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The impact of the national stay-at-home order on emergency department visits for suspected opioid overdose during the first wave of the COVID-19 pandemic

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ABSTRACT

Background: Although national syndromic surveillance data reported declines in emergency department (ED) visits after the declaration of the national stay-at-home order for COVID-19, little is known whether these declines were observed for suspected opioid overdose.

Methods: This interrupted time series study used syndromic surveillance data from four states participating in the HEALing Communities Study: Kentucky, Massachusetts, New York, and Ohio. All ED encounters for suspected opioid overdose (n = 48,301) occurring during the first 31 weeks of 2020 were included. We examined the impact of the national public health emergency for COVID-19 (declared on March 14, 2020) on trends in ED encounters for suspected opioid overdose.

Results: Three of four states (Massachusetts, New York and Ohio) experienced a statistically significant immediate decline in the rate of ED encounters for suspected opioid overdose (per 100,000) after the nationwide public health emergency declaration (MA: -0.99; 95% CI: -1.75, -0.24; NY: -0.10; 95% CI, -0.20, 0.0; OH: -0.33, 95% CI: -0.58, -0.07). After this date, Ohio and Kentucky experienced a sustained rate of increase for a 13-week period. New York experienced a decrease in the rate of ED encounters for a 10-week period, after which the rate began to increase. In Massachusetts after a significant immediate decline in the rate of ED encounters, there was no significant difference in the rate of change for a 6-week period, followed by an immediate increase in the ED rate to higher than pre-COVID levels.

Conclusions: The heterogeneity in the trends in ED encounters between the four sites show that the national stay-at-home order had a differential impact on opioid overdose ED presentation in each state.

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1. Background

The initial months of the COVID-19 pandemic saw a significant change in health care-seeking behavior and health care delivery. Stay-at-home orders were enacted by most states by the end of March 2020, and many health systems began prioritizing urgent visits and delaying/ceasing elective care to prepare for a potential surge in COVID-19 patients. By May 2020, the national syndromic surveillance program (NSSP) reported that emergency department (ED) visits declined 42 % during the early months of the pandemic (Hartnett et al., 2020). Even visits for events necessitating emergent care (e.g., myocardial infarction and stroke) declined during this time (Lange et al., 2020). Fear of COVID-19 exposure, unintended consequences of public health recommendations to minimize non-urgent health care, and stay-at-home orders have been postulated as contributors to this decline in care-seeking behavior (Lange et al., 2020; Wong et al., 2020).

The impact of the COVID-19 pandemic and national and state stay-at-home orders will likely have a disproportionate adverse effect on individuals with opioid use disorder (OUD) due to disruptions in the availability and accessibility of treatment, changes in social support and networks, isolation, and stress-associated increases in substance use or relapse (Enns et al., 2020). Service organizations changed naloxone distribution practices, which may have decreased distribution (Ostrach et al., 2021). Disruptions to drug supply chains (Shelley, 2020) may lead individuals to obtain substances with which they are less familiar. For those in treatment for OUD, interruptions to care due to reduced access to treatment programs providing medications for opioid use disorder (MOUD), behavioral health services, and recovery support services may place people with OUD at higher risk for relapse and potential overdose (Alexander et al., 2020; Becker and Fiellin, 2020). Additionally, isolation physical distancing, closure of recreation and community facilities, and limits on cultural and religious gatherings may affect social support systems that help people cope with stress and addiction. These changes in social support may lead to higher levels of anxiety, depression, and despair (Holingue et al., 2020; Liu et al., 2020; Munk et al., 2020; Papandreou et al., 2020), known risk factors for substance use disorders and relapse.

EDs are critical touch points where individuals with OUD are identified and linked to recovery and treatment resources (Larochelle et al., 2019; Samuels, 2014). Accordingly, surveillance of opioid overdoses (OOD) treated in the emergency department is a critical component of the public health response to OUD. Because it is timelier than death data, ED data can identify emergent trends in nonfatal drug overdoses, highlighting opportunities for rapid public health response to prevent overdoses (Vivolo-Kantor et al., 2020). Health departments can use ED syndromic data to identify changes in overdose burden quickly and disperse naloxone and alerts to communities at risk (Houry et al., 2018). This type of surveillance is particularly important during a public health crisis, such as the COVID-19 pandemic, because widespread disruption to the public health system may lead to unexpected changes in ED utilization for OOD. Such changes may complicate the use of indicators of nonfatal overdose for public health surveillance activities, perhaps rendering them less reliable or less representative of overdose rates. Examining the dynamics of ED syndromic data before and after the declaration of the national stay-at-home order and throughout the initial wave of the pandemic may lead to important insights into how ED utilization for OOD was affected by the crisis.

