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Changes to opioid overdose deaths and community naloxone access among Black, Hispanic, and White people from 2016 to 2021 with the onset of the COVID-19 pandemic: An interrupted time series analysis in Massachusetts, USA

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Abstract

Background and aims: The onset of the coronavirus disease 2019 (COVID-19) pandemic was associated with a surge in opioid overdose deaths in Massachusetts, particularly affecting racial and ethnic minority communities. We aimed to compare the impact of the pandemic on opioid overdose fatalities and naloxone distribution from community-based programs across racial and ethnic groups in Massachusetts.

Design: Interrupted time series.

Setting and cases: Opioid overdose deaths (OODs) among non-Hispanic White, non-Hispanic Black, Hispanic and non-Hispanic other race people in Massachusetts, United States of America (January 2016 to June 2021)

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Measurements: Rate of OODs per 100,000 people; rate of naloxone kits distributed per 100,000 people; and ratio of naloxone kits per opioid overdose death as a measure of naloxone availability. We applied five imputation strategies using complete data in different periods to account for missingness of race and ethnicity for naloxone data.

Findings: Before COVID-19 (January 2016 to February 2020), the rate of OODs declined among non-Hispanic White people (0.2% monthly reduction [95% confidence interval: 0.0%-0.4%]), yet was relatively constant among all other population groups. The rate of naloxone kits increased across all groups (0.8%-1.2% monthly increase) and the ratio of naloxone kits per OOD death among non-Hispanic White was 1.1% [0.8%-1.4%] and among Hispanic people was 1.0% [0.2%-1.8%]. After the onset of the pandemic (March 2020 and after), non-Hispanic Black people experienced an immediate increase in the rate of OODs (63.6% [16.4%-130%]), whereas rates among other groups remained similar. Trends in naloxone rescue kit distribution did not substantively change among any groups, and the ratio of naloxone kits per OOD death for non-Hispanic Black people did not compensate for the surge in OODs deaths in this group.

Conclusions: With the onset of the COVID-19 pandemic, there was a surge in opioid overdose deaths among non-Hispanic Black people in Massachusetts, USA with no compensatory increase in naloxone rescue kit distribution. For non-Hispanic White and Hispanic people, opioid overdose deaths remained stable and naloxone kit distribution continued to increase.

Keywords

opioid overdose deaths; naloxone availability; racial and ethnic disparities; COVID-19; interrupted time series

Introduction

There was a rapid escalation in drug overdose deaths in the United States of America (USA) and Canada since the beginning of the coronavirus disease 2019 (COVID-19) pandemic in 2020 (1, 2). According to Centers for Disease Control and Prevention provisional data, drug overdose deaths soared to over 107,000 in 2021 in the USA, up 15% from the previous record of over 93,000 set in 2020, and nearly 50% higher than in 2019 (3). In 2021, deaths involving synthetic opioids other than methadone, primarily fentanyl, continued to rise, accounting for 66% of all drug overdose deaths (4). Social isolation and economic distress during the COVID-19 pandemic may have worsened existing substance use disorders while increasing the risk of recurrence in those who are not actively using or in recovery (5). Disruptions in the drug supply as well as the delivery of health care services and medications for opioid use disorder (OUD) due to understaffing and resource strain have further exacerbated the risk of overdose and mortality (6). Early modeling studies suggested that COVID-related interruptions to OUD care delivery will result in sustained elevations in overdose deaths (7).

The impact of COVID-19 has not been evenly distributed across population groups, as evidenced by the fact that Black and other racial and ethnic minority populations are disproportionally represented among COVID-19 cases, hospitalizations, and deaths (8, 9). The differential impacts are also evident among people who use drugs (10–12). In

Massachusetts, while the overall rate of opioid overdose death (OOD) increased 5% in 2020 compared to a year earlier, the rate showed a slight decrease among the non-Hispanic White people, but increased by 10% among the Hispanic people and 57% among the non-Hispanic Black people (both exceeding the rate for non-Hispanic White people for the first time) (13). In states like Massachusetts with a majority of non-Hispanic White people, trends among race/ethnic groups representing smaller proportions of the population are often obscured within the overall trend in overdose deaths. Race and ethnicity-stratified analysis is necessary to unpack the differential impacts on each subpopulation group (14).

Naloxone distribution is a key component of the public health response to the opioid overdose epidemic; however, recent studies have demonstrated that naloxone distribution was significantly disrupted by the COVID-19 pandemic (15). An analysis of national pharmacy claims data found a 26% decline of naloxone prescriptions per week in March 2020, which remained low throughout the pandemic period (16). In a previous study of community-based overdose education and naloxone distribution (OEND) prior to the COVID-19 pandemic in Massachusetts, we found lower rates of naloxone receipt among Hispanic and non-Hispanic Black people than their non-Hispanic White counterparts (17), with such variations also identified in several other studies (18–20). COVID-19 pandemic may also affect naloxone access differently across racial and ethnic groups, but this has not previously been investigated. This study aims to compare the changes that occurred after the onset of the COVID-19 pandemic on OOD rates and naloxone access from OEND programs by race and ethnicity groups in Massachusetts, a state heavily affected by both the COVID-19 pandemic and the overdose crisis.

