2020 Data Hackathon - Final Report

HEXCEL_DROP (Team #6)

In light of the opioid crisis in Philadelphia, local organizations hosted a data science hackathon to better understand the characteristics of overdose events in the region and the impact of interventions such as Narcan administration on survival.

The 2020 event was organized by Code for Philly, DataPhilly, the Philly Data Jawn, Health Federation of Philadelphia, and Prevention Point. The 2020 presenting sponsor for the project is AT&T with additional support from CompassRed.

EXECUTIVE SUMMARY

Data obtained from Prevention Point surveys, Philadelphia Department of Public Health, and the Substance Abuse and Mental Health Services Administration (SAMHSA) are summarized. Datasets that have been cleaned (e.g., removing typos and implausible values) are provided as Excel spreadsheets with associated data dictionaries (i.e., explanations of each variable).

The following results were obtained from data voluntarily entered by Pennsylvania criminal justice agencies and some third-party (e.g., EMS) first responders. Due to the voluntary nature of data recording, the dataset may not be representative of all overdose and/or naloxone administrations involving PA criminal justice agencies and should not be used to represent incidents among all first responders.

- Naloxone/Narcan is associated with lower mortality from drug overdoses.
- Narcan is administered less often when Fentanyl is the only involved drug, although Fentanyl increases the mortality without Narcan.
- The protective effect of Narcan is greater for older OD victims.
- Counties with higher overdose tallies already have a higher probability of administering Narcan, but there is still room for improving utilization.
- Overdose rates increase during weekends and evenings; however naloxone administration percentage rates stay consistent and can slightly decrease during peak times.

CONTRIBUTORS

HEXCEL_DROP team members hail from Drexel University and the Children's Hospital of Philadelphia.

Samara Andrieux, MPH in Epidemiology is a Clinical Research Coordinator (CRC) at CHOP Main Hospital and graduated from Temple University with an MPH in epidemiology. During her graduate program she began working with statistical programs such as R studio, SPSS, Epi Info, and mapping programs such as GIS. She enjoys learning new skills and improving her current skill set.

Sybil Andrieux, MS in Epidemiology is a REDCap Administrator and Data Analyst for the Hyperinsulinism (HI) Frontier Program at CHOP. She started off her academics in biology and then into public health majoring in epidemiology. Her primary job is reviewing and assisting in the building of REDCap data collection projects as well as analyzing data for the HI team. She enjoys exploring datasets and learning new tools to use for exploratory analysis.

Carrie Gerace, MSOD started coding in BASIC at a very young age but spent the bulk of her formal education learning how to communicate. She is a database programmer with over 10 years of experience with higher ed systems and analytics and is currently employed at Delaware County Community College as their Director, Enterprise Applications.

Joey Logan is a Database Reports Specialist at CHOP and a Student at the College of Computing and Informatics in Drexel. He specializes in extraction, preprocessing, and data engineering. He also builds reporting solutions in a multitude of systems. Recently, he has developed custom reports and solutions for cloud based systems like Workday. He enjoys using Census, CDC, city, county, organizational, and state data to make a positive impact on the community.

Ou Stella Liang, MHA is a PhD student at the College of Computing and Informatics in Drexel University. Her research is primarily focused on temporal data analysis as applied to road injury prevention using machine learning and graph models. She is passionate about helping women (and pregnant women) with OUD and has been collaborating with Drexel physicians on several research initiatives. She enjoys writing words and codes.

Mitchell Maltenfort, PhD lurched into academic life as a computational neurobiologist before drifting into the less recherché field of biostatistics. He knows just enough to make a complete hash out of things and is creative enough to salvage them afterwards. In his brutish culture, this tradition is known as "larnin'" For tax purposes, he is employed as a biostatistician at CHOP, where he has generated risk scores for hospitalization, analyzed diagnostic variations among clinics, compared international trends in childhood mortality, and evaluated patient-reported outcome scores.

Grace Pham is a Data Science student from Drexel University. She is doing an internship at CHOP as a Business System Analyst, working with OnCore and REDCap teams. She enjoys learning new skills of analysing, visualizing datasets and scraping web data.

Zoë Wilkinson Saldaña is a data educator and librarian. As part of the Arcus Data Education team, Zoë designs and leads workshops for researchers and clinicians throughout CHOP. Previously she worked as the Social Science and Geospatial Data Librarian at Cornell University. She is especially interested in supporting learners and newcomers to data science and encouraging critical data science practices. Outside of data, she plays in two pinball leagues and enjoys learning more about Philadelphia communities.

Chun Su, PhD is a bioinformatics scientist at CHOP and R-ladies Philly co-organizer . Her research focuses on the effect of 3-dimensional genome change on gene expression network regulation and its influence on the genetic susceptibility for childhood diseases.

Julia Schuchard, PhD is a clinical researcher at CHOP. Her current research focuses on the development and application of patient-reported outcome measures to assess health and quality of life.

PROBLEM DEFINITION AND DATASET

1. How effective is Narcan administration in preventing deaths?
2. Where is Narcan most used, and by what methods?
3. Who are the most vulnerable groups for opioid deaths?
4. What are the gaps in Narcan administration? Temporal/location
5. Who is participating in Narcan training?
6. What is the scope of opioid deaths in Pennsylvania?

SUMMARY OF RESULTS

Drug Overdoses in Pennsylvania: Who, when, and how many?

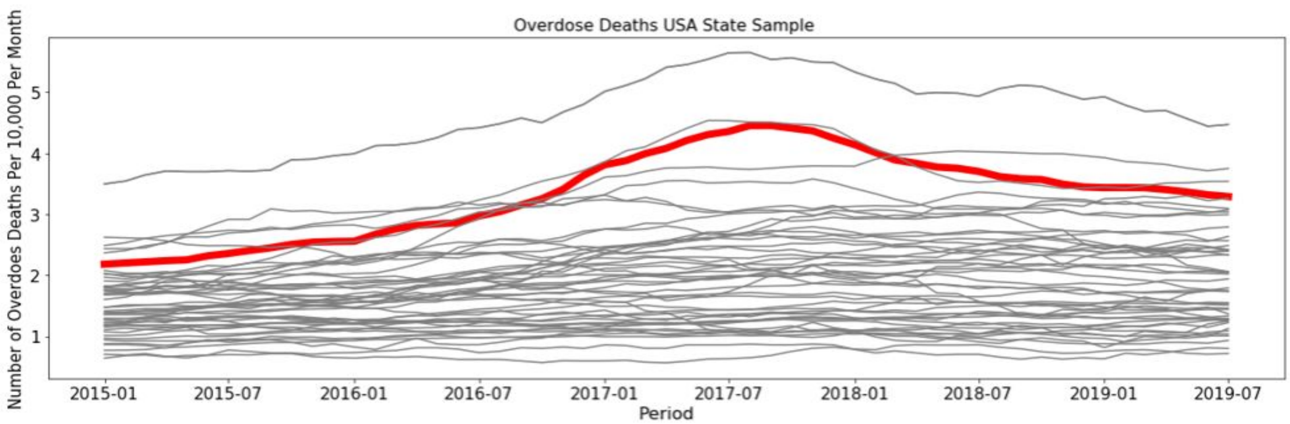
In an effort to better understand overdoses and naloxone administration, the team evaluated data from the following sources:

- CDC (national overdose rates)

- PA.gov overdose data: Data voluntarily entered by Pennsylvania criminal justice agencies and some third-party (e.g., EMS) first responders (not representative of all PA overdoses)
- Prevention Point naloxone refill participants

A broad view of overdose statistics brings to light the staggering overdose problem in Pennsylvania; in 2019, the state experienced the 5th highest rate of overdoses in the US (50 states).

Overdose Fatalities 2015-2019
(Monthly Deaths per 10,000 Population)

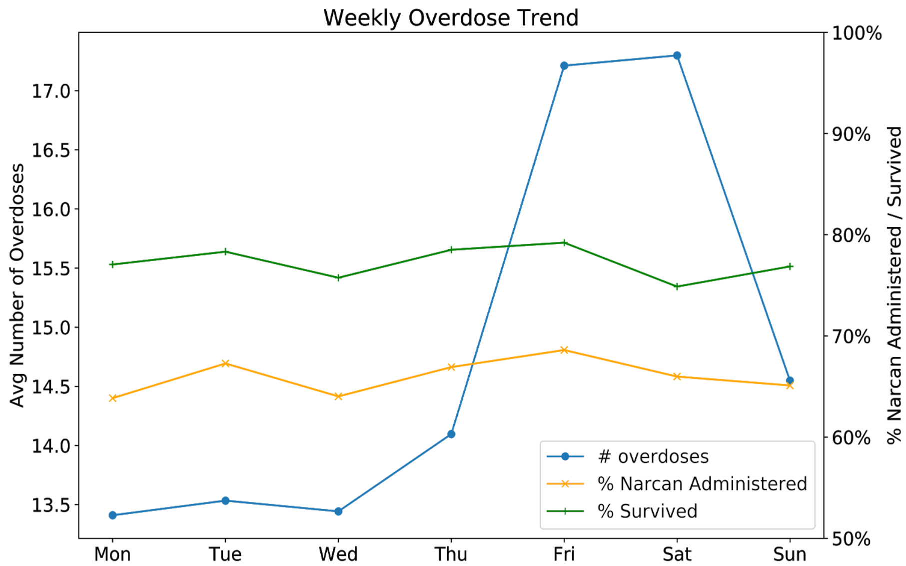


Data Source: PA.gov

When do Pennsylvania Overdoses Peak?

A temporal analysis of overdose data indicates that overdose events peak towards the end of the work week and during the evening hours. The trends are derived from two years of data from PA.gov (1/1/2018-12/31/2019).

Weekly Overdose Trends



Data Source: PA.gov

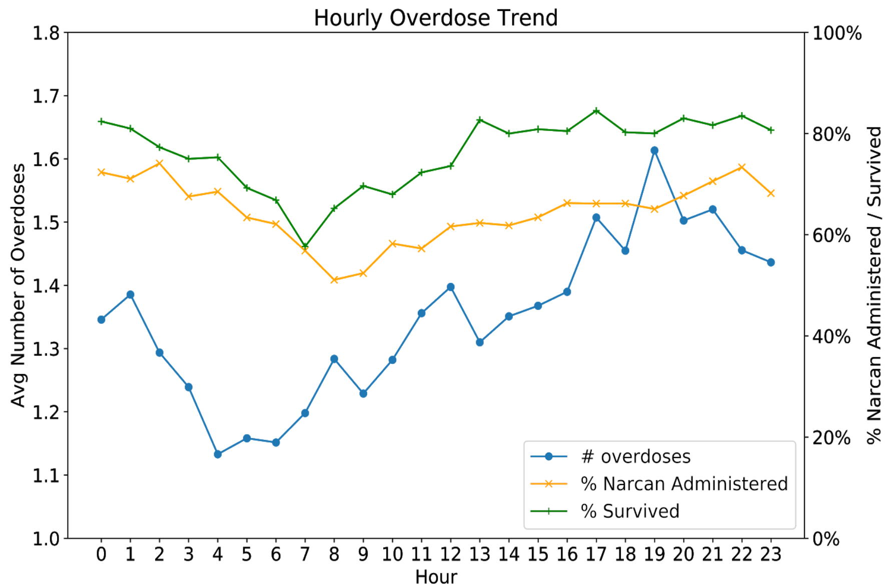
Overdose cases start to rise on Thursdays and peak on Fridays and Saturdays. In contrast to the overdose spike on weekends, Narcan administration and survival rates remain consistent.