2. Methods

2.1. Data and study population

The HCS is a multi-site study in 67 communities across four states (Kentucky, Massachusetts, New York, and Ohio) (‘HEALing Communities Study,’ 2019). The goal of the HCS is to test the impact of the Communities That Heal (CTH) intervention, a community-based approach to adopting and implementing evidence-based programs to reduce OOD fatalities. The intervention began in January 2020 with a protracted community engagement phase. Implementation of the EBPs was not fully underway until late summer and did not directly affect the ED trends examined here. The HCS communities were selected because they were some of the most highly affected by the opioid crisis. This unique aspect of the study design allowed us to examine whether the national stay-at-home order for COVID-19 impacted ED encounters for suspected OOD differentially in highly affected (HCS) vs. less affected (non-HCS) communities. We utilized data from state syndromic surveillance systems (Hennig, 2004) (which report ~95 % of all statewide ED encounters) to quantify the frequency of ED encounters for suspected OOD. Encounter definitions were based on presence of opioid poisoning codes using the International Classification of Diseases, 10th revision, Clinical Modification (ICD-10-CM) with relevant keywords and state-specific definitions (Supplementary Appendix A). Encounters that occurred during the first 31 weeks of 2020 (weeks ending 1/4/2020-8/1/2020) were included.

For each state, counts of ED encounters for suspected OOD were aggregated by the Morbidity and Mortality Weekly Report (MMWR) week (Centers for Disease Control and Prevention (CDC), 2016) for: 1) the state, 2) HCS communities, and 3) non-HCS communities. Data for New York excluded New York City. Encounters from facilities reporting partial data for the study period were excluded. HCS communities are defined geographically by zip codes corresponding to cities and towns (Massachusetts), county (Kentucky and Ohio), or both (New York). Population denominators used the 2019 NCHS bridged-race population estimates for communities mapping to counties (Ohio, Kentucky, and some New York communities) and the 2014–2018 American Community Survey population estimates for communities mapping to zip codes (Massachusetts and some New York communities).

Daily number of COVID-19 cases for each state was obtained from the CDC COVID tracker website (https://covid.cdc.gov/covid-data-tracker/#datatracker-home). State-level data were aggregated by MMWR week and divided by the total population to create rates.

This study was approved by Advarra, the single institutional review board, on October 16, 2019 (Protocol Title: The HEALing Communities Study: Intervention Protocol, # Pro0003808).

2.2. Statistical methods

We used an interrupted time series design with segmented regression with autoregressive error (Slavova et al., 2018; Wagner et al., 2002; Walley et al., 2013) to model trends in the rate of weekly ED encounters for suspected OOD (per 100,000 population) for three segments of the study period defined by two change points. The first change point was pre-specified as MMWR week 12, the week following the national emergency declaration (March 15–21, 2020). To identify the second change point and model the potential for a leveling off or reversal of
trend, we tested each week between MMWR weeks 13–27 and selected the model with the best fit based on the maximum likelihood estimates for the Akaike’s Information Criteria (AIC). The end of the time series was MMWR week 31 (July 26–31, 2020), which allowed for a 4-week run-out period after the last potential change point to measure slope accurately. A model with no second change point was also assessed (Supplemental Appendix A).

Each model examined autoregressive parameters up to order 14 and dropped autocorrelation terms using backward selection when significance >0.05 to account for possible temporal autocorrelation. Each state’s data were analyzed separately, additionally comparing HCS to non-HCS communities within the state. Parameter estimates and 95% confidence intervals are reported. Average weekly rates and standard deviations (SD) were reported by state and time-period. We compare differences across states and between HCS and non-HCS communities by comparing overlap in the confidence intervals of estimates. All analyses were performed using SAS software, Version 9.4 (SAS Institute Inc, 2013).

3. Results

Fig. 1 shows trends in the rate of ED encounters for suspected OOD by state. The solid line represents the week ending March 14, 2020. Kentucky and Ohio experienced increased ED rates after the nationwide state of emergency. Massachusetts experienced an initial decline in ED rates followed by a rebound to slightly higher rates, and New York exhibited little change over the study period. Summary statistics for ED encounters for suspected OOD by state and study period are shown in Table 1.