Methods

Using Massachusetts OEND and OOD data from January 2016 to June 2021, we applied interrupted time series (ITS) models to analyze and compare the immediate (i.e., level) and gradual (i.e., trend) change in three outcomes of interest stratified by race and ethnicity at the state level after the onset of the COVID-19 pandemic (March 2020): (1) the monthly rate of OOD (2) the monthly rate of naloxone kits dispensed from OEND programs, and (3) naloxone availability, measured by the ratio of naloxone kits distributed per OOD.

Data

We extracted monthly, race and ethnicity stratified OODs classified as unintentional in Massachusetts between January 2016 to June 2021 from data collected by the Injury Surveillance Program at the Massachusetts Department of Public Health (MDPH) (21). We also used OEND program data during the same period provided by MDPH, which collects individual-level information, including race and ethnicity of the naloxone kit recipient (22). We chose January 2016 as the starting time point since it allowed us to capture the period where the rate of OOD became stabilized in Massachusetts (after 2016) as well as to balance the number of data points before and after the onset of the pandemic. Monthly OOD and OEND data were aggregated by race and ethnicity at the state level into the following mutually exclusive categories, consistent with the MDPH surveillance (13): non-Hispanic White [White], non-Hispanic Black [Black], Hispanic (any race) [Hispanic], non-Hispanic

other race [Other]. The non-Hispanic Other category included any race or ethnic category that was not Hispanic, non-Hispanic White, or non-Hispanic Black. For deaths, race and ethnicity information were sourced from next of kin and documented on death certificates by the Office of the Medical Examiner. For naloxone recipients, race and ethnicity were self-reported by participants documented by OEND program staff. The population size of each racial and ethnic group in each year was derived from census data from the U.S. Census Bureau (23).

Between January 2016 and February 2020 (defined as the pre-COVID-19 period), data with missing race and ethnicity information for naloxone kit recipients accounted for between 7% and 23% of all kits distributed by OEND programs. However, after March 2020 during the COVID-19 period the proportion of records with missing data surged to 47% to 79% (Appendix Figure S1), largely due to changes in distribution models (e.g., secondary distribution of program naloxone among people who use drugs, bulk distribution, high-risk drop-off distribution) (24, 25) and understaffed and overstretched programs. To address missing data during the pre-COVID-19 period, we estimated, among naloxone data with known race and ethnicity information, the proportions of naloxone kits received by each racial and ethnic group in each month, and then imputed the missing data in the same month assuming the same proportions assigned to each racial and ethnic group. We then imputed the missing data during the COVID-19 period with a similar approach by pooling five different periods of data with complete information to assess robustness of our analysis,: (1) in the same month; (2) during the COVID-19 period (March 2020 to June 2021); (3) during the last 32 months (November 2018 to June 2021, 16 months each during the pre-COVID-19 and COVID-19 period); (4) during the pre-COVID-19 period (January 2016 to February 2020); and (5) during the last two years of the pre-COVID-19 period (March 2018 to February 2020). For example, if among known data 70% of naloxone kits were received by White people in a given period, we assumed 70% of the naloxone kits with missing data were also received by White people in each month during the COVID-19 period.

The data used in this study were obtained from MDPH that captures all opioid overdose deaths and naloxone kits distributed from OEND programs in the entire state. As such, this population-level dataset is representative of the Massachusetts population, despite some limitations associated with missing or incomplete data.

Outcome measures

We examined changes at the outset of the COVID-19 pandemic to the following outcome measures: (1) monthly rate of OODs per 100,000 people, total and stratified by race and ethnicity; (2) monthly rate of naloxone kits distributed from OEND programs per 100,000 people, total and stratified by race and ethnicity; and (3) ratio of naloxone kits from OEND programs per OOD, total and stratified by race and ethnicity. Based on previous studies (22, 26), we used the ratio of naloxone kits per OOD, as calculated by the ratio between the number of naloxone kits received by a population group in a given month and the number of OODs that occurred in the same population group and month, as a measure for naloxone availability. When modeling this ratio outcome, we excluded the “Other” racial and ethnic

group because of small population size (and resulting large variation) and zero OODs in several data points.

Statistical analysis

We used an ITS analysis to assess the changes to opioid overdose deaths and community naloxone access after the onset of the COVID-19 pandemic. We used different regression models in the ITS analysis for different outcome measures (see below). In all models, in addition to a time variable (measured by months since January 2016) that captured the slope of the estimated outcome from baseline, an indicator variable was used to define the COVID-19 period and estimate the change in level after the onset of COVID-19. We also included an interaction term between the COVID-19 period and time elapsed since the beginning of the COVID-19 period to estimate the change in the trend during the COVID-19 period, compared with the pre-COVID-19 period.

In analyzing the rate of OODs and naloxone kits distributed from OEND programs, we fit the data with a negative binomial regression model using the size of the corresponding population group as an offset. In modeling the ratio of naloxone kits per OOD, we used lognormal regression models given that the response variable was right-skewed.