The percentage of overdose events with Narcan administration and overdose survival percentages track consistently, indicating an association between Narcan administration and survivability. Days that have higher rates of Narcan administered also see higher survival rates, except the slight discrepancy on Sundays.

The peak overdose on Saturdays also coincides with one of the lowest Narcan administration rates and survival rates, calling for greater availability of Narcan on Saturdays due to the case loads. Wednesdays, despite relatively lower overdose cases, see another low point in Narcan administration and survival rates, suggesting possibly fewer good samaritans in the middle of the week.

Hourly Overdose Trends

Overdose cases start at the lowest around 4am and gradually climb up to 7pm to reach the peak. Between 5pm and midnight see the most overdose cases. Consistent with the weekly trends, the narcan administration and survival rates track each other consistently.



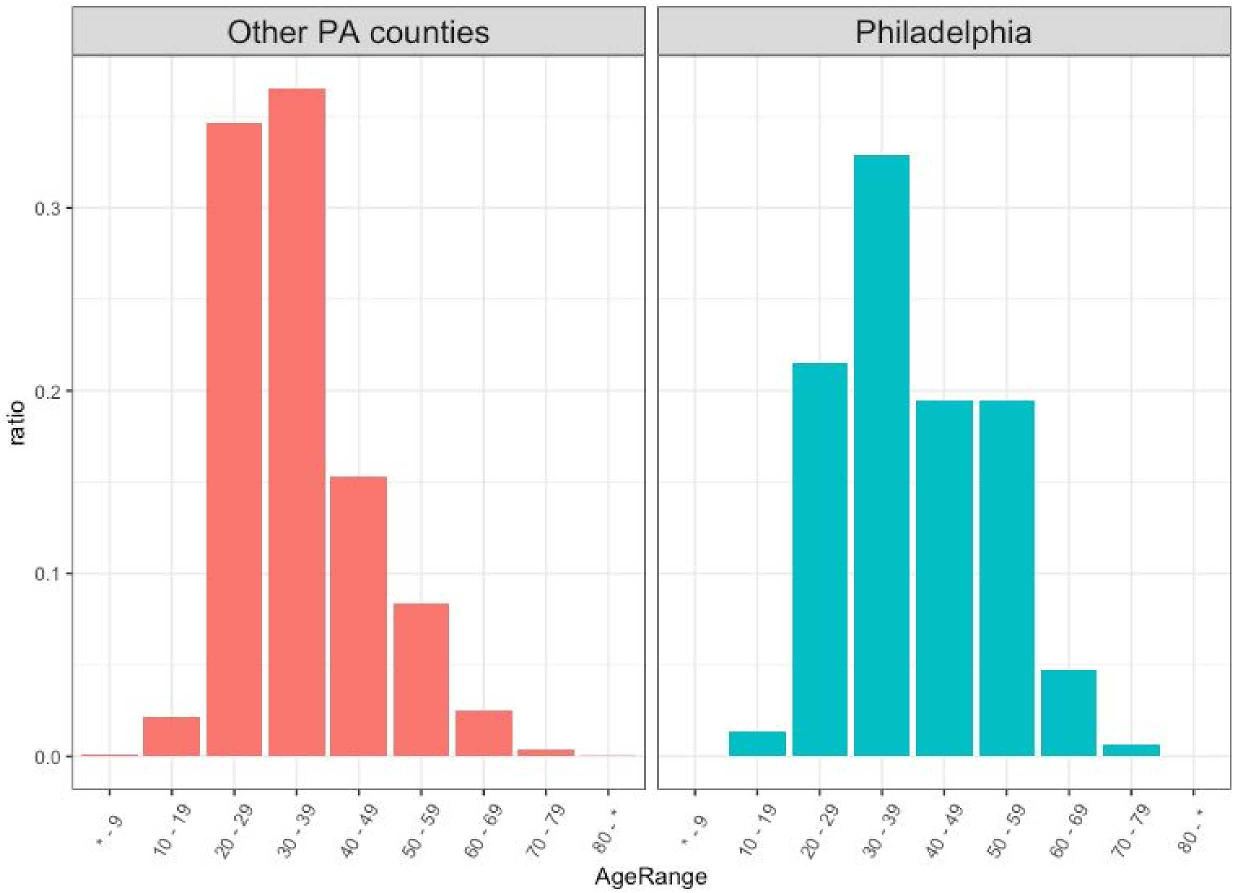
Data Source: PA.gov

We do see greater variability in the Narcan administration rate as the day goes by. Every morning between 8am and 9am sees the lowest percentage of cases administered with Narcan at about only 50%, compared to the hourly average 65%. The lowest survival rate happens in the 7th hour of the day.

People aged 30-39 make up the highest percentage of overdose incidents in PA

The charts below summarize the distribution of overdose events in Pennsylvania by age range. These data are collected by the state of Pennsylvania and published by the state on PA.gov.

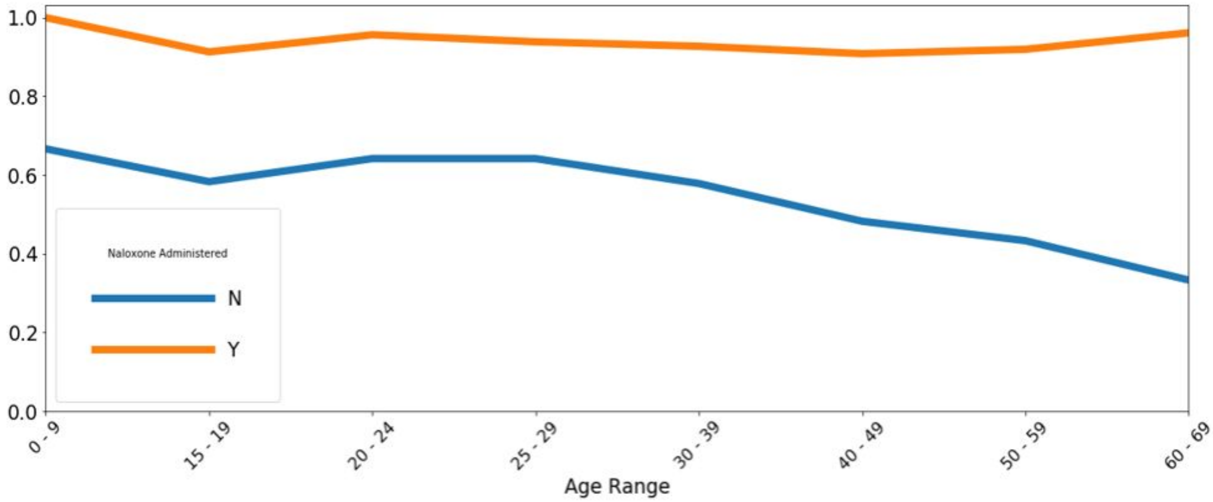
Overdose Rates by Age Range



The Y axis on the above charts indicates the percentage of overdoses by age range. Pennsylvania counties outside of Philadelphia follow the same bell curve, with overdose events in Philadelphia county skewing older.

When Narcan is not administered, people over 30 are more vulnerable to death from overdose. Survivability further declines with age.

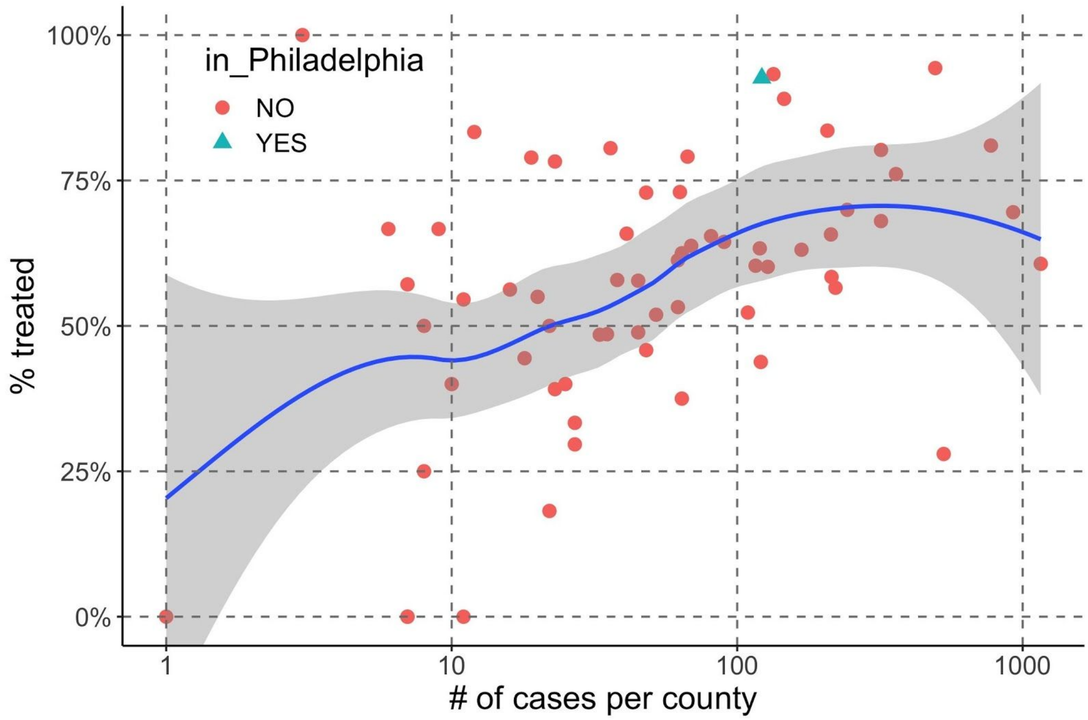
Survival Rates by Age Range



However, administration of naloxone is consistently associated with survival across the age ranges. Naloxone greatly reduces risk of death from overdose.

In Pennsylvania, Narcan treatment rate increases with the OD case load

Communities are responding to overdose rates by increasing Narcan treatments. The graph below reflects the administration rate of Narcan relative to all overdose events per county.



Source: PA.gov data

The red dots represent Pennsylvania counties that are not Philadelphia. Philadelphia is represented with a blue triangle. Counties with high overdose rates show higher Narcan administration rates.