3.1. Primary analysis: statewide models

Segmented regression analysis of statewide data (Fig. 2, Table 2) found that on MMWR week 1 (the pre-COVID intercept), the rate of ED encounters for suspected OOD per 100,000 residents was highest in Massachusetts with a rate of 3.99/100,000 population (95% CI: 3.60, 4.38), followed by Kentucky (1.78; 95% CI: 1.45, 2.11), Ohio (1.63; 95% CI: 1.45, 1.81) and New York (1.06; 95% CI: 1.00, 1.12). New York and Kentucky had small but significant positive slopes before March 14 (0.03 and 0.07, respectively), while Massachusetts and Ohio did not. We identified a statistically significant immediate decline in ED rates after March 14 in Massachusetts, New York, and Ohio, but not in Kentucky (e.g., COVID-19 Period 1 intercept change). Three states had a significant difference in the slope of the weekly ED rate regression lines before and after 3/14/2020; Kentucky and Ohio both saw an increase in rates (estimated slope change of 0.17 and 0.09, respectively), whereas New York saw a decrease (-0.08), and Massachusetts had no significant change.

The timing of the second change point differed across states. Massachusetts was earliest (week ending 5/2/2020), followed by New York (week ending 5/30/2020), Kentucky (week ending 6/20/2020), and Ohio (week ending 6/27/2020). Kentucky experienced an estimated immediate drop in ED encounters of 1/100,000 (95% CI: -1.67, -0.32) in the week ending 6/20/2020 compared with the previous week’s estimated rate. Furthermore, there was a significant change (-0.35; 95% CI: -0.49, -0.21) in the slope of Kentucky’s trend during COVID-19 Period 2 compared to Period 1. Ohio did not see a significant estimated immediate drop in the ED rate in COVID-19 Period 2, but there was a significant change in the slope of Ohio’s trend during Period 2 compared with the previous period (-0.18; 95% CI: -0.25, -0.10). New York (0.34, 95% CI: 0.23, 0.44) and Massachusetts (1.33; 95% CI: 0.07, 1.97) both had a significant immediate increase in the estimated ED rate in the COVID-19 Period 2, though only New York saw a small but significant change in the slope of the trend in Period 2 (0.03; 95% CI: 0.02, 0.05).

Taken together, these results indicate that national stay-at-home order impacted ED rates within each HCS state, but the dynamics differed across HCS states. We observed an initial decrease in visits in Massachusetts, New York and Ohio, but not Kentucky. After 3/14/2020 Kentucky and Ohio experienced a sustained rate of increase for an~13-week period, after which rates declined again. New York saw a decline in rates after 3/14/2020, before rising to rates similar to January 2020 at the end of May. After a significant decline in rates after 3/14/2020, Massachusetts experienced relatively little change, but then had a large increase at the second change point (5/2/2020) to a rate slightly higher than January 2020.
3.2. Secondary analysis: HCS vs. non-HCS community models

The initial rate of ED encounters for suspected OOD was higher in HCS vs. non-HCS communities in Kentucky, New York, and Massachusetts (no overlap in 95 % CIs), but not Ohio. Trends in ED encounters for HCS communities differed from trends in non-HCS communities (Fig. 3, Table 2). In HCS communities, there was a statistically significant immediate drop in the estimated rate of ED encounters after 3/14/2020 in Massachusetts (-2.53; 95 % CI: -3.69, -1.37) and Ohio (-0.38; 95 % CI: -0.72, -0.03), but not in Kentucky or New York. For non-HCS communities, there was a significant immediate drop in the estimated rate of ED encounters after 3/14/2020 in Kentucky (-0.72; 95 % CI: -1.22, -0.22), Massachusetts (-1.56; 95 % CI: -1.96, -1.16), and New York (-0.22; 95 % CI: -0.44, 0.00), but not in Ohio (-0.24; 95 % CI: -0.51, 0.04).

In HCS communities, two states saw significant slope changes for weekly ED encounter regression lines before and after 3/14/2020; Kentucky saw a significant increase (estimated slope change of 0.34), whereas New York saw a decrease (-0.21). In the non-HCS communities, Kentucky, Massachusetts, and Ohio saw a significant increase in the slope of the weekly ED encounters compared to the pre-COVID-19 period, to levels higher than before the national emergency was declared (slope change of 0.14, 0.13, 0.08, respectively).