The potential autocorrelations and seasonality terms were determined using visualization and the autocorrelation and partial autocorrelation functions (27). The results confirmed that no adjustment for autocorrelation or seasonality was required for models focusing on the rate of OODs, and the ratio of naloxone kits per OOD. However, we identified seasonality in the rate of naloxone kits distributed from OEND programs (e.g., lower in winter months) and used a Fourier term (two pairs, 12 months per cycle) to account for seasonality in the corresponding models. We used a significant level of five percent for all analyses and reported all outcomes with their 95% confidence intervals.

The five imputation strategies were based on the assumption that the missing naloxone data had the same racial and ethnic distribution as those with complete information during the corresponding periods. To assess the sensitivity of the results to this assumption, in an additional sensitivity analysis, we estimated the proportion of naloxone kits with missing race and ethnicity that would need to be assigned to Black people to be able to compensate for the increase in opioid overdose deaths among Black people during the COVID-19 period.

The analysis was undertaken in R 4.2.1 (28) using the “lmtest” (29), “MASS” (30), and “tsModel” (31) packages. Analysis code of this study is available on request from the corresponding author. The data supporting the findings of this study are available within the article and its supplementary materials. This study was deemed exempt from human subjects research review by Brown University, Boston University Medical Campus, and MDPH Institutional Review Boards, as this work involved analysis of aggregate data only. The analysis was not pre-registered and the results should be considered exploratory.

Results

We presented in Table 1 the distribution of population, OODs and naloxone kits distributed from OEND programs between January 2016 to June 2021. Based on data with complete information and without imputing missing values, before the COVID-19 pandemic, the average monthly number of OODs was 166 (79.6%, 5.2%, 13.2%, 2.0% among White, Black, Hispanic, and Other people, respectively), with an average of 2,890 naloxone kits distributed from OEND programs per month (75.8%, 7.3%, 13.2%, 3.7% among White, Black, Hispanic, and Other people, respectively). The average number of OODs and naloxone kits distributed per month increased to 175 (73.7%, 9.0%, 14.8%, 2.6% among White, Black, Hispanic, and Other people, respectively) and 3,977 (73.1%, 7.9%, 15.7%, 3.2% among White, Black, Hispanic, and Other people, respectively) during the COVID-19 period, respectively.

Figure 1 Panels A to C show the overall rate of OOD, rate of naloxone kits distributed from OEND programs, and ratio of naloxone kits from OEND programs per OOD, across all population groups, before and after the start of the COVID-19 pandemic. Overall, the rate of OOD remained relatively constant before the pandemic (monthly rate ratio: 0.999, 95% confidence interval [CI]: 0.997 to 1.000, $p>0.1$). After the pandemic, the rate did not change significantly for either level (rate ratio: 1.08, 95% CI: 0.97 to 1.20) or trend (monthly rate ratio: 1.001, 95% CI: 0.992 to 1.011). The rate of naloxone kits distributed from OEND programs significantly increased over time before the COVID-19 pandemic (monthly rate ratio: 1.01, 95% CI: 1.008 to 1.012). The pandemic was not associated with a significant change in the level (rate ratio: 1.02, 95% CI: 0.904 to 1.149) or trend (monthly rate ratio: 0.996, 95% CI: 0.985 to 1.007) of kits distributed from OEND programs, indicating the pre-pandemic rate was sustained during the pandemic. The ratio of naloxone kits per OOD demonstrated a similar pattern to the rate of naloxone kits distributed, where the ratio was estimated to increase by 1.1% per month (95% CI: 0.8% to 1.3%) over time, while the level and trend for the ratio did not change significantly after the start of the COVID-19 pandemic.

In a race and ethnicity stratified analysis for the rate of OODs (Figure 2, Table 2), we found that there was a significant, pre-COVID-19, decreasing trend for the rate among White people (monthly rate ratio: 0.998, 95% CI: 0.996 to 1.000, $p=0.03$). In contrast, the rate showed an increasing trend for the other three racial and ethnic groups, although not statistically significant. We found a 1.64 (95% CI: 1.16 to 2.30) incidence rate ratio (level change) for the rate of OODs among Black people as the pandemic began. However, neither the level of OOD rates among the other three groups, nor the trend among all groups changed significantly after the beginning of the pandemic.

The stratified analysis for the rate of naloxone kits distributed using different imputation strategies yielded very similar results (Figure 3, Table 2, Appendix Table S1, Figure S2-S6). In all imputation scenarios but one, the pre-COVID-19 trend (i.e., rate ratio) was the only variable found to be significant across all racial and ethnic groups, which was highest among the Hispanic group and lowest among the Black group, e.g., imputing missing data using data during the COVID-19 period, monthly rate ratio for White: 1.010, 95% CI:

1.008 to 1.012; Black: 1.008, 95% CI: 1.005 to 1.011; Hispanic: 1.012, 95% CI: 1.010 to 1.015; Other: 1.009, 95% CI: 1.006 to 1.011. In the imputation scenario using the same month's data, there was a significant further increase during the COVID-19 period among Black people (monthly rate ratio: 1.021, 95% CI: 1.005 to 1.037, Appendix Table S1). The COVID-19 pandemic was not found to be associated with any discernible level change in the rate of naloxone kits distributed to any racial and ethnic groups.