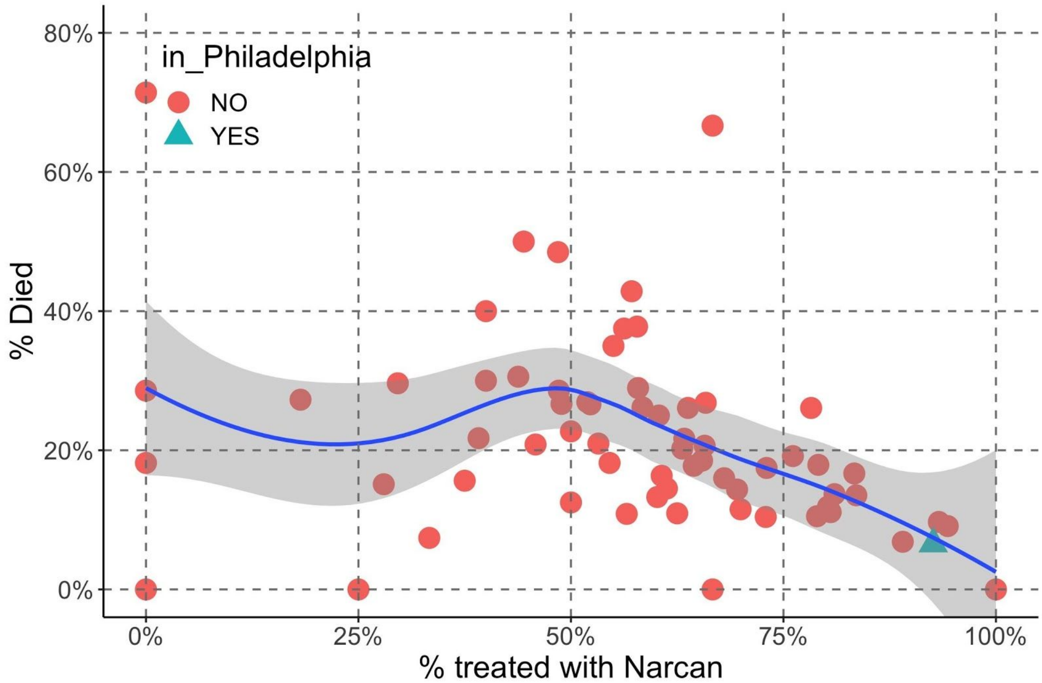
Local polynomial regression is used to smooth data. The shaded region represents a 95% confidence interval. A logarithmic scaling of the x axis is used to improve graph clarity.

Saving Lives: Naloxone Administration

Higher rates of naloxone administration are associated with lower overdose death rates for PA counties.

The figure below charts counties in the context of their naloxone administration and overdose death events.

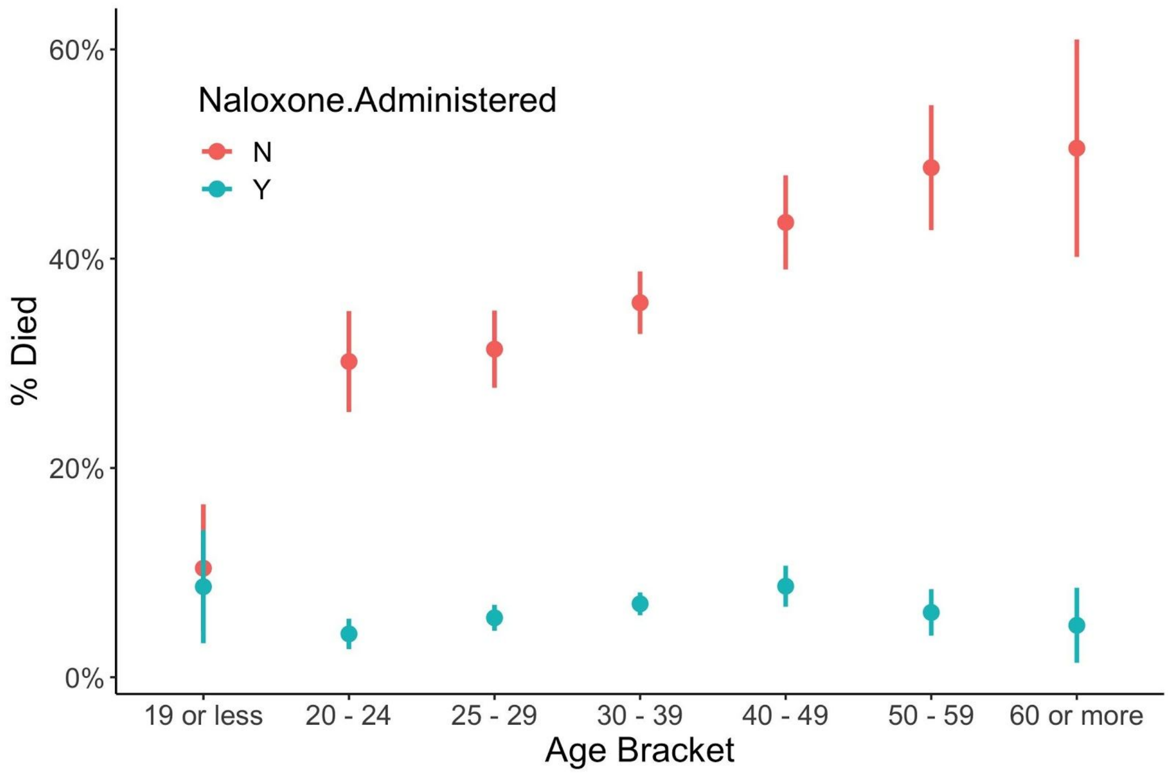
Pennsylvania County Naloxone Treatment and Overdose Deaths



Source: PA.gov data

Counties with a higher Naloxone administration rate tend to have a lower mortality rate. Philadelphia county is high in Naloxone administration rate and low in overdose mortality rate.

Pennsylvania Naloxone Treatment and Overdose Death Rates



Data Source: PA.gov

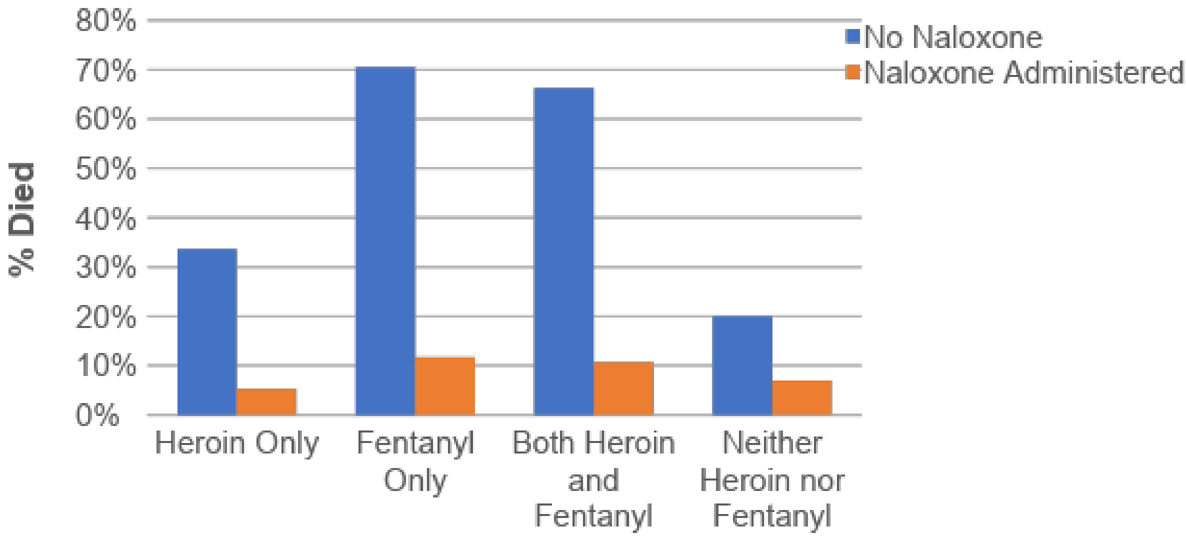
Based on approximation prediction, the chance of death due to overdose increases in absence of naloxone administration. The disparity between death rates without naloxone administration and survival rates with naloxone administration increases with age. The positive impact of naloxone administration on survival improves with age.

The error bars on the chart above are at a 95% confidence interval based on the Gaussian approximation for standard error of proportions.

Naloxone administration in Pennsylvania is associated with lower death rates for heroin and fentanyl

In Pennsylvania, the presence of fentanyl in overdose events drastically increases the probability of death as an outcome.

Death Rates in Overdose Events with Fentanyl and Heroin



The figure above demonstrates that the presence of Fentanyl drastically increases the overall death rate. However, naloxone administration greatly increases the survival rate across the board in events with heroin only, fentanyl only, a mix of both heroin and fentanyl.

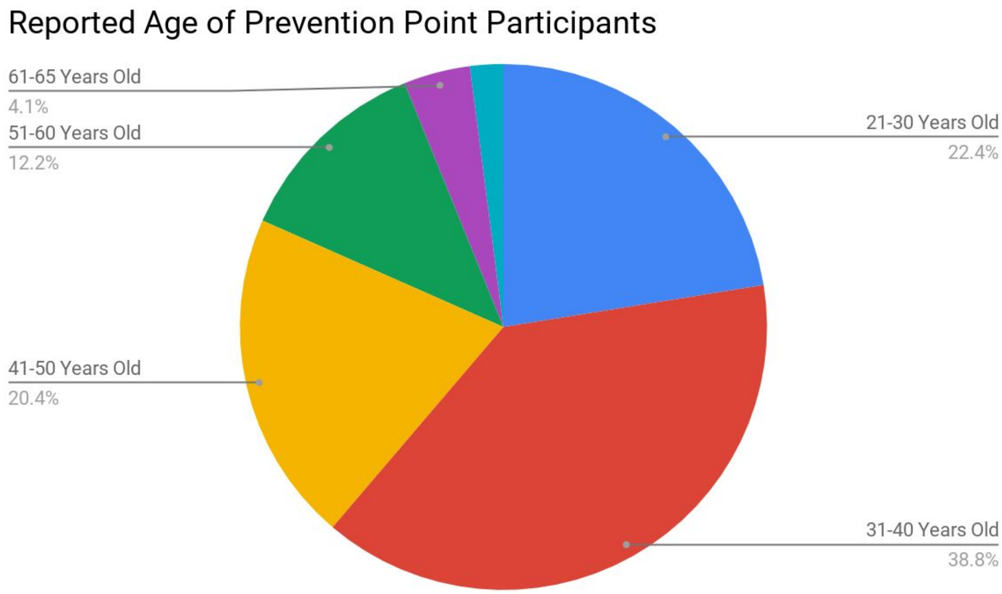
2018 Prevention Point Naloxone Refill Survey Data

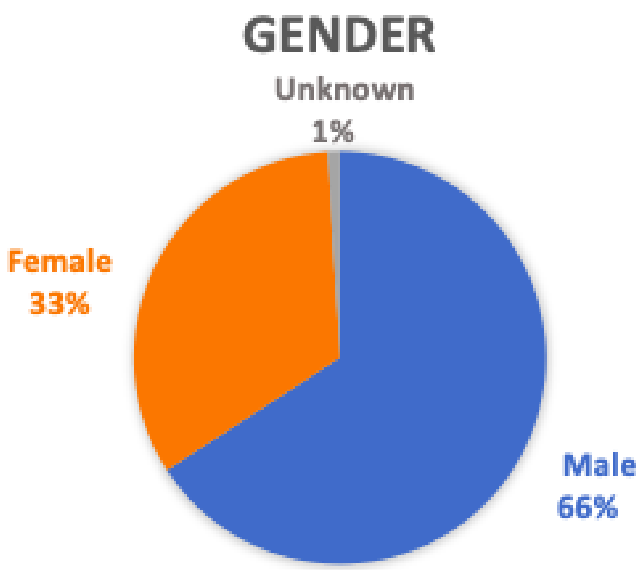
Prevention point is a non-profit in Philadelphia that provides harm reduction services in the Philadelphia area. Their service portfolio includes the training and distribution of Narcan to participants.

