.2)</td>
<td>41.6</td>
</tr>
<tr>
<td>55-64</td>
<td>30 (11.2)</td>
<td>7.2</td>
<td>20 (7.9)</td>
<td>4.5</td>
<td>30 (11.2)</td>
<td>6.5</td>
<td>30 (10.0)</td>
<td>6.4</td>
<td>62 (14.5)</td>
<td>13.9</td>
<td>52 (10.2)</td>
<td>10.7</td>
<td>110 (16.2)</td>
<td>22.1</td>
<td>144 (16.3)</td>
<td>28.5</td>
<td>148 (15.4)</td>
<td>29.0</td>
</tr>
<tr>
<td>65+</td>
<td>2 (0.7)</td>
<td>0.4</td>
<td>0 (0.0)</td>
<td>-</td>
<td>1 (0.4)</td>
<td>0.2</td>
<td>9 (2.7)</td>
<td>1.5</td>
<td>5 (1.2)</td>
<td>0.9</td>
<td>14 (2.7)</td>
<td>2.5</td>
<td>21 (3.1)</td>
<td>3.7</td>
<td>16 (1.8)</td>
<td>2.4</td>
<td>17 (1.8)</td>
<td>2.8</td>
</tr>
</tbody>
</table>

* Percentages may not sum to 100 due to rounding or missing values
/ Rate per 100,000 population based on state estimates of age, sex, and race distribution produced annually by the National Center for Health Statistics (NCHS).
4.1 Age Distribution

Across all years, the most represented age group was 25 to 44, which made up nearly half of all victims at 49.4% (Table 1).

While the OI deaths in the 15-24 age group remained relatively stable across the study period, ages 25 and older made up the bulk of the increase in OI fatalities (Figure 3). The 55+ age group saw the largest increase in death rate from 2009 to 2017; fatalities aged 55-64 increased by about 4 times, while fatalities aged 65 and older increased by 7 times.

Figure 3. Opioid-Involved Deaths by Age Group.

All age groups aged 15 and up demonstrated a rise in fentanyl-involved (FI) overdoses, with the initial increase beginning around 2013 and sharply accelerating for ages 25 to 44 in 2015 (Figure 4). Since the onset of the fentanyl crisis in 2013 to 2017, ages 44 and under experienced the largest death rate increase. The death rate for the 34 and under age group increased by over 3 times, while the death rate for the 35-44 age group increased by about 2.3 times.
The mean and median age at death consistently hover around age 40, with a standard deviation between 11 and 13. The first two modes for each year provide some insight into the bimodal nature of the age data.

Table 2: Measures of Central Tendency for Age at Death.

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean (SD)</th>
<th>Median</th>
<th>1st Mode</th>
<th>2nd Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>39.7 (11.3)</td>
<td>40.0</td>
<td>42.0</td>
<td>29.0</td>
</tr>
<tr>
<td>2010</td>
<td>40.9 (11.0)</td>
<td>43.0</td>
<td>44.0</td>
<td>46.0</td>
</tr>
<tr>
<td>2011</td>
<td>38.6 (12.1)</td>
<td>38.0</td>
<td>29.0</td>
<td>28.0</td>
</tr>
<tr>
<td>2012</td>
<td>40.0 (12.7)</td>
<td>40.0</td>
<td>29.0</td>
<td>31.0</td>
</tr>
<tr>
<td>2013</td>
<td>40.8 (12.4)</td>
<td>42.0</td>
<td>44.0</td>
<td>26.0</td>
</tr>
<tr>
<td>2014</td>
<td>41.0 (11.9)</td>
<td>41.0</td>
<td>44.0</td>
<td>35.0</td>
</tr>
<tr>
<td>2015</td>
<td>42.0 (12.9)</td>
<td>42.0</td>
<td>55.0</td>
<td>28.0</td>
</tr>
<tr>
<td>2016</td>
<td>41.7 (12.2)</td>
<td>42.0</td>
<td>33.0</td>
<td>31.0</td>
</tr>
<tr>
<td>2017</td>
<td>41.2 (12.2)</td>
<td>39.5</td>
<td>33.0</td>
<td>31.0</td>
</tr>
<tr>
<td>All</td>
<td>41.0 (12.2)</td>
<td>41.0</td>
<td>29.0</td>
<td>44.0</td>
</tr>
</tbody>
</table>

