



PUBLIC HEALTH PRACTICE

Web Application to Investigate Butler County Overdose Death Data

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ABSTRACT

Background: Drug overdose deaths, specifically opioid-related deaths, are a public health crisis in the United States with high incidence observed in many Midwestern states, including Ohio. Butler County, Ohio, has the third highest opioid-related death rate in the state. Information on overdose deaths, collected by the county coroner, can serve as a data source for analysis of this public health concern. Given this access, stakeholders can investigate trends in their community for their idiosyncratic interest.

Methods: A web application was developed, using the R Shiny package, to visualize and explore the characteristics of all overdose deaths in Butler County between 2013 and 2018. Demographics of the decedents, drugs found in the decedents' postmortem toxicology analyses, annual trends in overdose deaths, and the location of these cases can be examined.

Results: The web application provides a graphical user interface that allows a user to request specific analyses and summaries. "Who is dying from opioid overdoses?," "What drugs, including opioids, are found in people dying from drug overdoses?," and "Has the number of opioid involved deaths increased in a specific community over time?" are examples of questions that can be explored using this application.

Conclusion: This application empowers both the public and local policymakers to investigate the impact of overdose deaths on their communities. Understanding characteristics of the epidemic is an important first step to addressing this problem. The expansion of this application to include other counties in Ohio could be truly beneficial to communities that need it.

Keywords: Epidemic; Ohio; Opioid; Overdose death; R Shiny application

INTRODUCTION

In the United States, more than 46 000 people died from an opioid-involved overdose, including prescription and illicit opioids, in 2018.¹ Opioids include heroin, fentanyl, and prescription drugs such as oxycodone.¹ To put that number into perspective, roughly 36 000 people died of a fatal motor vehicle crash that same year.² Ohio had the fourth highest rate of opioid-related drug overdose deaths in the United States in 2018; 29.6 deaths per 100 000 people in Ohio versus 14.6 deaths per 100 000 people in the United States.³ Ohio also had the fifth highest rate of drug overdose deaths in general in 2018 in the United States; 35.9 deaths per 100 000 people in Ohio versus 20.7 deaths per 100 000 people in the United States.⁴ Butler County, Ohio, has the second highest overdose death rate in the state with 43 deaths per 100 000 people.⁵

A web application displaying various interactive data visualizations regarding overdose deaths was created to spread awareness of the issue and to educate the community of Butler County. Stakeholder access to these data and to summaries of these data can be provided on the internet. Given this access, stakeholders can investigate patterns in trends in their community and for their idiosyncratic interest. This article describes that web application with hopes of empowering the public to use it to query and explore a critical public health issue in their community.

The interactive application provides an accessible way to see and understand trends, outliers, and patterns in the Butler County overdose death data through various views. Users can explore the demographics (gender/sex, race/ethnicity, and age) of the decedents and specific drugs (eg, heroin, fentanyl, carfentanil) detected by postmortem toxicology analyses. For the purposes of this appli-



cation, gender was used synonymously with sex. Likewise, race was also used synonymously with ethnicity in this application. Users can also analyze annual trends of categories of drugs (eg, opioids, fentanyl analogs, stimulants) found in decedents. The application also provides insight on location information including a map of Butler County displaying the locations of each overdose incident, annual trends of overdose incidents by city/township, and the types of places the overdose incidents and deaths occurred (eg, home, motel).

The goal of the application is to provide a framework to answer basic questions about the opioid epidemic at a local level. Questions such as “Who is dying from opioid overdoses?,” “What drugs, including opioids, are found in people dying from drug overdoses?,” and “Has the number of opioid involved deaths increased in a certain community over time?” are examples of questions that can be explored. This article delves into the process of using such an application to answer these kinds of questions.

METHODS

Data Source

Overdose mortality data was collected by the Butler County Coroner’s Office. According to the Ohio Revised Code Title III Chapter 313, all records in the coroner’s office that are public records are open to inspection by the public, and any person may receive a copy of any such record or part of it upon demand in writing.⁶ Similar to the disclaimer on the Ohio Department of Health (ODH) website,⁷ the data in this web application are to support ongoing activities such as public awareness, surveillance, investigation, assessment, and evaluation. The developers of this application specifically disclaim responsibility for any analyses, interpretations, or conclusions.