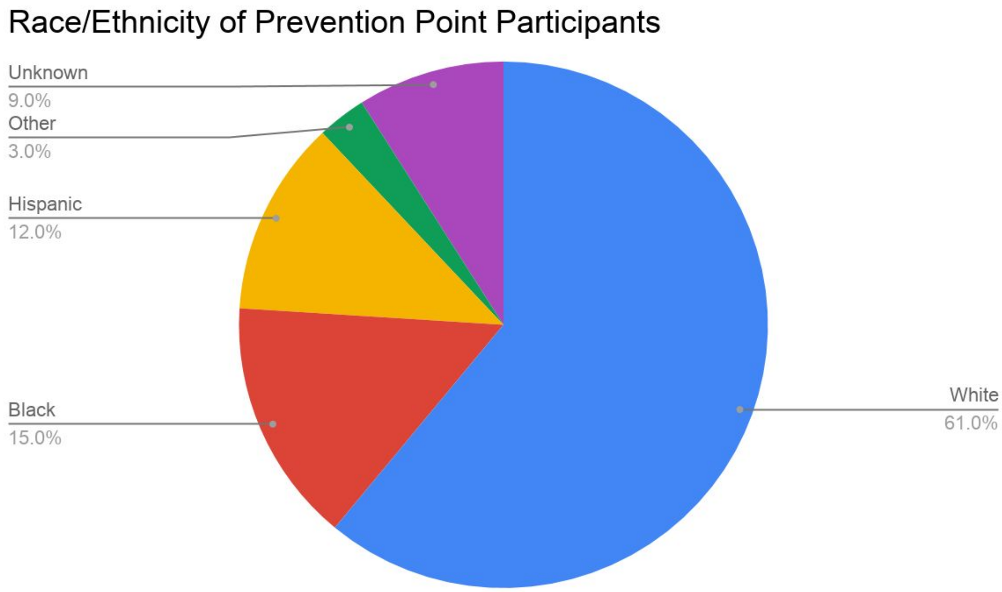
Upon obtaining Narcan refills, participants are surveyed on their characteristics and the outcomes of previous overdose events.

Prevention Point Participants

Prevention point served **2,359** participants in 2018.


Reported Age of Prevention Point Participants
61-65 Years Old
4.1%
51-60 Years Old
12.2%
21-30 Years Old
22.4%
41-50 Years Old
20.4%
31-40 Years Old
38.8%


GENDER
Unknown
1%
Female
33%
Male
66%



Prevention Point Refill Events

There were a total of **3,767** naloxone refill events at Prevention Point in 2018.

- 2,435 overdoses involving heroin
- 1,471 overdoses involving fentanyl
- In 60% of overdoses, EMS were *not* called
- In 62% of overdoses, the victim was *not* taken to the ED

RESULTS

Logistic Regression

CONTRIBUTORS
Mitchell Maltenfort

Data Preparation

The data in *Overdose_Information_Network_Data_CY_January_2018_-_Current_Monthly_County_State_Police.csv* was converted from a "long" format with every drug given a separate line within an incident/victim combination to a "wide" format where every drug had a separate column and every incident/victim combination had only one line. The resulting file had 8,369 incidents and 8,525 victims (Tables 1 and 2). Each victim occurred only once by Victim ID, although there may be issues with longitudinal tracking. There were 2,319 incidents with multiple victims, averaging 2.42 victims per such incident, with a range of 2-12.

Because of small cell counts, the only drugs examined specifically were HEROIN (73.13% of overdoses), FENTANYL(15.92%) and UNKNOWN (15.33%). All other drugs had less than 5% occurrence.

Covariates were recoded to merge categories with small counts. Race was consolidated into White, Black, or Unknown/Other. The three lowest age brackets were combined into 19 or lower, and the three highest into 60 or older. If the Gender Desc field was “Female” then the victim was considered Female, otherwise not.

Survive had three levels – Y, N or U – so Died was Survive==”N” as opposed to “Y” or “U.”

R packages used

The *tidyverse* suite of packages was used to expedite data import, workflow, and graphing. Initial exploration with logistic regression used the *rms* package. Finally, mixed-effects logistic regression was implemented using the *lme4* package.

Structure of Model

To generate a tractable model, the *rms* package in R was used to identify consistent features for a logistic regression model. The original model had the form:

Died = f(Naloxone.Administered x [HEROIN x (FENTANYL+UNKNOWN) + Female+Age.Range + Race +Ethnicity.Desc+Day)])

which allowed for Naloxone to interact with all variables and included Ethnicity and Day. Backwards feature selection was performed on bootstrapped model iterations via the *validate* command and the model was pruned based on which terms dropped out most frequently.

The reduced model had the structure

Died =f(Naloxone.Administered x [HEROIN x FENTANYL + UNKNOWN + Age.Range)]) +Female +Race

where Ethnicity and Day fell out and so did interaction between Naloxone and Race or UNKNOWN (unknown drug). Performance of this reduced model was good – AUC of 0.804, 0.799 after optimism correction. Calibration curves also matched the ideal performance between 0 and 80% probability of death.

Using the *lme4* package, the logistic regression model was adjusted by first adding a random intercept per county to allow for variations in death rate, then by further adding a random slope so that each county might have varying efficacy with naloxone. Changes in AIC suggested that the random slope+intercept model was the best to use. The ICC for the model was 0.06, suggesting that the county-level effect only accounted for 6% of the outcome variation. Small, but statistically significant.

Pennsylvania Overdoses

Table 3 shows the distribution of OD cases based on whether naloxone was given. Although the p-value is significant for most comparisons, that's a consequence of the high number of cases. There is some difference in the distribution of HEROIN, FENTANYL and UNKNOWN (unknown drug), and a clear difference in survival.

Table 3: Variations between OD cases with and without naloxone	**No naloxone**	**Naloxone Given**	**p-value**
n	2,864	5,661	
Age.Range (%)			<0.001
0 - 9	6 (0.2)	4 (0.1)	
10 - 14	10 (0.3)	2 (0.0)	
15 - 19	80 (2.8)	98 (1.7)	
20 - 24	348 (12.2)	724 (12.8)	
25 - 29	606 (21.2)	1338 (23.6)	
30 - 39	989 (34.5)	2109 (37.3)	
40 - 49	467 (16.3)	793 (14.0)	
50 - 59	269 (9.4)	452 (8.0)	
60 - 69	76 (2.7)	123 (2.2)	
70 - 79	12 (0.4)	17 (0.3)	

80 - *	1 (0.0)	1 (0.0)	
Race (%)			<0.001
White	2516 (87.8)	4730 (83.6)	
American Indian or Alaskan Native	0 (0.0)	3 (0.1)	
Asian or Pacific Islander	6 (0.2)	20 (0.4)	
Black	243 (8.5)	418 (7.4)	
Unknown	99 (3.5)	490 (8.7)	
Ethnicity.Desc (%)			0.274
Not Hispanic	2222 (77.6)	4310 (76.1)	
Hispanic	151 (5.3)	299 (5.3)	
Mongolian	4 (0.1)	4 (0.1)	
Unknown	487 (17.0)	1048 (18.5)	
Gender.Desc (%)			0.023
Female	914 (31.9)	1740 (30.7)	
Male	1939 (67.7)	3914 (69.1)	
Unknown	11 (0.4)	7 (0.1)	
HEROIN (%)	1995 (69.7)	4239 (74.9)	<0.001
FENTANYL (%)	535 (18.7)	822 (14.5)	<0.001
UNKNOWN DRUG (%)	282 (9.8)	1025 (18.1)	<0.001
Survive (%)			<0.001
N	1038 (36.2)	367 (6.5)	
U	129 (4.5)	436 (7.7)	
Y	1697 (59.3)	4858 (85.8)	

Table 4 shows the variation of OD cases based on whether the victim used Heroin, Fentanyl, Neither or Both. The age variation is slight but there is a larger variation with race - whites are less likely to use neither Heroin nor Fentanyl, and Black individuals and individuals of Unknown Race are more likely to use neither. The reported presence of an Unknown Drug is much less likely when Heroin or Fentanyl are suspected. Naloxone administration is least likely when Fentanyl alone is present, but Fentanyl alone also has the worst survival rates.

Table 4 - variations of OD cases based on Heroin x Fentanyl	**Neither**	**Heroin only**	**Fentanyl Only**	**Both**	**p-value**
N	2,101	5,067	190	1,167	
Age.Range (%)					<0.001
0 - 9	4 (0.2)	4 (0.1)	0 (0.0)	2 (0.2)	
10 - 14	12 (0.6)	0 (0.0)	0 (0.0)	0 (0.0)	
15 - 19	96 (4.6)	69 (1.4)	3 (1.6)	10 (0.9)	
20 - 24	251 (11.9)	644 (12.7)	24 (12.6)	153 (13.1)	
25 - 29	384 (18.3)	1239 (24.5)	36 (18.9)	285 (24.4)	
30 - 39	680 (32.4)	1928 (38.1)	63 (33.2)	427 (36.6)	
40 - 49	347 (16.5)	708 (14.0)	38 (20.0)	167 (14.3)	
50 - 59	233 (11.1)	371 (7.3)	21 (11.1)	96 (8.2)	
60 - 69	81 (3.9)	88 (1.7)	5 (2.6)	25 (2.1)	
70 - 79	12 (0.6)	15 (0.3)	0 (0.0)	2 (0.2)	
80 - *	1 (0.0)	1 (0.0)	0 (0.0)	0 (0.0)	
Race (%)					<0.001
White	1354 (64.4)	4643 (91.6)	171 (90.0)	1078 (92.4)	
American Indian or Alaskan Native	1 (0.0)	1 (0.0)	1 (0.5)	0 (0.0)	

Asian or Pacific Islander	8 (0.4)	12 (0.2)	1 (0.5)	5 (0.4)	
Black	263 (12.5)	313 (6.2)	11 (5.8)	74 (6.3)	
Unknown	475 (22.6)	98 (1.9)	6 (3.2)	10 (0.9)	
Ethnicity.Desc (%)					<0.001
Not Hispanic	1207 (57.4)	4113 (81.2)	160 (84.2)	1052 (90.1)	
Hispanic	137 (6.5)	233 (4.6)	11 (5.8)	69 (5.9)	
Mongolian	3 (0.1)	4 (0.1)	0 (0.0)	1 (0.1)	
Unknown	754 (35.9)	717 (14.2)	19 (10.0)	45 (3.9)	
Gender.Desc (%)					<0.001
Female	739 (35.2)	1532 (30.2)	63 (33.2)	320 (27.4)	
Male	1356 (64.5)	3526 (69.6)	127 (66.8)	844 (72.3)	
Unknown	6 (0.3)	9 (0.2)	0 (0.0)	3 (0.3)	
Naloxone Given (%)	1337 (63.6)	3502 (69.1)	85 (44.7)	737 (63.2)	<0.001
UNKNOWN DRUG	1205 (57.4)	77 (1.5)	4 (2.1)	21 (1.8)	<0.001
Survive (%)					<0.001
N	247 (11.8)	710 (14.0)	84 (44.2)	364 (31.2)	
U	266 (12.7)	248 (4.9)	7 (3.7)	44 (3.8)	
Y	1588 (75.6)	4109 (81.1)	99 (52.1)	759 (65.0)	

The mixed-effects logistic regression model for death had significant p-values for all included terms (Table 5). Interaction terms are hard to interpret for a regression model but the raw data (Table 6) tells the story. Fentanyl has similar effects on mortality with or without Heroin, and Naloxone improves survival consistently. If there is no unknown drug present, the effects are similar to Heroin alone. If an unknown drug is suspected, the effects are midway between Heroin and Fentanyl.