Fatal overdose data for age at death in Connecticut is not normally distributed. Instead, it’s necessary to view a frequency distribution to understand the true nature of the age data. A frequency distribution reveals that for all OI deaths, each year exhibits a bimodal age distribution with one peak around age 25 and another peak near age 45 (Figure 5). This is consistent with previous findings that from 2012 to 2016, EMS naloxone administrations and opioid overdose deaths had a bimodal age distribution at the national level (Cash et al., 2018). The major mode oscillates between the older and younger age groups; the older age group has the major mode in 2009, 2010, 2013, and 2014, while the younger age group has the major mode in 2011 and 2017. For other years, the modes appear near equal.
Among FI cases, the bimodal distribution is apparent for several years in the study period, including 2009, 2010, and 2012, for which the major mode is the older age group. There is no apparent bimodality to 2013 or 2014. It is important to note that the total number of FI fatalities was quite small (n < 100) until 2015. The 2015-2017 bimodal distributions are subtle, but it appears the major mode is concentrated near the younger years for each of these final years, indicating that the fentanyl crisis is primarily among the young. This is consistent with previous findings (Clinton et al., 2019).
4.2 Race & Ethnicity Distribution

Across all years, white, non-Hispanic (W-NH) individuals made up 82.1% of all victims. In 2009, the rate of OI deaths among the W-NH population (8.8 per 100,000) was about 2.3 times that of the black, non-Hispanic (B-NH) population (3.8 per 100,000) and 1.5 times that of the Hispanic, White (H-W) population (5.7 per 100,000).

In 2017, the rate of OI deaths among the W-NH population (29.9 per 100,000) was about 1.6 times the B-NH population (18.7 per 100,000) and 1.4 times that of the H-W population (21.6 per 100,000) in 2017.
When compared to other race groups and adjusted for population size, W-NH individuals have consistently made up the majority of OI deaths across the study period. However, people of color do make up a sizable proportion of the epidemic. OI deaths among B-NH and among H-W individuals have increased in recent years, particularly since 2014. While W-NH deaths increased 212% between 2013 and 2017, B-NH deaths increased by 267%, H-W deaths increased by 227%, and deaths among Other/Unknown races increased by 425%. Thus, the OI fatality crisis is accelerating at a faster rate among people of color.

Similarly, although W-NH individuals remain the most represented race among FI deaths from 2009 to 2017 (both by raw total and when adjusted for population size), mortality among people of color is also considerable (Figure 8).

Figure 7. Opioid-Involved Deaths by Race.

Figure 8. Fentanyl-Involved Deaths by Race.
4.3 Sex Distribution

Among all OI fatalities in CT, males have consistently been over-represented when compared to females, particularly after adjusting for CT’s population which has been approximately 5% more female across all study years (CT DPH, 2019).

Across all study years, most victims were male (72.8%). The rate of OI deaths in males in 2009 (10.8 per 100,000) was about 2.3 times that of females (4.6 per 100,000) in 2009, but it was about 3.3 times that of females in 2017. While OI fatalities increased among females by 274% from 2009 to 2017, OI fatalities increased among males by 385% in the same time period. These findings indicate that the crisis is becoming more male over time.

Figure 9. Opioid-Involved Deaths by Sex.

Figure 10. Fentanyl-Involved Deaths by Sex.
Among FI fatalities, males have also been more highly represented. In 2017, males had approximately 4 times the incidence of females (30.3 versus 7.5 per 100,000), indicating the fentanyl problem is more male than the overall opioid crisis.

4.4 Opioid Categories

Overall, across all years, most OI fatalities involved illicit opioids (3417, 75.1%) compared to deaths that were caused by pharmaceutical opioids only (1067, 23.5%). The rate of fatalities due to pharmaceuticals only has remained relatively steadily over time while fentanyl-only deaths have increased sharply. Deaths involving a combination of opioid types have increased over this time period while heroin-only deaths have decreased since 2015 (Figure 11). These findings are consistent with the CDC’s description of the three waves of the epidemic, including the increase in heroin deaths after the reformulation of Oxycontin.