The stratified analysis for the ratio of naloxone kits per OOD also produced relatively consistent results across all imputation scenarios (Table 2, Figure 4, Appendix Table S1, Figure S7-S11). With missing data imputed using data during the COVID-19 period, during the 50-month pre-COVID-19 period, there was a steady increase in the ratio among White (baseline trend: 1.1% increase per month, 95% CI: 0.8% to 1.4%) and Hispanic (1.0% increase per month, 95% CI: 0.2% to 1.8%) people. However, a similar trend was not found to be significant among Black people. While we found no significant changes in the level or trend of the ratio during the COVID-19 period across all subpopulations, the immediate level reduction in the ratio following the pandemic was large but not significant (36.3%-44.3% across different imputation scenarios) for Black people.

In the sensitivity analysis, we varied the proportion of naloxone kits with missing data assigned to Black people until the estimated level change with the onset of COVID-19 to the ratio of naloxone kits distributed per opioid overdose death becomes greater than one. We estimated that at least 15% of naloxone kits with missing data during the COVID-19 period needed to be assigned to Black people, which was nearly twice as high as the estimated proportion in the other five imputation scenarios (7.23%-7.9%), and it would require the proportion of kits received by Black people to increase from 7.3% during pre-COVID-19 period to 12% during the COVID-19 period (Appendix Table S2).

Discussion

In this interrupted time series analysis, we used Massachusetts Department of Public Health data to estimate the rate of OODs and naloxone kits distributed by OEND programs, as well as the ratio between the two as a measure for naloxone availability. We evaluated and compared the impact of the COVID-19 pandemic on these outcomes overall and stratified by race and ethnicity. Throughout the study period between January 2016 to June 2021, we observed a constant or declining rate of OODs that was unchanged among non-Black groups during the COVID-19 pandemic period. In contrast, the OOD rate increased sharply by 64% among Black people immediately after the beginning of the pandemic. Following a steady increase in the rate of naloxone kits distributed and naloxone availability prior to the start of the pandemic, the pandemic was not found to have any significant immediate (level change) or sustained (trend change) impact across all racial and ethnic groups except for the Black group.

Unsurprisingly, given that over 70% of the Massachusetts population are White, the overall trends for all three outcome measures resembled those among White people. Without stratified analysis, contrary trends among minoritized racial and ethnic groups would be masked by trends in the White people. These results underscore the necessity for stratified

data collection and analysis, which is essential to monitoring trends by race and ethnicity, identifying racial inequities in health outcomes, helping set priorities, and guiding equity improvement strategies (32). To our knowledge, Massachusetts is one of the few states that collects demographic information for each naloxone kit distributed through OEND programs, which provides unique opportunities to assess the disparities in naloxone access in response to the changing dynamics of the opioid overdose epidemic and understand the gaps in naloxone supply and demand.

Our estimates are generally in line with prior studies. One study in Philadelphia found a greater than 20% decrease in OOD counts from 2019 to 2020 during the COVID-19 period among non-Hispanic White people, as opposed to over 50% increase among non-Hispanic Black people (10). Another study conducted in California also showed that the gap in Black-White drug overdose mortality rate doubled during the COVID-19 pandemic (33). A nationwide analysis also found greater percentage increase in overdose mortality among Black (48.8%) than White (26.3%) people in 2020 (11). However, none of these studies addressed the impact of the pandemic on the distribution of naloxone.

Massachusetts has put substantial effort into curbing fatal opioid overdoses and expanding community-based access to naloxone, as observed by the continuous reduction in the overall rate of OODs, as well as the steady rise in the rate of naloxone kits distributed to all population groups, a trend that even continued during the COVID-19 period. However, since the pandemic began, the increase in the demand for naloxone, as seen by the increase in OOD rate, has outpaced the naloxone expansion efforts among Black people. Thus, the current naloxone allocation and distribution models may be insufficient to ensure equitable access to naloxone and to adapt to new needs associated with the rapidly evolving epidemic.

Although we identified some temporal associations between the pandemic and changes in the rate of OODs and naloxone availability among different racial and ethnic groups, there is more to learn regarding the causal factors of these disparities. Further research is needed to understand whether the surge in the rate of OODs among Black people was due to increased presence of fentanyl in specific drug supplies (e.g., cocaine) and patterns of polysubstance use (11, 33), interruptions to other healthcare services such as emergency medical services and medications for OUD (34), increasing solitary drug use due to isolation requirements (35, 36), or a combination of these factors. It is also imperative to assess whether structural factors and preexisting challenges that have been exacerbated during the pandemic, such as unstable housing, mental health issues, poverty, poor access to health care, social isolation, and stigmatization (37), are affecting Black people who use drugs disproportionally in the COVID-19 era. For example, known disparities in healthcare access are attributed to the long history of racialization of attitudes toward addiction and addiction treatment in the USA (38). Public health response strategies are urgently needed to meet the increasing needs and focus on engaging Black and other racial and ethnic minority individuals at elevated risk for overdose to counteract the effects of interpersonal and structural racism (34). These strategies may include raising awareness about the worsening disparities, improving access to OUD treatment, harm reduction services and integrating them into routine clinical care, using innovative service delivery models, and implementing a holistic community-based response to overdose prevention (12). Providing naloxone kits and training to people who

use stimulants without intending to use opioids, who often lack awareness of fentanyl and access to naloxone, has also became increasingly important (39).