Table 5: P-values for terms in model for death	Df	Likelihood Ratio	P-value	
Race2	2	11.3946	0.0034	**
Female	1	3.9549	0.0467	*
Naloxone.Administered:UNKNOWN	1	4.4457	0.0350	*
Naloxone.Administered:Age2	6	26.7518	0.0002	***
Naloxone.Administered:HEROIN:FENTANYL	1	10.1642	0.001	**

Table 6: Mortality by OD cause and Narcan administration	No Narcan			Narcan			
Heroin x Fentanyl	**# Victims**	**# Died**	**% Died**	**# Victims**	**# Died**	**% Died**	**Odds Ratio (95% CI)**
Neither Heroin nor Fentanyl	764	153	20.03 %	1337	94	7.03 %	0.30 (0.23-0.40)
Heroin Only	1565	526	33.61 %	3502	184	5.25 %	0.11 (0.09-0.13)
Fentanyl Only	105	74	70.48 %	85	10	11.76 %	0.06 (0.03-0.12)
Both Heroin and Fentanyl	430	285	66.28 %	737	79	10.72 %	0.06 (0.04-0.08)
Unknown Drug							
No Unknown Drug	2582	954	36.95 %	4636	297	6.41 %	0.12 (0.10-0.13)
Unknown Drug	282	84	29.79 %	1025	70	6.83 %	0.17 (0.12-0.25)

The effect of Narcan as victim age varies can be seen in Figure 1 below. There is no difference for the youngest patients, but as victims age the rate of death without Narcan increases and the rate of death with Narcan is roughly steady.

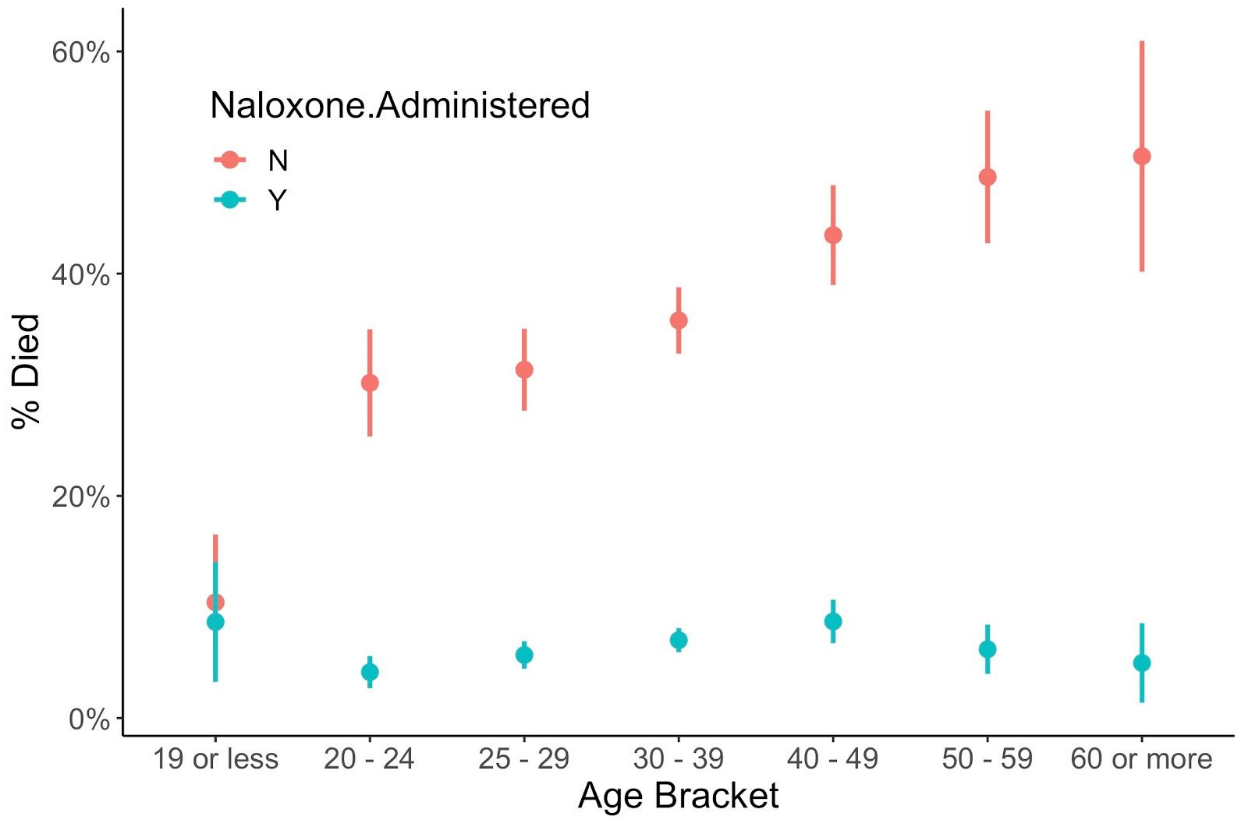


Figure 2 shows the distribution of mortality rates by county, based on whether Naloxone was administered. There was a sharp decrease in mortality rates, and no relationship between mortality rates with and without naloxone in the same county. Confidence bands based on Gaussian approximation for proportions. There is some indication that the protective effect of Narcan is greater for older patients. Conversely, below age 20 Narcan seems to have no benefit. We cannot tell from the data whether this reflects pharmacological efficacy or OD patterns varying between the different age groups.

Figure 3 shows the percentiles of Narcan usage in each county. The green triangle in the upper right represents Philadelphia.

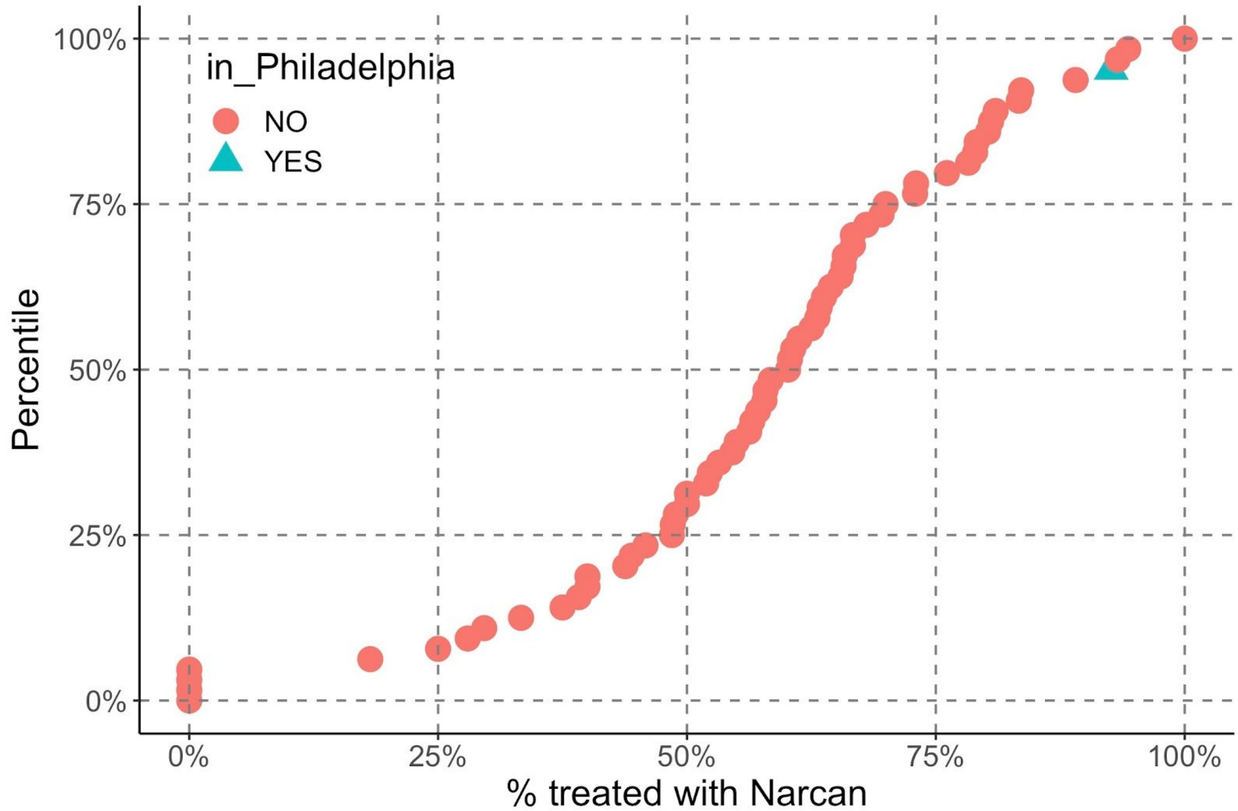


Figure 4 shows the relationship between case load and Narcan usage by county. A logarithmic scale is used for clarity. The smoothed curve between cases and Narcan rate shows a clear trend upward -- counties hardest hit are using Narcan more. Philadelphia is in the upper right but is not an outlier.