Setting

Butler County is in the southwest corner of Ohio, with Indiana on its western border. The major cities in the county include Middletown and Hamilton. According to the United States Census Bureau, almost a third of the population of Butler County residents live in either Hamilton or Middletown. The cities of Hamilton and Middletown have lower median household incomes than Butler County and the entire state of Ohio. These cities also have twice the percentage of people in poverty compared to the county and statewide percentages. The race/ethnicity compositions of the cities are similar to Butler County and Ohio, in general. The percentage of people with a bachelor’s degree or higher in Hamilton and Middletown is lower than the county and state percentages. Supplemental Material Table 1 provides a more detailed comparison of the demographics of Middletown, Hamilton, Butler County, and Ohio.⁸

The coroner’s office investigates when any person dies as a result of criminal or other violent means such as by casualty, by suicide, or in any suspicious or unusual manner.⁹ This includes all suspect-

ed overdose deaths that occur in the county. Deaths investigated by the coroner’s office that had drug toxicity listed as a cause of death and manner was ruled accidental were identified as overdose deaths and used in this analysis. The term “toxicity” is used consistently by this coroner to identify cause of death in these cases. The Ohio Department of Health (ODH) would classify the cause of death as “poisoning” and apply an International Classification of Diseases (ICD) diagnosis code, ICD-10. Suicide and undetermined manners of death were not included in these data. Data used in this application were provided by the coroner’s office and already classified as overdose deaths according to the criteria defined above. These data contain information on opioid and nonopioid drugs detected in postmortem toxicology analyses. Data from 2013 to 2018 were included in the application.

Procedures and Program Description

The application was developed to allow the exploration of drug overdose death data in Butler County by community members and decision makers. The application, using the Shiny package¹⁰ in the R¹¹ software system, was developed in the RStudio IDE.¹² The RStudio IDE, R software, and the packages utilized for data cleaning and visualization are free open source technologies.¹⁰⁻¹² The Shiny server (dataviz.miamioh.edu) hosting this application uses a paid license on a virtual server that is provided by the Department of Statistics at Miami University. This Shiny server also hosts other applications that can be accessed through a main gallery page. Google Analytics was installed on the main gallery page; however, these were not installed on the individual application. If the process were restarted, it would include analytics to track the demand of this application. In addition to the obvious benefit of cost, an advantage to open source software is the abundance of online tutorials.¹³⁻¹⁷ Links to a few online tutorials for the software used in the creation of this application are provided in the Supplemental Material. Also included in the Supplemental Material is a flow diagram to clarify the procedure to create the application.

The application originated as a client project for the coroner in a data visualization course. Later, one student continued to enhance this web application and launched the application on a Shiny server hosted at Miami University on April 25, 2018. Finally, the application was enhanced, updated, and relaunched on May 1, 2019.

To illustrate the features and controls of this application, we demonstrate how questions such as “Who is dying from opioid overdoses?,” “What drugs, including opioids, are found in people dying from drug overdoses?,” and “Has the number of opioid involved deaths increased in a specific community over time?” would be addressed by a user of this application.

Measures and Outcomes

Demographic data available in the database included date of birth, date of death, age, gender/sex, and race/ethnicity. Location information, such as place (eg, home, motel), city/township, and ad-



dress of an overdose incident, as well as the place, city/township, and address of the actual death were provided. Postmortem analysis of blood and urine were performed to determine drugs present in the decedent at the time of death. Data from 2013 to 2018 included up to 3 or 4 drugs detected in each decedent. For deaths occurring between June 2016 and August 2018, information was also collected on fentanyl analogs, a new and potentially more dangerous category of opioids.