This study has several limitations. First, there was substantial missing data on the race and ethnicity of naloxone recipients in 2020 and 2021 largely due to changes in distribution models and resource and staffing challenges faced by OEND programs. Physical distancing policies, stay-at-home orders, and staff and participant COVID exposure, impacted the ability of program staff to engage in traditional face-to-face encounters where demographic data could be collected. Concerns were raised that the missingness of data could be differential across racial and ethnic groups as a result of structural racism in data collection stemming from challenges in staffing of programs serving more racial and ethnic minority people. However, the percentages of naloxone kits received by different subpopulations among known data remained relatively constant prior to and during the pandemic (Table 1). Furthermore, we used data from five different periods with complete information to impute missing data during the COVID-19 period. The five imputation scenarios yielded similar results, strengthening the robustness of our study findings. As an additional sensitivity analysis, we estimated the proportion of naloxone kits with missing race/ethnicity would need to be assigned to Black people to be able to compensate for the increase in opioid overdose deaths among Black people during the COVID-19 period (Appendix Table S2). Future research investigating individual naloxone distribution programs and incorporating more recent data will help ascertain whether data missingness is differential. Second, based on the best data available to us, our analyses categorized the Massachusetts population into four mutually exclusive racial and ethnic categories. While analyzing the data using these categories allowed us to examine potential racial and ethnic inequities, they also over-generalize and obscure the different experiences and inequities likely faced by more specific racial and ethnic populations. As an example, non-Hispanic, American Indian Massachusetts residents have a three-fold higher opioid overdose death rate than the overall population, yet we did not analyze this group as its own category due to small numbers (13). Third, it is recommended that interrupted time series analyses include at least 24 time points to improve adjustment for seasonality (27) and equal numbers of time points before and after the interruption to ensure sufficient statistical power (40). However, in our analysis, we only had 16 time points during the COVID-19 period (up until June 2021), versus 50 before the pandemic, because newer data during the COVID-19 period were not yet available, which might result in widened confidence intervals in the estimates. Forth, while the OEND programs in Massachusetts only collected information about the recipients of naloxone kits, there may be a discrepancy between the race and ethnicity of the naloxone recipient and the person for whom the naloxone is ultimately administered. However, research has indicated that drug use networks often form clusters based on race and ethnicity (41, 42), and the OEND programs in Massachusetts prioritize distribution to individuals who use drugs and their social networks, including friends, partners, and family members who are most likely to witness an overdose (43). As such, the OEND programs are likely to reach people who share similar racial and ethnic backgrounds as those who are ultimately administered the medication. Lastly, we did not include naloxone kits distributed from pharmacies since person-level, race and ethnicity-stratified pharmacy naloxone data were not available during the study period. A previous study, however, found that individuals at

risk of opioid overdose were significantly less likely to collect a naloxone kit at a pharmacy site compared to community-based sites (44).

Conclusions

We did not find any significant trends in OOD or access to naloxone among non-Hispanic White and Hispanic people in Massachusetts during the COVID-19 pandemic. However, among Black people, a surge in opioid overdose deaths was found in the period immediately following the beginning of the pandemic, while the availability of naloxone appeared to worsen during the pandemic (although this latter change was not found to be statistically significant). These findings highlight the need for overdose prevention and naloxone distribution interventions tailored to the minoritized communities that have been most affected by overlapping public health crises.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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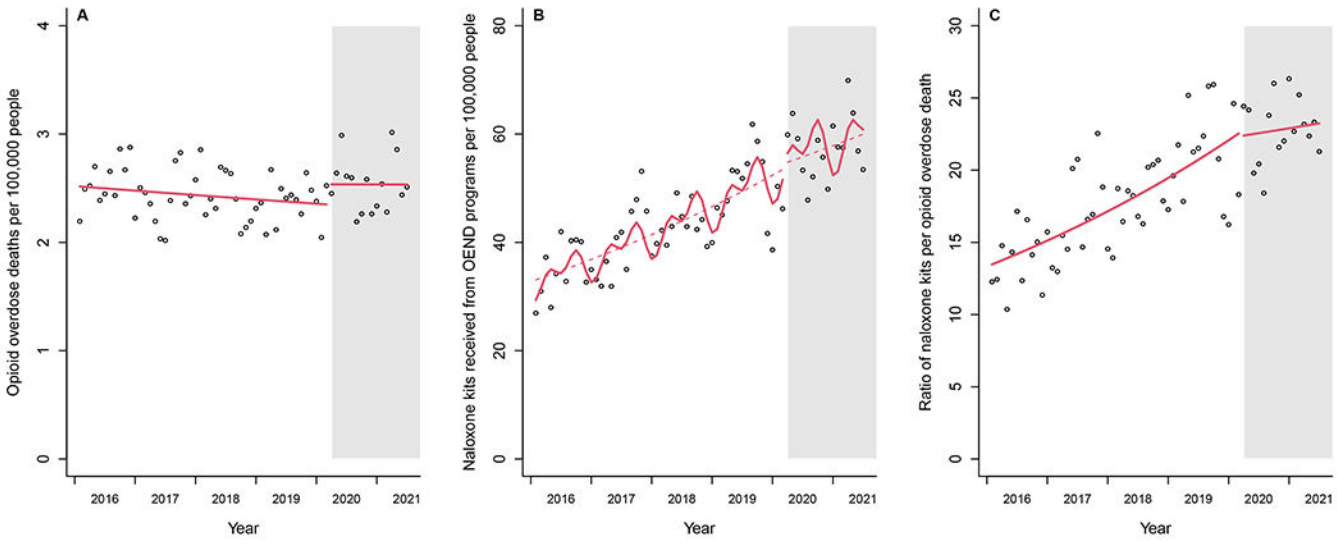