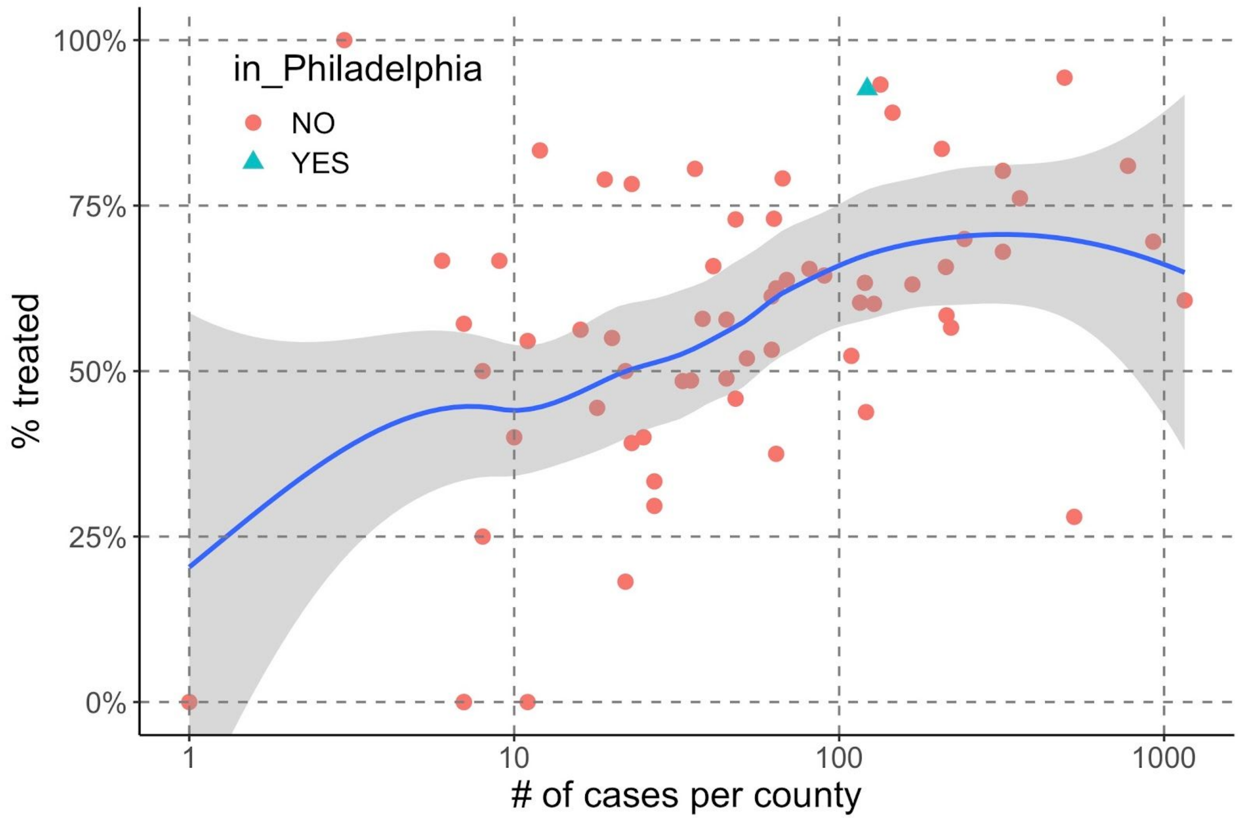
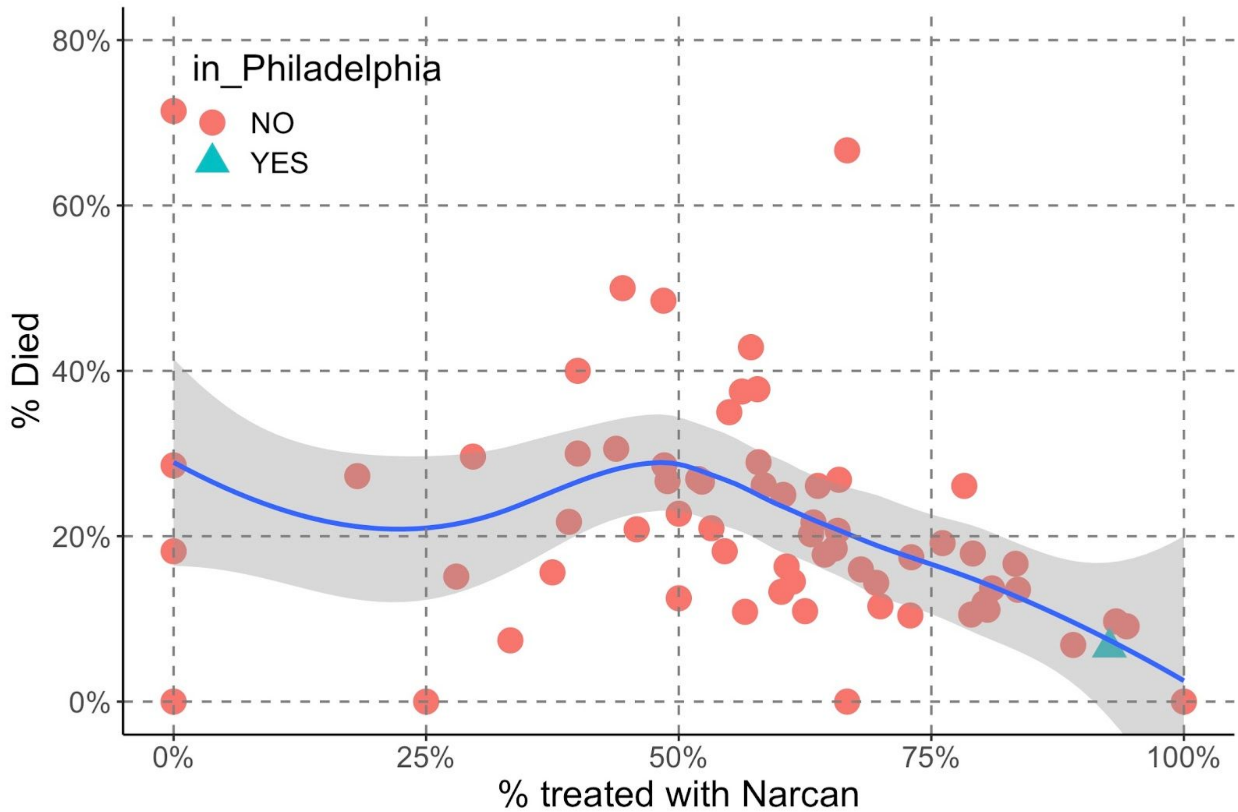


Figure 5 shows the relationship between Narcan treatment rate and death rate by county. The smoothed line suggests that Narcan becomes effective in reducing deaths when used in 50% or more of cases. We can only speculate whether that reflects greater efficacy in counties where there is more experience in using Narcan or handling overdoses.



Conclusions and next steps

- *Pooling of multi-state information*

Collaborating with institutions in other states would allow us to pool data for drugs with a low rate of occurrence in overdoses and get a sharper picture of how Narcan is prescribed and effective for these drugs.

- *Recruitment initiatives*

The data indicate that use of Narcan is greatest in counties with higher overdose counts but still less than 100%. Although it may be more difficult to recruit in counties with fewer overdoses, there may also be room to recruit in these areas. Prevention point data suggests that more could be done to recruit women and non-white participants for Narcan training.

CDC and Census Data Analysis

CONTRIBUTORS:

Joey Logan

Data Preparation

*Overdose_Information_Network_Data_CY_January_2018_-_Current_Monthly_County_State_Police.csv :*had the following feature engineering: Filtering to opioids and events where survive was determined, counting overdoses by age range, transforming survive ‘Y’ and ‘N’ to 1, 0 for calculation. Lastly, grouping by Age range, If Naloxone was administered and if the person survived.

Census.gov: State Population Totals and Components of Change: 2010-2018: Had the following feature engineering. Column names were changed to numeric and consolidated to prepare for linear regression. Because, this data was blended with the CDC state set, we needed create a linear regression algorithm to predict state population for 2019

CDC: Opioid Data Analysis and Resources:
VSRR_Provisional_Drug_overdoth_Death_Counts.csv

Columns were limited to relevant values and for states that had a total drug overdose number per month. This dataset was merged with the above census.gov data set by state. Then, *the percent* of drug overdoses relative to the state population for that year was calculated. This way, the impact of drug overdose deaths by the state population could be measured.

Python packages used

Pandas was used in much of the feature engineering, scikit-learn was used for the linear regression model, matplotlib was used to plot graphs.

Overdose Deaths

CDC and Census

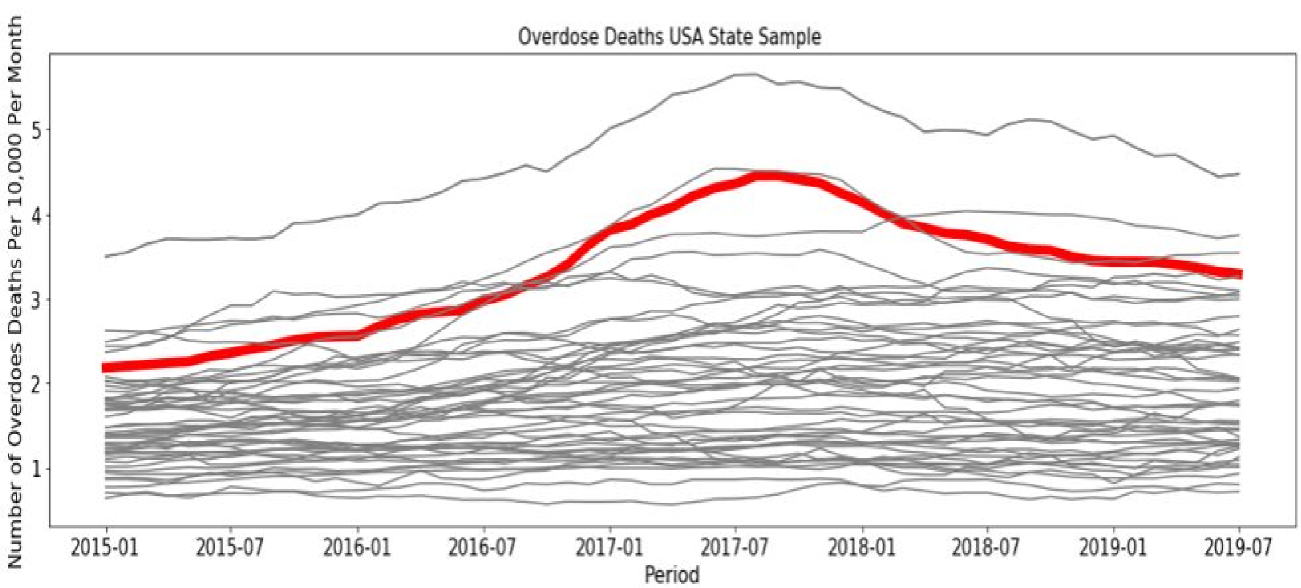
The CDC dataset had total drug overdose deaths for each state. However, it did not have opioid overdose deaths for many states including Pennsylvania. We used that dataset combined with census data to measure the percent of overdose deaths relative to the states population. The census data did not have 2019, so we use a linear regression algorithm to predict 2019 state population.

Of the 50 states, Pennsylvania had the 5th highest deaths from all drug overdoses relative to the state population.