The second change point in Kentucky and Ohio was earlier in HCS communities compared to non-HCS communities (Table 1), and the slope of the regression line after the second change point was negative, indicating a decreasing trend. In Massachusetts, rather than a drop after 3/14/2020 with a rebound at the second change point to nearly identical levels, HCS communities experienced a drop in March followed by a
Table 2
Parameter estimates for interrupted time series regression analysis of weekly rates of ED encounters for suspected opioid overdose, January 1, 2020 to July 31, 2020.

| Parameter Estimates | Pre-COVID-19 | COVID-19 Period 1 | COVID-19 Period 2 | COVID-19 Period 3 | COVID-19 Period 4 |
|---------------------|--------------|------------------|------------------|------------------|------------------|
| Intercept           | 1.78         | 0.07             | -0.05            | 0.17             | -0.10            |
| Slope Change        | (1.45, 2.11) | (0.01, -0.39)    | (0.10, -1.67)    | (0.49)           |                  |
| MA                  | 3.99         | 0.03             | -0.99            | 0.33             |                  |
| Slope Change        | (3.60, 4.38) | (0.03, -1.75)    | (0.24, 0.70)     | (0.13, 0.32)     |                  |
| NY                  | 1.06         | 0.03             | -0.10            | 0.08             | 0.34             |
| Slope Change        | (1.00, 1.12) | (0.02, -0.20)    | (0.09, 0.23)     | (0.02, 0.23)     | 0.03             |
| OH                  | 1.63         | 0.00             | -0.33            | 0.09             | -0.14            |
| Slope Change        | (1.45, 1.81) | (-0.03, -0.58)   | (0.06, -0.48)    | (0.25, 0.10)     | -0.10            |

Notes: Data from New York exclude New York City.

a Immediate intercept change (difference between the estimated end of the regression line for Pre-COVID Period and beginning of regression line for COVID-19 Period 1).

b Change in slope between pre-COVID period and Period 1.

c Immediate intercept change (difference between the estimated end of the regression line for COVID-19 Period 1 and beginning of regression line for Period 2).

d Change in slope between Period 1 and Period 2.

The intercept and slope change parameter estimates for Period 1 and Period 2 represent changes from the prior period: The COVID-19 Period 1 (2) Intercept change is the immediate change in ED encounter rates at the first (second) time point. The COVID-19 Period 1 (2) Slope change is the change in slope with respect to the prior period.

4. Discussion

Study results support our hypothesis of a significant impact of the national stay-at-home order on ED encounters for suspected OOD in the 4 HCS states, but indicate that the dynamics of this impact differed across the four states. ED encounters in New York and Massachusetts appear to mirror a general decrease in overall ED visits observed across the US. Kentucky and Ohio provide a counterpoint to this finding as both experienced increases in ED encounters for suspected OOD after the national emergency was declared. Results also indicate different dynamics between HCS and non-HCS communities suggesting communities with higher rates of OOD likely experienced differential effects of the stay-at-home order than communities with lower rates. Notably, this distinction was not apparent in Ohio where both HCS and non-HCS communities have high OOD rates. We also hypothesized that changes in ED encounters for overdose might be short-term in nature. Our analyses support this hypothesis as the regression models for all 4 states identified a second change point after which the slope or the intercept for ED encounters changed.

Research on the impact of the COVID-19 pandemic on OOD events is limited and results are mixed. Studies have used both ED and emergency medical services (EMS) encounter data to examine changes in OOD events. A national study using NSSP data, comparing ED visit counts for OOD for March 15–October 10, 2020 to the same period in 2019, found a significantly higher number in 2020 (Holland et al., 2021). Similarly, a study of 25 emergency departments across 6 states compared rates of OOD visits in 2018–2019 to visits during the COVID-19 pandemic and found a 10.5 % increase in 2020 despite a 14 % decline in all-case ED visits (Soares et al., 2021). Conversely, a study of 108 EDs in 18 U.S. states compared ED visits from March-July 2020 to the same period in 2019 found a decline in rates for OOD which began in mid-March (Pines et al., 2021). The authors also found substantial heterogeneity across states, though only a few states were directly compared and only Florida showed an increase in OOD during this time.