Statistical Analysis

Bar graphs and segmented bar graphs were used to represent the number of times a specific drug was traced in a decedent. As more than 1 drug could be detected during testing, decedents could be counted in multiple bars within the ‘number of times drug traced’ graph. Bar graphs were also used to represent the number of overdose deaths in a specific city and a specific place, such as a home or motel. Line graphs were used to visualize the number of drugs or categories of drugs traced over time, along with the frequency of overdose deaths in cities and townships. Maps were used to illustrate the specific locations of overdose deaths.

RESULTS

The web application can be accessed at dataviz.miamioh.edu/Butler_County_Overdose_Deaths/. The landing page describes the

contributors to the application and the years of data included in the application.

The left sidebar contains 4 options. The landing page is **Home**. The **How to Use the App** tab provides instructions to use and explore the application with notes of a few details specific to these data. The **Drugs Found in Overdose Decedent** tab is a drop-down menu with 3 options, **Demographics**, **Annual Trends**, and **Annual Category Trends**.

By selecting the **Demographics** tab, the application displays a bar graph of the most frequent number of times a drug was traced in a decedent. **Figure 1** shows a screenshot of this bar graph. The 3 boxes above the segmented bar graph are used to specify gender/sex, age, and race/ethnicity of the decedent to be displayed.

Figure 1 can be used to explore the demographics of who is dying (restricted here to ages 31-60 years and white decedents) in the opioid epidemic in Butler County during 2013 through 2018 and from what drugs. Fentanyl and heroin were the 2 most common drugs traced in drug overdose deaths in this age-race group during this time. In addition, of the top 12 drugs traced in decedents, more were traced in males than females.

The second tab, **Annual Trends**, shows a line graph that describes the patterns and trends of the number of times a drug was found