Below: Rank of highest % of Overdose Deaths relative to state population

State Name	Date	% Of OD Deaths Vs Total Population
West Virginia	2019-07-01	0.0445144
Delaware	2019-07-01	0.0435752
District of Columbia	2019-07-01	0.0431014
Maryland	2019-07-01	0.0375683
Ohio	2019-07-01	0.0353822
Pennsylvania	2019-07-01	0.0328897
Rhode Island	2019-07-01	0.0326151
Massachusetts	2019-07-01	0.0309514
Connecticut	2019-07-01	0.0307605
New Jersey	2019-07-01	0.0303302
Kentucky	2019-07-01	0.0299313
New Hampshire	2019-07-01	0.0298947
Tennessee	2019-07-01	0.0279479

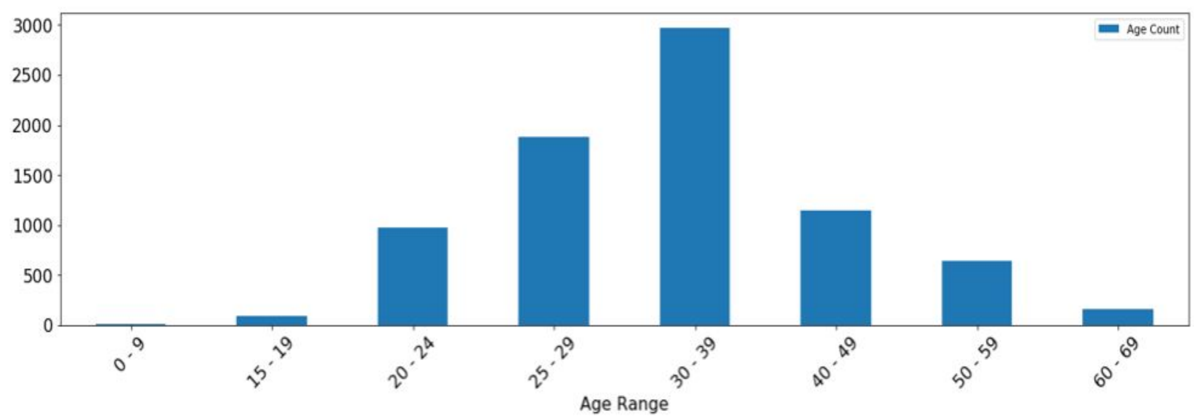
Below: A selection of states in a time series to show all overdose deaths relative to total state population



Impact of Naloxone Administration on Survival Rates

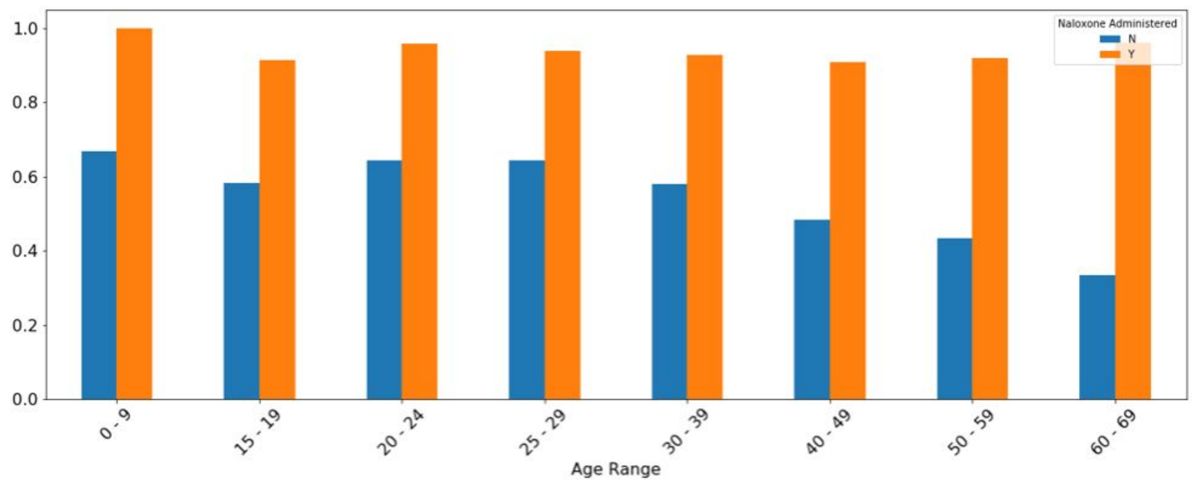
PA.gov Analysis

We examined the PA.gov dataset for an opioid overdose age range analysis to first measure the age ranges with the most overdoses, then to measure naloxone's effectiveness over the various age ranges. There is a prevalence of opioid overdoses in the 30-39, 25-29, and 40-49 age range.

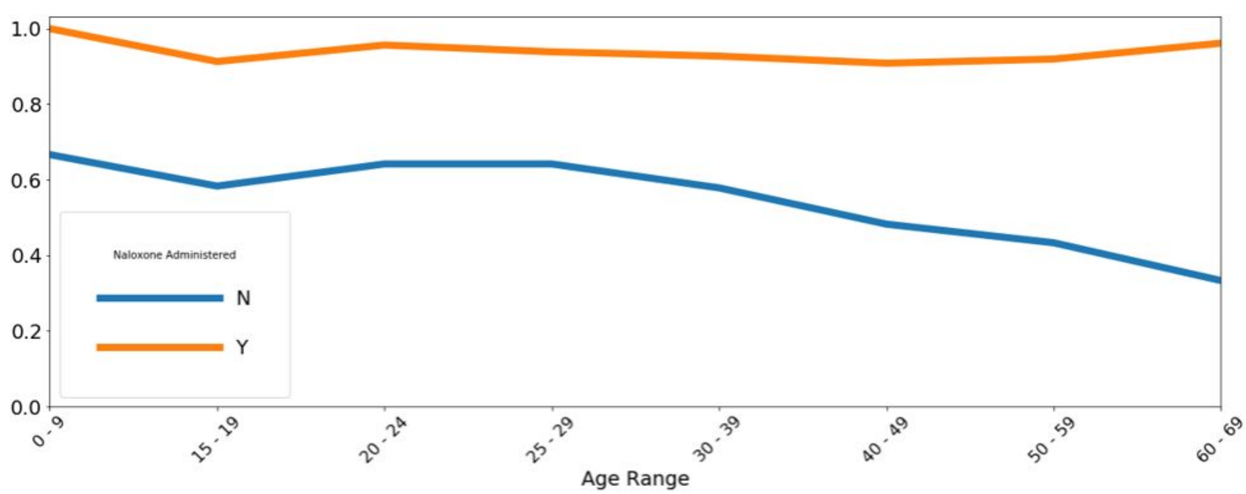


Next, we measured Naloxone's effectiveness by age range to find insights. Every single age range had a greater than 90% survival rate when naloxone was administered. However, when Naloxone was not administered, the age group with one of the highest survival rates(25-29) only had a 64% survival rate compared to a 94% survival rate for the same age group. Additionally, the survival rates drastically decrease at higher age ranges for those who are not administered Naloxone. For example age range: 40-49 at 48% without compared to 91% with, 50-59 at 43% without compared to 92% with naloxone.

Below: Charts showing the high survival rate of naloxone(orange), compared to the low survival rate(blue) across all age ranges.



Below: A line chart showing those who are administered naloxone (orange) with consistent survival rates across all ages, and those who are not administered naloxone (blue). Note the consistent decrease in survival for older age ranges.

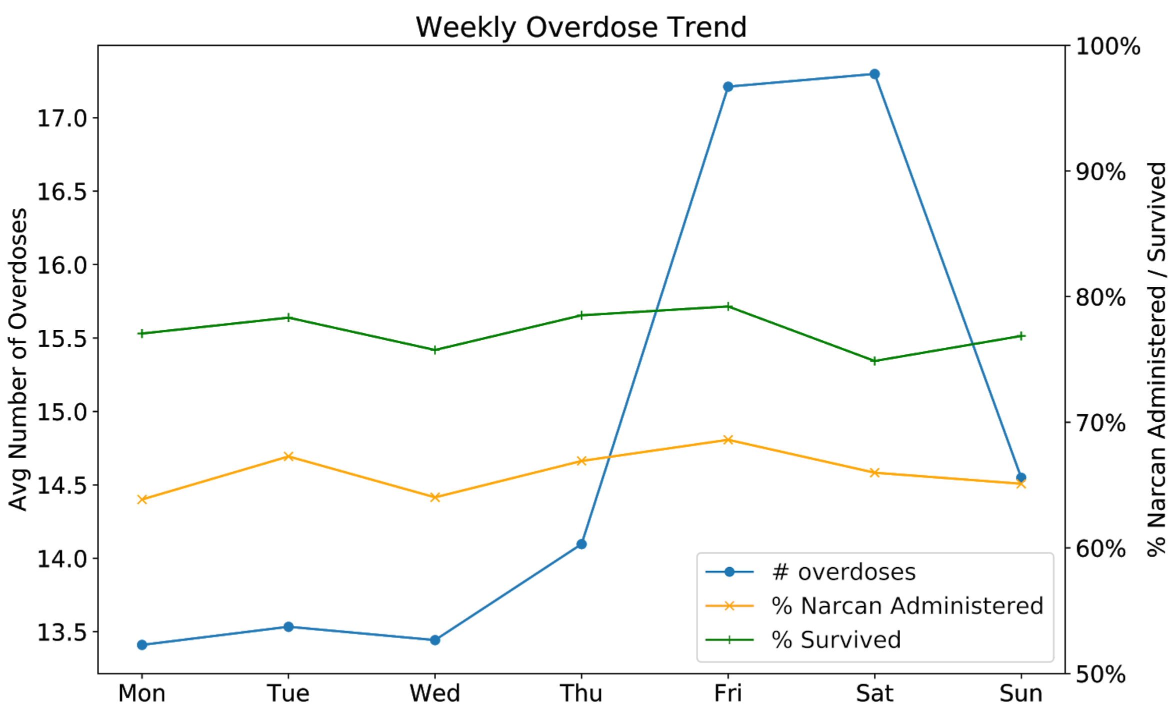


Temporal Analysis of Overdose Events

CONTRIBUTORS:
Ou Stella Lang

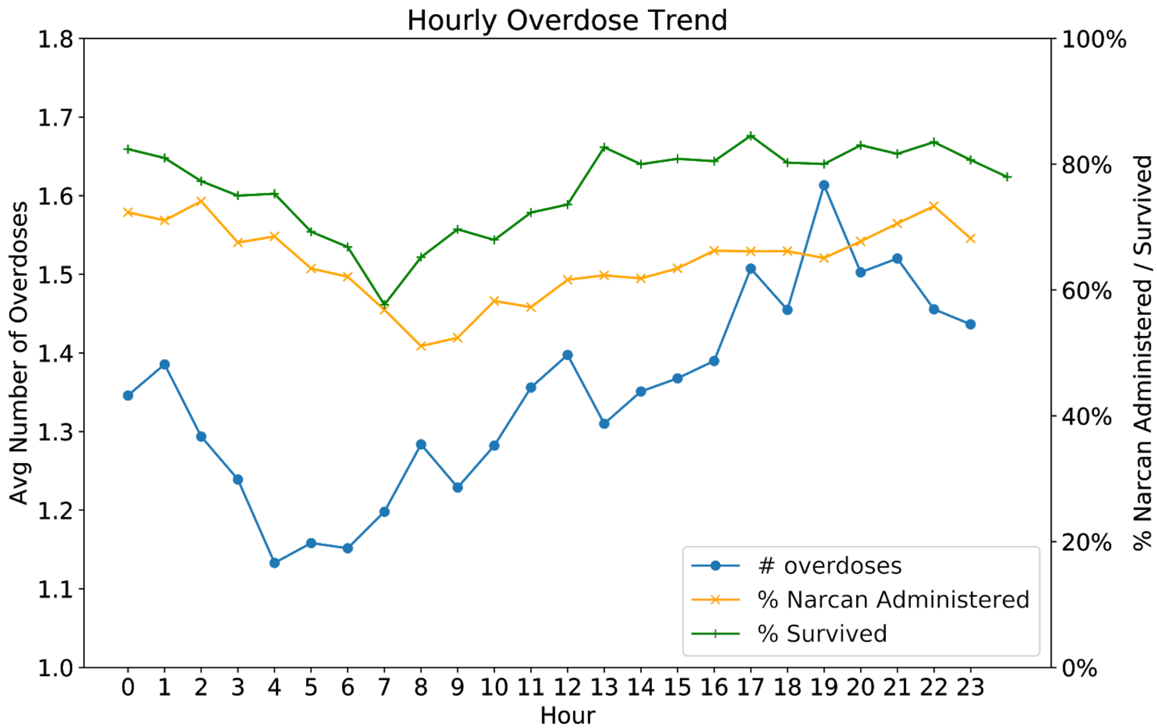
We were interested in exploring the temporal patterns related to overdose occurrences. Using the PA.gov data (1/1/2018-12/31/2019), we plotted the number of overdose cases, % cases administered Narcan, and the survival rate by day of week and hour of day. Notably, in order to accurately reflect the hourly overdose counts, we excluded ~10% cases whose incident time was recorded as 00:00 at midnight, which are more likely to be a system default for cases missing an account of actual incident time. Not excluding these cases would artificially inflate the number of cases at the midnight point.