Figure 1. Interrupted time series analysis on the overall impact of the COVID-19 pandemic across all racial and ethnic groups on: A: rate of opioid overdose deaths per 100,000 people; B: rate of naloxone kits distributed from opioid education and naloxone distribution (OEND) programs; C: ratio of naloxone kits per opioid overdose death.

Dots represent observed outcome measures. Solid red lines represent predicted outcome measures based on the interrupted time series models (for Panel B, it represents predicted rate of naloxone kits distributed from OEND programs with seasonality terms). Dashed red lines represent de-seasonalized predicted rate of naloxone kits distributed from OEND programs. Grey area represents the COVID-19 period.

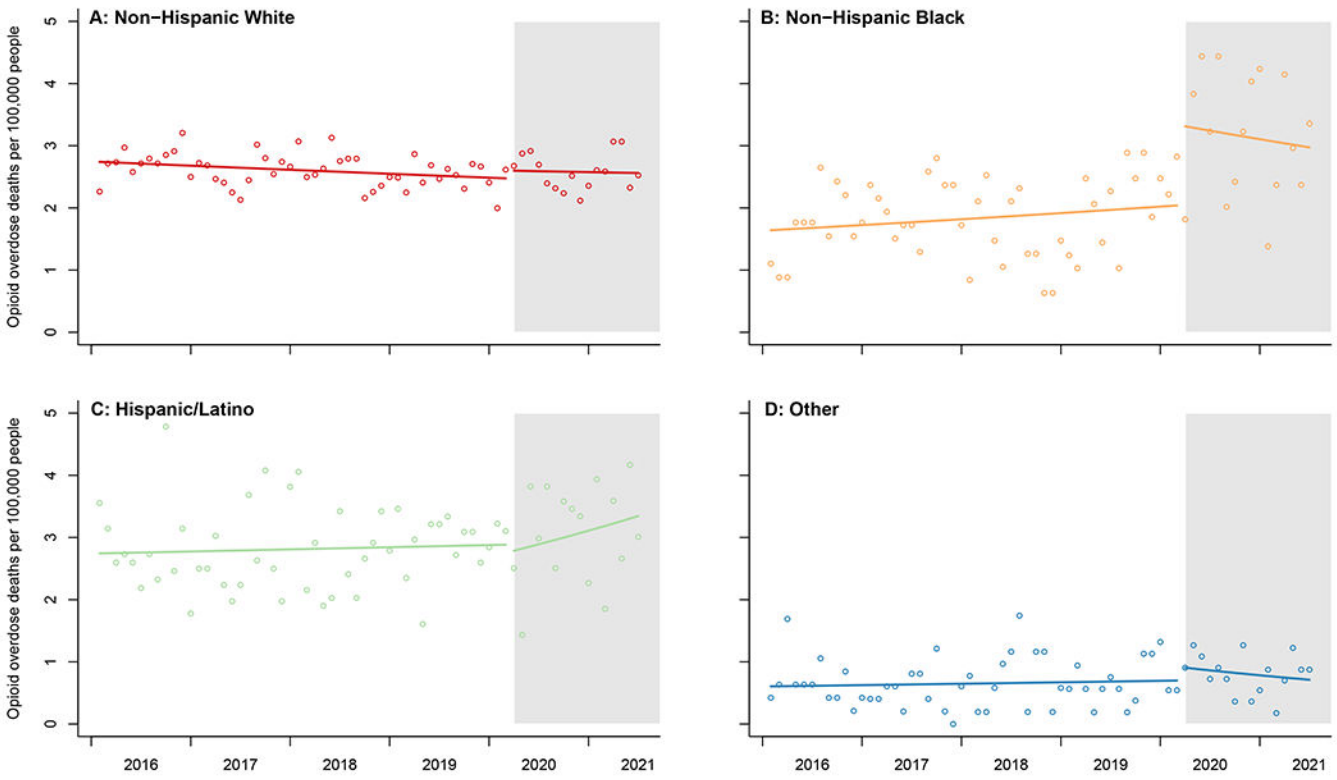

Figure 2. Rate of opioid overdose deaths per 100,000 people among different racial and ethnic groups in Massachusetts before and during the COVID-19 pandemic.

Dots represent observed rate of opioid overdose deaths. Solid lines represent predicted rate of opioid overdose deaths based on the interrupted time series model. Grey area represents the COVID-19 period.