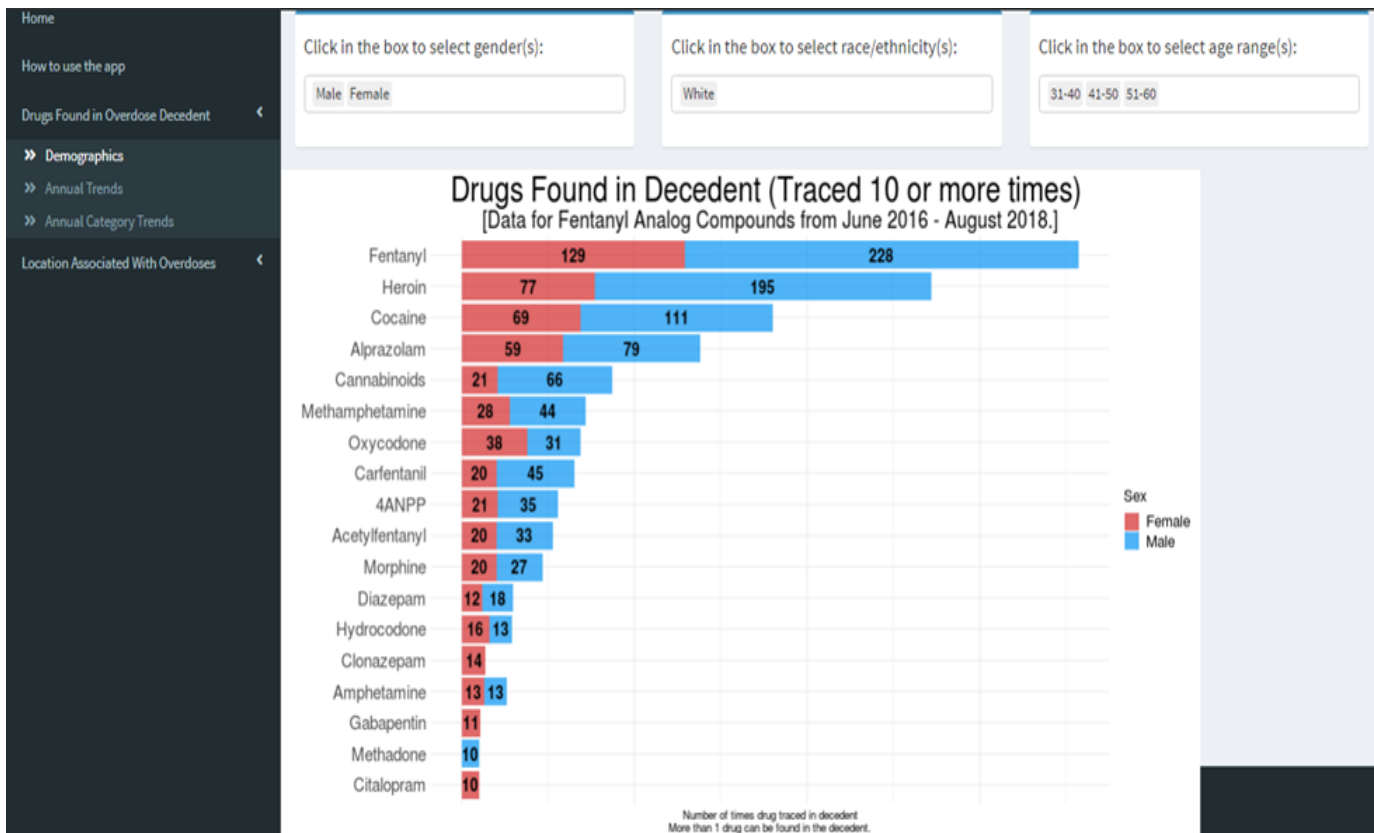


Figure 1. Segmented Bar Graph Illustrating Number of Times Drug Detected in White Male and Female Decedents Between Ages 31 and 60 years from 2013 to 2018



in a decedent over time. **Figure 2** shows a screenshot of this line graph. The selection box above the graph can be used to specify the drugs to be highlighted.

Figure 2 also displays the trends in which drugs, including opioids, are found in overdose deaths. Fentanyl and methamphetamine have increased rapidly since 2014 and remain some of the most common drugs traced in decedents. Other drugs such as heroin have had rapid declines in the number of times traced since 2015. Other drugs are displayed as light gray connected segments but will change color once the drug associated with that segment is selected.

The third tab, **Annual Category Trends**, produces a line graph that describes the number of times a drug category was found in a decedent over time. This value was calculated by utilizing the individual drug data used in Figure 2 and sums the ‘number of times drug traced’ for each drug category. This display is similar to Figure 2; however, Figure 2 displays individual drugs. Drug categories combine similar drugs into a category to provide ease and clarity on the type of drugs playing large roles in this epidemic. This line graph helps to easily identify patterns and trends in the categories of drugs in the epidemic.

The **Location Associated with Overdoses** tab is a drop-down menu with 3 options, **Address of Overdose Incidents**, **Trends by Cities Townships**, and **Location of Incident vs Death**. By selecting the **Address of Overdose Incidents** tab, the application displays a map of the address where the presumed overdose incident happened (eg, drug was used at this location) with an animation to show the addresses’ change over time.

The last tab, **Location of Incident vs Death**, contains 2 different bar graphs controlled by a drop-down menu that can be changed to view the overdose incident or death data. The location of the presumed incident is the location of overdose, which may not be the same as the location of death. The first bar graph on the left side illustrates the number of overdoses in each location of incidents/deaths within each city or township. The second bar graph illustrates the number of overdoses within each place of overdose incidents/deaths faceted by city or township selected. Examples of place of death include home, vehicle, or motel. **Figure 3** contains a screenshot of this visualization. The input boxes above the graphical displays allow for the selection of the location of the incident and the city/township where the incident occurred.