EMS clinicians surveyed between April–May 2020 reported substantial variation with 20 % of surveyed communities experiencing an increase in OOD and events during which naloxone was administered, while 40 % experienced a decrease (Cone et al., 2020). An interrupted time series study in Kentucky found a 17 % increase in the number of EMS OOD runs with transportation to an ED, and a 71 % increase in runs with refused transportation (Slavova et al., 2020). Similarly, an analysis of the National EMS Information System identified large increases in overdose-related cardiac arrest in the initial months of the pandemic (Friedman et al., 2021). There is inconsistency between the initial NSSP studies showing a decline in overall emergency department use and both the conceptual understanding of how the COVID-19 pandemic may affect individuals with OUD and the few studies reporting an increase in EMS utilization for suspected OOD. This difference could be related to the difference in study endpoints (ED vs. EMS), but prior studies have shown that OOD-related ED visits and EMS calls for suspected OOD follow similar trends over time (Lasher et al., 2019; Lindstrom et al., 2015).

Several reasons could account for that the differential impact of the national stay-at-home order across states and between HCS and non-HCS communities. The COVID-19 epidemic curves for the HCS states (Fig. S1) show very different dynamics. State and local governments chose to implement (and relax) a diverse set of mitigation measures, which affected health systems, care-seeking behaviors, social isolation, and economic stress differentially. Both New York and Massachusetts saw a rapid and significant spike in COVID-19 cases between April and May, with a marked decline through July and August, while Ohio and Kentucky experienced much slower and gradual growth in COVID-19 cases throughout the summer, surpassing New York and Massachusetts by early June (Centers for Disease Control and Prevention (CDC), 2020). Health systems in New York and Massachusetts were immediately overwhelmed, which could account for the initial drop in ED visits for suspected OOD in these states. The relatively quick rebound in opioid-involved ED rates experienced by Massachusetts is somewhat puzzling; in the statewide model, the decrease in ED rates for OOD lasted small but significant increase, and a second drop after 7/4/2020 with a second increase in slope. In New York, HCS communities saw a non-significant increase in ED encounters after the second change point while non-HCS communities saw a decrease.
for ~6 weeks before returning to early-2020 levels. Massachusetts hospitals were at the peak of the epidemic curve during this time and continued to have substantial burden of COVID-19, indicating hospital capacity issues may not be a main factor associated with observed declines. While a detailed analysis of the drivers behind the heterogeneity in ED rates is outside of the scope of this study, we examined whether there was a simple linear relationship between ED rates for OOD and community-level COVID-19 rates (results not shown) and found no consistent relationship across states, suggesting that the heterogeneity in ED rates for OOD was not mediated by local COVID infection rates. Future work is needed to examine the complex community dynamics that drove ED encounters for OOD throughout the COVID-19 pandemic.

Differences in the progression of the epidemic and state/local responses may also have affected EMS transports. An increase in patients refusing transport could impact the number of ED encounters for suspected OOD. One study of EMS OOD runs in Kentucky reported a large and significant increase in runs with transportation to ED in late March–April 2020 (Friedman et al., 2021), concordant with the Kentucky trends observed here. Another study in Massachusetts found a small increase in transport refusals after the statewide emergency was declared (from 5.0% to 7.5%) (Weiner et al., 2020), and we find a small but measurable drop in ED encounters for suspected OOD as well. These findings suggest that the relationship between EMS opioid runs and ED encounters for suspected OOD is complex and warrants further research.

While there is little empirical evidence on the impact of the pandemic on illicit drug markets, researchers have suggested that travel restrictions may disrupt established drug supply chains leading to substitutions of potentially more deadly analogues (Dietze and Peacock, 2020; Giommoni, 2020). Drug market changes could be responsible for the differences we observed in ED encounters for suspected OOD across HCS states. A recent study (Niles et al., 2021) examined clinical drug testing results from a national clinical laboratory before and during the COVID-19 pandemic and found a significant increase in illicit fentanyl/fentanyl drug combinations. Preliminary mortality data from Kentucky and Ohio indicate an increase in fentanyl-involved deaths in the first half of 2020 (Ohio Department of Health (ODH), 2021; Slavova et al., 2020); reports from Massachusetts and New York do not indicate similar trends (Massachusetts Department of Public Health, 2020; New York, 2021). Preliminary data from the Centers for Disease Control and Prevention confirms a 29.4% increase in drug overdose deaths through December 2020 over the prior year. This includes an increase of 53.7% in Kentucky, 1.9% in Massachusetts, 32.3% in New York, and 21.9% in Ohio (Centers for Disease Control and Prevention (CDC), 2021).