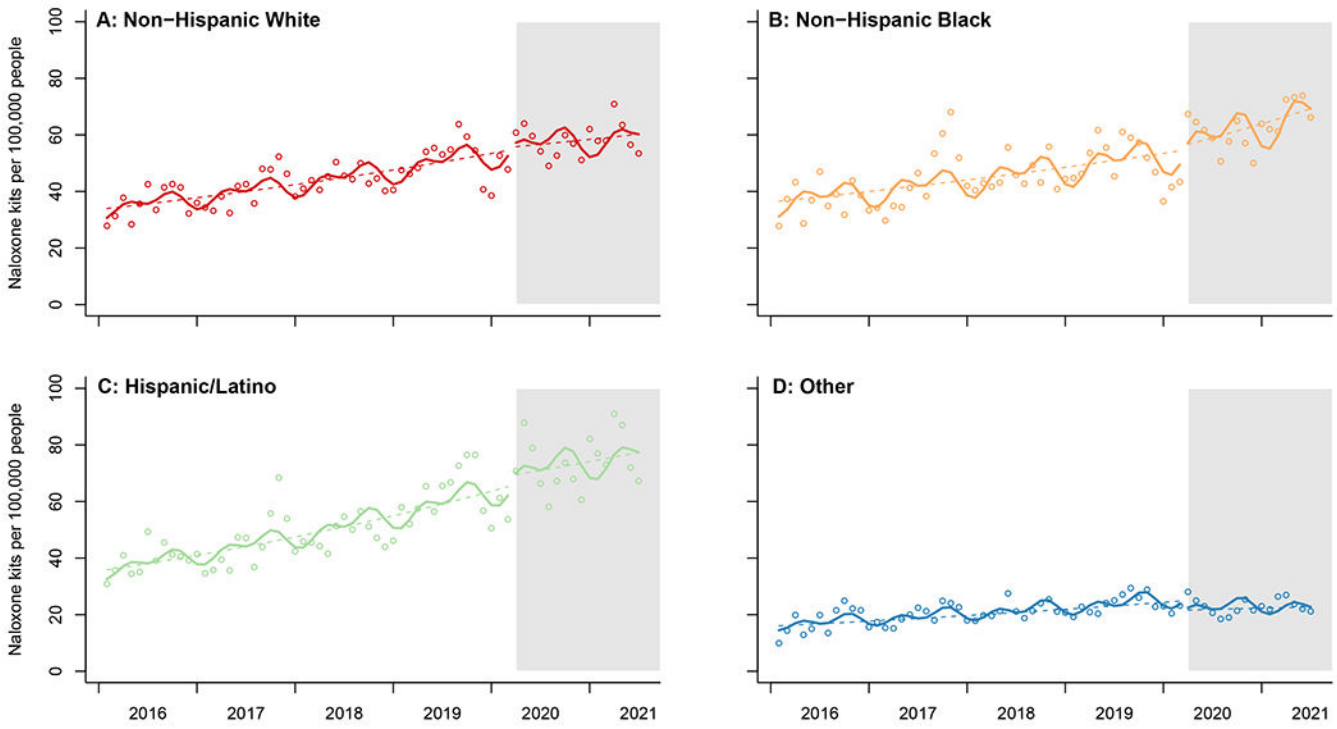

Figure 3. Rate of naloxone kits distributed from opioid education and naloxone distribution programs per 100,000 people among different racial and ethnic groups in Massachusetts before and during the COVID-19 pandemic, with missing data imputed with data during the COVID-19 period with complete information.

Dots represent observed rate. Solid lines represent predicted rates based on the interrupted time series models with seasonality terms. Dashed lines represent de-seasonalized predicted rates. Grey area represents the COVID-19 period. Results in other imputation scenarios are similar and are available in Appendix Figure S2-6.