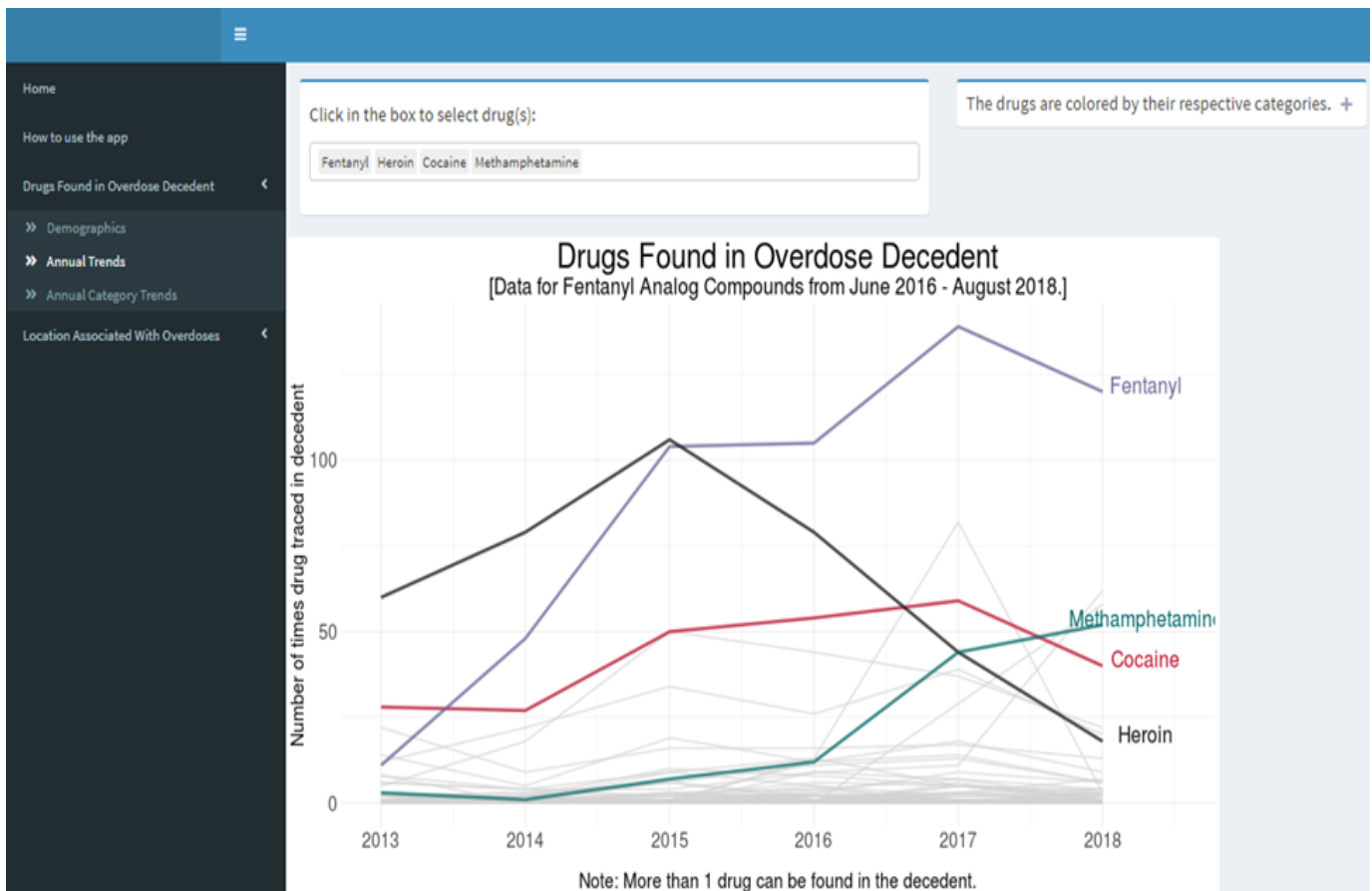


Figure 2. Line Graph Illustrating Number of Times Each Drug Found in Overdose Decedents 2013 to 2018