![Figure 11. Evolution of Opioid Types Represented in Opioid-Involved Deaths.](image)

When comparing 2009 to 2017, pharmaceutical only deaths have increased by 1.13 times and heroin only deaths have increased by 1.25 times. In contrast, fentanyl only deaths have increased by 40 times and combination deaths have increased by 6.3 times. In other words, 2017 looked a lot like 2009 with regard to heroin and pharmaceutical only fatalities, but with the addition of a significant number of combination and fentanyl only deaths.
In light of the recent increase in illicit fentanyl (Rudd et al. 2016), we sought to clarify whether the possibility of detection bias could have occurred over the period in question. According to the Chief Medical Examiner, fentanyl is routinely tested for and does not depend on positivity of an opioid screen. There has been no change in toxicology test procedures since 2009 that would explain the increase in detected FI deaths (Gill, 2019). However, many, but not all, fentanyl analogues are detected and may vary over time as new tests for these compounds are developed.

4.5 Spatial Patterns

By raw total and across all years, the areas along the I-95 and I-91 corridors have been most heavily impacted by the opioid crisis. It seems that many of the most-impacted areas had opioid deaths in the earlier years of analysis and that the issue has intensified in these areas while spreading to new areas. For example, the Torrington and Norwich areas had two or more deaths per year in the earlier years represented, but have progressed to having 24 or more in recent years.

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Table 3. Opioid-Involved Fatalities Per 100,000 Population by Opioid Type, Connecticut, 2009-2017 (N = 4547).

<table>
<thead>
<tr>
<th>Opioid Type</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total, n (%)</td>
<td>Rate</td>
<td>Total, n (%)</td>
<td>Rate</td>
<td>Total, n (%)</td>
<td>Rate</td>
<td>Total, n (%)</td>
<td>Rate</td>
<td>Total, n (%)</td>
</tr>
<tr>
<td>Combination</td>
<td>65 (24.3)</td>
<td>1.9</td>
<td>89 (19.3)</td>
<td>1.4</td>
<td>34 (12.7)</td>
<td>1.9</td>
<td>27 (8.1)</td>
<td>0.8</td>
<td>64 (14.9)</td>
</tr>
<tr>
<td>Heroin Only</td>
<td>80 (32.1)</td>
<td>2.4</td>
<td>78 (30.7)</td>
<td>2.2</td>
<td>114 (42.5)</td>
<td>3.2</td>
<td>159 (57.4)</td>
<td>4.4</td>
<td>221 (51.5)</td>
</tr>
<tr>
<td>Pharmaceutical Only</td>
<td>106 (40.3)</td>
<td>3.1</td>
<td>114 (44.9)</td>
<td>3.2</td>
<td>106 (39.6)</td>
<td>3.9</td>
<td>95 (31.9)</td>
<td>2.7</td>
<td>118 (27.5)</td>
</tr>
<tr>
<td>Fentanyl Only</td>
<td>8 (3.0)</td>
<td>0.2</td>
<td>10 (3.9)</td>
<td>0.3</td>
<td>9 (3.4)</td>
<td>0.3</td>
<td>19 (6.4)</td>
<td>0.3</td>
<td>19 (4.4)</td>
</tr>
</tbody>
</table>

* Percentages may not sum to 100 due to rounding or missing values

Rate per 100,000 population based on state estimates of age, sex, and race distribution produced annually by the National Center for Health Statistics (NCHS).
Across all years when adjusted for population size, there are very few areas which have been left unscathed by the crisis (Figure 13). Interestingly, there are pockets of low incidence surrounding the high-incidence areas of Canaan and Torrington. Overall, although the crisis is often characterized as a rural issue, fatalities are still concentrated in urban areas even when accounting for their considerable populations.
Figure 13. All Opioid Fatalities for All Years by ZIP Code Tabulation Area (ZCTA) by 100,000 Population. Raw totals were normalized by population size using 2010 US Census totals.
Figure 14. Space-Time Cube and Emerging Hot Spot Analysis of All Opioid-Involved Mortality. Consecutive Hot Spot: A single, uninterrupted run of hot time step intervals comprised of < 90% of all intervals; New Hot Spot: The most recent time step interval is hot for the first time; Not Emerging: No Trend; Oscillating Hot Spot: Some of the time step intervals are hot, some are cold; Sporadic Hot Spot: Some of the time step intervals are hot.

The space-time cube for all OI mortality used spatial bins that were 1,582 square meters and temporal bins of 6 months each (both calculated by default in ArcGIS), for a total of 18 time step intervals (bins). The space-time cube uses the Mann-Kendall test, a non-parametric method used to detect a trend in a series of values. Overall, there is a statistically significant increase in point counts over time for CT, and the trend direction is increasing with a Mann-Kendall trend statistic of 4.92 (p-value <0.0001).