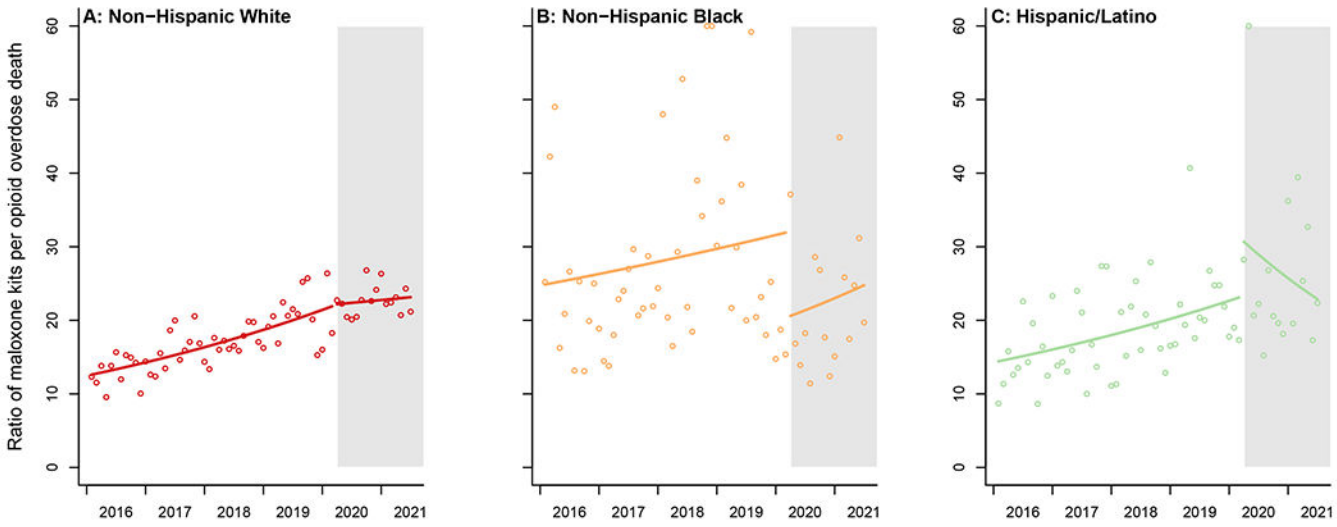

Figure 4. Ratio of naloxone kits distributed from opioid education and naloxone distribution programs per opioid overdose death among different racial and ethnic groups in Massachusetts before and during the COVID-19 pandemic, with missing data imputed with data during the COVID-19 period with complete information.

Dots represent observed ratio. Solid lines represent predicted ratio based on the interrupted time series models. Grey area represents the COVID-19 period. Results in other imputation scenarios are similar and are available in Appendix Figure S7-11.

Table 1.

Characteristics of opioid overdose deaths and naloxone kits distributed from Overdose Education and Naloxone Distribution (OEND) programs among overall population and racial and ethnic subgroups before and during the COVID-19 pandemic

	Prior to COVID-19 pandemic (Jan 2016 to Feb 2020)	During COVID-19 pandemic (Mar 2020 to Jun 2021)
Population size *		
Overall population	6,806,713	6,908,307
Non-Hispanic White	5,055,217	5,001,289
Non-Hispanic Black	470,486	499,762
Hispanic	775,168	847,671
Non-Hispanic Other	505,842	559,586
Monthly average number of opioid overdose deaths [rate per 100,000 people]		
Overall population	166 [2.43]	175 [2.53]
Non-Hispanic White	132 [2.61]	129 [2.58]
Non-Hispanic Black	9 [1.84]	16 [3.14]
Hispanic	22 [2.81]	26 [3.06]
Non-Hispanic Other	3 [0.65]	5 [0.80]
Monthly average number of naloxone kits distributed from OEND programs [rate per 100,000 people]		
Overall population	2,890 [42.5]	3,977 [57.6]
Percentage of naloxone kits distributed from OEND programs ^		
Non-Hispanic White	75.8%	73.1%
Non-Hispanic Black	7.3%	7.9%
Hispanic	13.2%	15.7%
Non-Hispanic Other	3.7%	3.2%
Average ratio of naloxone kits distributed per opioid overdose death		
Overall population	17.5	22.7
Percentage of naloxone kits with missing race and ethnicity data		
Overall population	16.5%	57.1%

Legend:

* Based on census data.

^ Based on naloxone data with complete race and ethnicity information only

Table 2.

Race and ethnicity-stratified interrupted time series analysis on the rate of opioid overdose death, rate of naloxone kits distributed from Overdose Education and Naloxone Distribution (OEND) programs, and ratio of naloxone kits per opioid overdose death before (baseline trend) and during (level/trend change) the COVID-19 era

Race and ethnicity	White	Black	Hispanic	Other
Rate of opioid overdose death per 100,00 people				
Baseline trend	**0.998 (0.996, 1.000)**	1.004 (0.998, 1.011)	1.001 (0.996, 1.006)	1.003 (0.992, 1.014)
Level change	1.050 (0.936, 1.178)	**1.636 (1.164, 2.300)**	0.955 (0.733, 1.244)	1.316 (0.752, 2.303)
Trend change	1.001 (0.991, 1.012)	0.988 (0.959, 1.019)	1.011 (0.987, 1.036)	0.981 (0.932, 1.033)
Rate of naloxone kits distributed from OEND programs per 100,00 people				
Missing data imputed with data during the COVID-19 period with complete information *				
Baseline trend	**1.010 (1.008, 1.012)**	**1.008 (1.005, 1.011)**	**1.012 (1.010, 1.015)**	**1.009 (1.006, 1.011)**
Level change	1.019 (0.904, 1.150)	1.028 (0.880, 1.201)	1.058 (0.915, 1.223)	0.871 (0.756, 1.003)
Trend change	0.995 (0.984, 1.007)	1.005 (0.991, 1.020)	0.995 (0.982, 1.008)	0.994 (0.981, 1.007)
Ratio of naloxone kits distributed per opioid overdose death				
Missing data imputed with data during the COVID-19 period with complete information *				
Baseline trend	**1.011 (1.008, 1.014)**	1.005 (0.996, 1.015)	**1.010 (1.002, 1.018)**	
Level change	1.010 (0.885, 1.153)	0.637 (0.315, 1.289)	1.355 (0.977, 1.880)	
Trend change	0.992 (0.980, 1.003)	1.007 (0.943, 1.076)	0.971 (0.942, 1.001)	

Legend: Cells with bold text represent estimates that were found to be statistically significant. Numbers in parentheses represent 95% confidence intervals. Trend change represents relative change in the slope gradient during the COVID-19 period compared to the pre-COVID-19 period.

* Results in other imputation scenarios are similar and are available in Appendix Table S1.