In the following figure, the average daily number of overdose ranges between 13.4 and 17.3 cases per day. Overdose cases start to rise on Thursdays and peak on Fridays and Saturdays. The % of cases administered with Narcan and the survival rate track each other consistently. Days that have higher rates of Narcan administered also see higher survival rates, except the slight discrepancy on Sundays. Narcan administration rate averages 66.0%, and survival rate averages to be 77.2%. The peak overdose on Saturdays also coincides with one of the lowest Narcan administration rates and survival rates, calling for greater availability of Narcan on Saturdays due to the case loads. Wednesdays, despite relatively lower overdose cases, see another low point in Narcan administration and survival rates, suggesting possibly fewer good samaritans in the middle of the week.



In the following figure, the average hourly number of overdoses ranges between 1.1 and 1.6 cases per hour. Overdose cases start at the lowest around 4am and gradually climb up to 7pm to reach the peak. Between 5pm and midnight see the most overdose cases. Consistent with the weekly trends, the Narcan administration and survival rates track each other consistently.

We do see greater variability in the Narcan administration rate as the day goes by. Every morning between 8am and 9am see the lowest percentage of cases administered with Narcan at about only 50%, compared to the hourly average 65%. The lowest survival rate happens in the 7th hour of the day.



Prevention Point, Philadelphia Department of Public Health, and SAMHSA Data Analysis

Prevention Point Data Summary

Data Preparation

Data from Prevention Point refill surveys were cleaned and used to create several new variables. The resulting spreadsheet is included (pp_refills_2018.xlsx) along with an explanation of each variable (pp_refills_2018_dictionary.xlsx). The following tables summarize data from the refill surveys.

Prevention Point Naloxone Refills

Table 1. 2018 Prevention Point Participant Characteristics

Total number of participants in 2018	*2359*	
	Number of Participants	**Percentage of Participants**
Number of 2018 refill events		
1 refill event	1443	61%
2-5 refill events	520	22%
6-10 refill events	52	2%
11-23 refill events	15	1%
Age		
21-30 years old	530	22%
31-40 years old	900	38%
41-50 years old	480	20%
51-60 years old	294	12%
61-65 years old	106	4%
Unknown	49	2%
Gender		
Male	1553	66%
Female	784	33%
Unknown	22	1%
Race/Ethnicity		
White	1446	61%
Black	359	15%
Hispanic	282	12%
Other	66	3%

Unknown	206	9%

	Median
Number of refills received from PP	2
Number of refills received from other locations	0
Number of overdoses witnessed	5
Number of persons revived with naloxone	2

Note. For participants who completed multiple surveys in 2018, data from the most recent survey was used. Surveys without participant identifying numbers were assumed to be separate individuals (i.e., not repeat visits).

Naloxone Event Characteristics

Table 2. 2018 Naloxone Event Characteristics (as reported by Prevention Point participants)

Total number of naloxone events	*3767*	
	Number of Events	**Percentage of Events**
Type of naloxone used		
Intranasal	2697	72%
Injectable	441	12%
Intranasal and injectable	42	1%
Unknown	587	16%
Med program used		
Sep-onsite	1492	40%
Sep-mobile	214	6%
Drop-in	228	6%
Other	364	10%
Unknown	1469	39%
Training program		
Sep-onsite	1449	38%
Sep-mobile	231	6%
Drop-in	286	8%
Other	422	11%
Unknown	1379	37%
EMS were called		
No	2269	60%
Yes	1131	30%
Unknown	367	10%

Police were called		
No	2142	57%
Yes	469	12%
Unknown	1156	31%
Person taken to ED		
No	2322	62%
Yes	284	8%
Unknown	1161	31%
Person survived		
No	55	1%
Yes	1584	42%
Unknown	2128	56%
Overdose involved heroin		
No	841	22%
Yes	2435	65%
Unknown	491	13%
Overdose involved fentanyl		
No	1807	48%
Yes	1471	39%
Unknown	489	13%
Overdose involved cocaine		
No	2857	76%
Yes	418	11%
Unknown	492	13%
Number of drugs involved from the following list: fentanyl, heroin, cocaine, other		
1 drug	1640	44%

2 drugs	990	26%
3 drugs	308	8%
4 drugs	26	1%
Unknown	803	21%

Number of overdose symptoms present from the following list: irregular/no breath, unresponsive, skin coloring, other

1 symptom	1871	50%
2 symptoms	618	16%
3 symptoms	602	16%
4 symptoms	35	1%
Unknown	641	17%

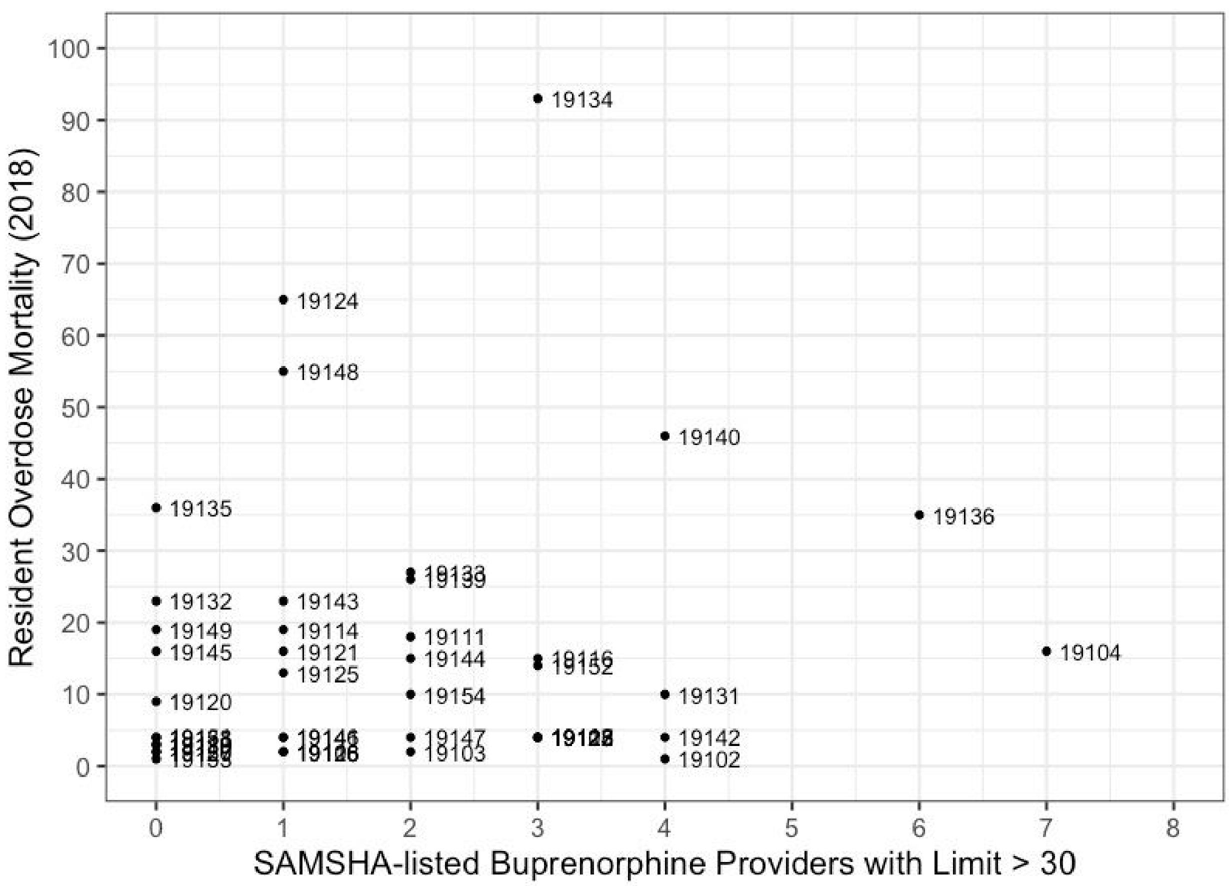
Buprenorphine Availability and Overdose Mortality

Data Preparation

Data from Prevention Point, Philadelphia Department of Public Health, and SAMHSA were cleaned and summarized by zip code. The resulting spreadsheet is included (zip_data.xlsx) along with an explanation of each variable (zip_data_dictionary.xlsx).

Analysis

Buprenorphine providers were manually searched using the SAMHSA Pharmacy Lookup form. This search resulted in 411 providers in Philadelphia, but only 19% of these providers were listed with a limit greater than 30 patients. The plot below displays the number of buprenorphine providers with a limit of more than 30 patients and the overdose mortality in 2018 by Philadelphia zip codes.



CONCLUSIONS

- Pennsylvania data show that naloxone administration is associated with lower probability of death from drug overdoses.
- Prevention Point is an important source of naloxone for Philadelphia residents.
- Certain age groups are more vulnerable to overdose. Naloxone is consistently protective across all age groups.
- Critical saturation of use of Narcan matters. Counties with more overall use of Narcan have higher survivability, especially as counties move from moderate to very high rates of administration (e.g., 50% towards 100%).
- We have the most detailed data at county-level. We need to learn more about individuals and communities, and we need more federal/cooperative data sources.

NEXT STEPS

- Examine naloxone administration in other states.
- Examine the possible relation to the slight decrease in naloxone administration on Saturdays, a day when public services are traditionally closed.
- Because Friday is the beginning of a spike in overdoses, examine the hourly overdoses compared to the other days of the week. This may help to suggest that overdoses widely occur by casual drug users during days and times that are not traditional work hours.
- Examine communities of varying sizes and Naloxone preparedness in public institutions (e.g., schools, libraries).