Consecutive hot spots cover the areas of Hartford, Waterbury, Norwich, and New London, which means that those locations have seen an uninterrupted series of statistically significant hot spot bins in the final time-step intervals but none of them had been statistically significant hot spots prior to the start of the consecutive run. This designation is reserved for bins where under 90% of all bins are statistically significant hot spots.
New Haven and Bridgeport are Sporadic Hot Spots, which means they have been statistically significant hot spots under 90% of the study period, but they have never been statistically significant cold spots (ArcGIS, 2018).

The space-time cube for FI fatalities used larger spatial bins (1,928 square meters), also calculated by default in ArcGIS. The time step interval remained 6 months each for a total of 18 time step intervals. For FI fatalities, there is a statistically significant increase in point counts over time and the overall trend direction is increasing with a Mann-Kendall trend statistic of 4.52 (p-value <0.0001).

Areas around Waterbury, Norwich, and New London are designated as consecutive hot spots, while Hartford, New Haven, and Bridgeport are oscillating hot spots. Oscillating hot spots are areas that are statistically significant hot spots for the final time-step interval but was historically a statistically significant cold spot during an earlier time step (ArcGIS, 2018).
5. Discussion

5.1 Increase in Fentanyl-Involved Deaths

Up until 2013, the number of cases involving fentanyl was relatively low and fairly stable over time with no more than 15 cases per year from 2009 to 2012. Beginning in 2013, we saw a sharp increase in the proportion of fentanyl-involved fatalities. Since then, the crisis has become more fentanyl-driven. The rate of fentanyl-involved deaths increased from 1.0 to 18.6 per 100,000 population from 2013 to 2017. Among only fentanyl-involved deaths, victims were predominantly male (79.1%) with over half of all victims aged between 25 and 44.

5.2 Implications

The Trump Administration has secured $6 billion in funding to fight the opioid epidemic as of late 2018, with efforts focused on securing borders against smuggling and improving prescribing practices (White House, 2018).

Efforts to reduce fentanyl overdose deaths specifically, including expanding access to testing strips and improving information dissemination regarding deadly batches, are needed to address the sharply rising number of fentanyl-involved deaths. In particular, males of all races under the age of 44 ought to be targeted by these interventions. Additionally, deploying EMS, increasing access to naloxone, and facilitating entry into medication-assisted treatment (MAT) programs in areas where fentanyl deaths are consistent or increasing, such as Norwich and New London, could go a long way to preventing future overdose deaths.

Further, more attention ought to be paid to communities of color, where the rate of overdose deaths are outpacing those in white, non-Hispanic communities.

5.3 Limitations

This study is subject to several limitations. First, the choropleth maps tracking annual changes by ZCTA are normalized by 2010 population data, the only data which were available for the ZCTA enumeration unit. This prevents the maps from accurately reflecting population changes during the study period. Second, because analysis is confined to a single state, external validity is limited. However, the results reveal insights that may be useful to Connecticut-specific fatal overdose prevention initiatives. Third, although the CT OCME is a rich data source for fatalities in Connecticut, all information is limited to what is contained in the medical examiner’s reports. Occasionally, these are incomplete. Third, because there is no toxicological test which can
distinguish between all pharmaceutical forms of fentanyl and morphine and all illicit forms of fentanyl and morphine, we assumed that all toxicology reports with measured values of fentanyl or morphine were illicit. Lastly, because our analysis did not include nonfatal overdoses, we underestimate the overall burden of overdose in Connecticut.

6. Conclusion

The epidemiology of fatal opioid overdose in CT exhibits distinct spatial, demographic, and temporal patterns. The recent increase in OI deaths can be attributed to fentanyl and fentanyl analogues, a finding which corresponds to the growing supply and use of illicitly manufactured fentanyl in the United States. Although much of the crisis has impacted white, non-Hispanic people, the burden on black, non-Hispanic and Hispanic, White populations continues to grow and outpace that of the white, non-Hispanic population. Additionally, fatalities among males are outpacing fatalities among females. Thus, future interventions ought to focus on preventing overdose death among males.
References


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19. Grau, Lauretta E (personal communication, April 12, 2019)
36. Understanding the Epidemic | Drug Overdose | CDC Injury