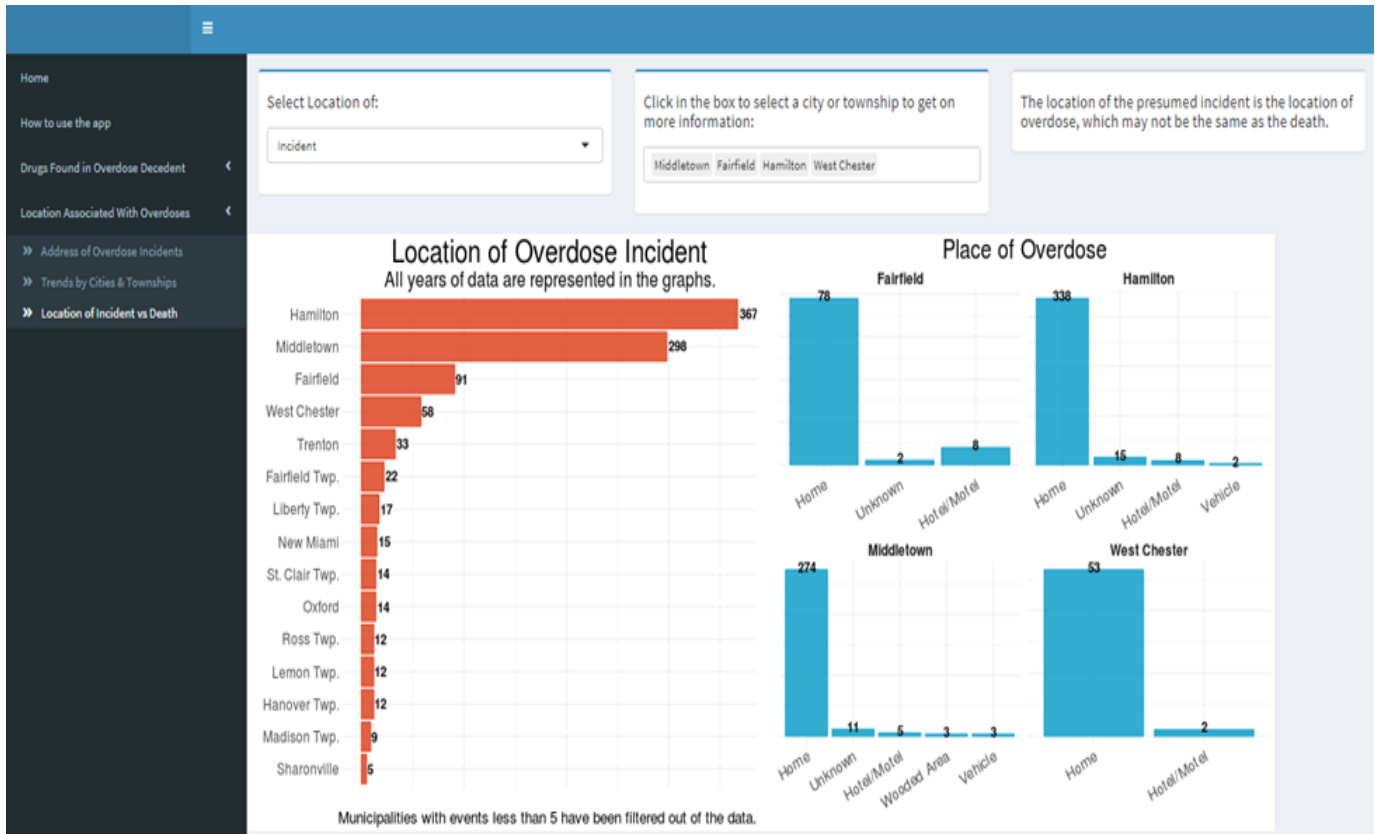


Figure 3. Bar Graph Illustrating Number of Overdoses 2013 to 2018 by Location of Incident/Death and Place of Overdoses by City/Township

Using Figure 3, we can see that most of the overdose incidents in the top 4 cities or townships—Hamilton, Middletown, Fairfield and West Chester—occurred in homes.

DISCUSSION

This application was developed with the intent of providing public access to information regarding drug overdose deaths in Butler County. More specifically, the purpose of this application was to provide the ability to look at specific drugs or drug categories over time and explore community locations of interest. For example, as stated above, drugs such as heroin have had rapid declines in the number of times detected in decedents since 2015. What could this mean? Policy changes might have contributed to this decline, but the number of times fentanyl has been traced has not decreased over time. Why is that? Also, why are more males dying from the opioid epidemic? Although we may not have answers to these questions, we realize the benefits of collaborative efforts from the public health subject matter experts and the data gathering and developing experts to gather necessary insights.