Assuming that overdose deaths and ED encounters for suspected OOD are correlated, the preliminary death data show that overdoses have increased, especially in Kentucky, New York, and Ohio, and suggest that an increase in fentanyl may be driving the increase in ED encounters in Kentucky (Slavova et al., 2020) and possibly Ohio. Similar trends were seen in 2015 when the increase in OOD deaths across the U.S. were driven by the introduction of illicitly manufactured fentanyl (Gladden et al., 2016; Park et al., 2021; Peterson et al., 2016).

Finally, we are careful to note that ED encounters for suspected OOD are only one component of community-level overdose rates. Historically, there has been an association in the overall trends in overdose morbidity and mortality data, and it is reasonable to expect that significant shifts in ED encounters for OOD would be indicative of significant shifts in mortality. However, the unprecedented nature of the COVID-19 pandemic may have disrupted this historical relationship.
between data sources of morbidity and mortality, given the recent CDC data documenting 2020 as having the highest historical rates of overdose death (Centers for Disease Control and Prevention (CDC), 2021). Rather, we suggest that the national stay-at-home order and the COVID-19 pandemic led to widespread and complicated changes in historical patterns of opioid misuse, overdose, and care seeking behaviors. These changes are reflected in the inconsistency and heterogeneity in the dynamics of ED encounters and EMS transports for OOD and OOD mortality noted in the current literature. If health departments are using ED syndromic data for surveillance purposes, officials should be aware that a decline in ED encounters for drug overdose may not be indicative of a larger community-wide decline. When states release their weekly and monthly counts of OOD deaths for 2020, researchers will be able to assess if the general association between mortality and morbidity overdose trends remained during the unprecedented circumstances of the COVID-19 pandemic.

We note a few limitations of this study. States’ syndromic systems vary in terms of data elements captured and completeness, leading to slightly differing OOD definitions. These differences may impact resultant magnitudes of cases and limit direct comparison between states. However, comparison of changes in patterns of overdose over time are relevant. Second, at baseline, the scalar differences between states’ syndromic OOD encounters are similar to historic differences seen in publicly available opioid-related hospital use provided by the Agency for Healthcare Research and Quality (Agency for Healthcare Research and Quality (AHRQ), 2021). The ability to detect opioid visits may differ by state and facility based on the percentage of ED visits with diagnosis codes. Third, while we examine ED encounters for suspected OOD as one indicator of rates of overdose in our communities, not all OOD are captured in ED data, so this is likely an underestimation of the problem. Finally, our analysis only extends through the first (summer) wave of the pandemic. It is possible that the dynamics of ED encounters were different for the second (winter) wave.

5. Conclusions

In this study, three of four states experienced a statistically significant decline in ED encounters for suspected OOD immediately after the national public health emergency was announced for the COVID-19 pandemic. The heterogeneity in the trends in ED encounters across the four states suggest that the national stay-at-home order had a significantly different impact on OOD in each state.

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Contributors

E.D. Root contributed to the conception and design of the study, conducted statistical analysis for Ohio and drafted the manuscript. S. Slavova contributed to the conception and design of the study. P. Rock and S. Slavova conducted statistical analysis for Kentucky and provided critical primary revisions to the manuscript. M. LaRochelle contributed to the conception and design of the study, conducted statistical analysis for Massachusetts, and provided critical primary revisions to the manuscript. D. Feaster contributed to the conception and design of the study, conducted statistical analysis for New York, and provided critical primary revisions to the manuscript. J. Villani contributed to the conception and design of the study and provided critical primary revisions to the manuscript. J. Delfiore-Hymer and K. Manchester developed analytic datasets from Ohio syndromic surveillance data (EpiCenter) and provided revisions to the manuscript. R. Ergas assisted with the Massachusetts syndromic surveillance data and provided revisions to the manuscript. M. Parikh and K. Gelberg assisted with the New York syndromic surveillance data and provided revisions to the manuscript. J. Villani, N. El-Bassel, R. Jackson and S. Walsh contributed to drafts of the manuscript, critical revisions, and approved the final manuscript.

Declaration of Competing Interest

M. LaRochelle reports receiving consulting funds for research paid to his institution by OptumLabs outside the submitted work. All other authors declare no conflicts of interest.

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Appendix A. Supplementary data

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