Although all drugs detected in overdose victims are presented, communities are most interested in the impact of opioid-related deaths. This information is available as public record from the coroner’s office. However, this tool allows the public to access that

information to answer specific questions. One of the challenges in developing and updating this application is the data cleaning process. The raw data from the coroner required custom data processing for use in this application. This mandates that every update to the application be manual. This would be especially challenging if this application were expanded to other counties in Ohio since there is no standard reporting format among all coroners.

The data set used in this application was provided by the coroner’s office. This data set was initially intended for internal use only, but then later developed into the public application it is now. Ideally, data can be structured and formatted for ease of use in an application and for ease of updating in an application. For example, future data sets could use ICD-10 codes. However, this would require adjusting the data set from previous years to be able to connect them.

Limitations of this data set are that it only contains reported overdose deaths in a single county and that the decedent had to have their postmortem specimens available for toxicology analysis. The data set used in this tool from the toxicology report only includes 3 to 4 substances with the largest quantities found in the decedent. It is important to note that the data set only includes over-



dose deaths while excluding nonfatal drug overdoses. In addition, the presumed location of the incident cannot always be verified if there is no evidence of drug use or eyewitness reports of the use. Another limitation is the lack of historical context. If data were available for years prior to 2013, the application would provide more historic context to these epidemic concerns. The application can be expanded as more recent data become available, although data processing and reformatting is required.

There are many ways to improve the application in the future. First, by creating a standardized data collection system both within counties and across counties, the data cleaning and preprocessing could be automated leading to a simple updating procedure of the application when new data become available. This could lead to real time displays of the data set within the application, rather than seeing data from the previous year. This could lead to different views as well such as displaying these data by months rather than over an entire year. It would also allow for offices such as the coroner to make decisions sooner when there are unusual trends observed in the data set. There is also room to enrich this application with external data, such as data regarding nonfatal drug overdoses, if data could be found at the city/township or zip code level. An additional major improvement would be expanding outside Butler County. By standardizing how every coroner collects their data, we could potentially expand to the entire state and address the epidemic directly. Also, adding to the tool when certain interventions were put in place would allow for stakeholders to directly see how policy and regulations are affecting the trends. We note that the Ohio Department of Health (ODH) provides a dashboard for “Emergency Department Visits for Suspected Drug Overdose Among Ohio Residents Ages 11 Years and Older” (odh.ohio.gov/wps/portal/gov/odh/know-our-programs/violence-injury-prevention-program/suspected-od-dashboard2). This site provides some demographic information for overdose cases encountered in emergency department visits; however, this does not capture the granularity of detail about drugs found in overdose decedents nor the detail of locations of cases in a county.

Other counties can implement similar applications such as this. The key to success when developing this application was close collaboration on a team that included the coroner, county health officials, and data scientists. Rapid prototyping of the application was needed to get feedback to improve the presentation of these data and the functioning of the application.

PUBLIC HEALTH IMPLICATIONS

The application developed and the results reported above have implications for public health practice and policymakers in Ohio. In addition to raising awareness about overdose deaths, this application allows the public to explore pertinent questions regarding this crucial matter. The policymakers in Ohio can use this information to make data driven decisions when passing new policy

and addressing issues. For example, the amount of the opioid reversing drug, naloxone (Narcan), available to first responders in a community can be increased or decreased based on the presence of opioids in that specific community. Once a community is aware of the number and type of overdoses, implemented policies or interventions may be able to reduce the number of overdose deaths over time. Knowing the place that most overdoses occur could identify areas where treatment resources could be made readily available. This application provides a way to understand the problem so subsequent actions can be taken to begin alleviating the problem.

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SUPPLEMENTAL MATERIAL

Supplemental File. Data Cleaning Files, Application Code and Creation Resources and Tutorials.

Supplemental Table 1. Demographic Characteristics of Residents in Ohio

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