Impact of COVID-19 on Emergency Medical Services Utilization and Severity in the U.S. Upper Midwest

Running head: Impact of COVID-19 on EMS Utilization

Brett Boggust, BS,[1] Moshe Shalom,[2] M. Carson Rogerson IV, MAS[3] Lucas A. Myers, BAH NRP,[4] Rozalina G. McCoy, MD MS[3-5]

1. Creighton University School of Medicine, Omaha, Nebraska, USA
2. Tel Aviv University Sackler School of Medicine, Tel Aviv, Israel
3. Mayo Clinic Ambulance, Rochester, MN, USA
4. Division of Endocrinology, Diabetes, and Nutrition, Department of Medicine, University of Maryland School of Medicine, Baltimore, MD, USA
5. University of Maryland Institute for Health Computing, Bethesda, MD, USA

Corresponding author: Rozalina G. McCoy, MD MS. Division of Endocrinology, Diabetes, and Nutrition, Department of Medicine, University of Maryland School of Medicine. 670 West Baltimore Street, Health Sciences Facility III, Room 4050, Baltimore, MD 21201. Phone: 410-706-7167. Fax:410-706-4060. Email: Rozalina.McCoy@som.umaryland.edu. ORCID 0000-0002-2289-3183

Word Count: Text 3274 words, 2 Tables, 3 Figures, 36 References

Key Words: COVID-19, emergency medical services, pandemic, prehospital care, overdose, intoxication, motor vehicle collision

ABSTRACT

The COVID-19 pandemic has claimed nearly one million lives and has drastically changed how patients interact with the healthcare system. Emergency medical services (EMS) are essential for emergency response, disaster preparedness, and responding to everyday emergencies. We therefore examined differences in EMS utilization and call severity in 2020 (pandemic period) compared to trends from 2015-2019 (pre-pandemic period) in a large, multi-state advanced life support EMS agency serving the U.S. Upper Midwest. Specifically, we analyzed all 911 calls made to Mayo Clinic Ambulance, the sole advanced life support EMS provider serving a large area in Minnesota and Wisconsin, in 2020 compared to those made between 2015-2019. We compared the number of emergency calls made in 2020 to the number of calls expected based on trends from 2015-2019. We similarly compared caller demographics, call severity, and proportions of calls made for overdose/intoxication, behavioral health, and motor vehicle accidents. Subgroup analyses were performed for rural vs. urban areas. We identified 262,232 emergent EMS calls in the pre-pandemic period and 53,909 calls in the pandemic period, corresponding to a decrease of 28.7% in call volume during the pandemic period. Caller demographics shifted towards older patients (mean age 59.7 [SD, 23.0] vs. 59.1 [SD, 23.7] years; $p<0.001$) and to rural areas (20.4% vs. 20.0%; $p=0.007$). Call severity increased, with 95.3% of calls requiring transport (vs. 93.8%; $p<0.001$) and 1.9% resulting in death (vs. 1.6%; $p<0.001$). The proportion of calls for overdose/intoxication increased from 4.8% to 5.5% ($p<0.001$), while the proportion of calls for motor vehicle collisions decreased from 3.9% to 3.0% ($p<0.001$). All changes were more pronounced in urban areas. These findings underscore the extent to which the COVID-19 pandemic impacted healthcare utilization, particularly in urban areas, and suggest that patients may have delayed calling EMS with potential implications on disease severity and

risk of death.

Introduction

The Coronavirus Disease 2019 (COVID-19) pandemic, caused by the viral agent SARS-CoV-2, has affected nearly 90 million Americans and claimed more than one million lives in the United States as of February, 2023. [1] COVID-19 most often presents as an acute respiratory syndrome, with higher risk of severe disease among individuals who are older, immunocompromised, or with multiple comorbid conditions. [2] High rates of COVID-19 cases, as well as mitigation efforts implemented by governments and private entities to curb the spread of the disease, have led to widespread disruptions across all sectors of life. [3] Several studies have observed decreases in hospital utilization for conditions other than COVID-19 infection throughout the pandemic, particularly during peaks of case incidence. [4-6] Health systems' deferral of elective surgical procedures and preventive medical encounters early during the pandemic, as well as patient avoidance of hospitals and clinics due to fear of contracting COVID-19 or concerns about inadequate capacity of the healthcare system to address less urgent concerns, likely contributed to these observed decreases. [4, 5] As a result, mortality due to both COVID-19 and unrelated causes increased significantly during the pandemic, particularly during its first year for which robust population-level data are now available. [7] Emergency medical services (EMS) are a core component of the U.S. healthcare system and serve as a first line of response in times of crisis. However, data on changes in EMS utilization, including call volume and acuity, during the pandemic are limited. This is particularly true in rural areas, where reliance on EMS may be greater and availability of alternative sources of healthcare may be more limited.

EMS plays an important role in the medical care of acutely ill and injured patients. For high acuity calls, such as acute myocardial infarction, stroke, and trauma, EMS transport to the emergency department (ED) is associated with reduced time to treatment, timely receipt of definitive therapy and reduced mortality. [8-13] Two recent studies described the impact of COVID-19 on EMS utilization, suggesting that call volumes may have decreased early in the pandemic. [14, 15] One study, conducted in Western Pennsylvania in the spring of 2020 when COVID-19 first emerged in the U.S., showed that there was a significant decrease in EMS response, but 911 callers comprised an overall sicker patient population than before the pandemic as gauged by greater prevalence of abnormal vital signs. However, there was also an increase in non-transport cases, suggesting that lower acuity calls may have also increased. [15] A French study conducted during the same early period of the pandemic similarly found an overall decrease in calls, but the number of calls related to infection, chest pain, and breathing difficulty increased. [14] However, data on EMS call volumes during later periods of the pandemic are scarce. Moreover, prior studies have not focused on rural areas of the U.S., where EMS utilization patterns, patient populations, and response to the COVID-19 pandemic may differ from the more studied urban areas.

As the COVID-19 pandemic continues through its third year, and new variants yield new spikes in disease spread, it is important to understand the impact of the pandemic – in its different phases – on EMS utilization. Leveraging contemporary data from a large, advanced life support (ALS) ambulance organization serving rural and urban communities across two states in the U.S. Upper Midwest, we compare the volumes and severity of EMS calls during the pandemic (2020, "COVID-19 period") to those at a baseline period between 2015-2019 ("pre-COVID-19 period"). We further probe for potential differences in call volume and severity as a function of rurality, as there is evidence of differences in COVID-19 prevalence between urban and rural communities. [16, 17] We hypothesized that EMS call volumes have decreased, while severity increased, reflecting the general public's underlying avoidance of hospitals and deferral of ambulatory care. Furthermore, we hypothesized that calls to EMS in rural areas decreased to a lesser extent than in urban areas, as rural communities are often more reliant on EMS than urban communities.

Methods

Study Design

This cross-sectional study was conducted using the Patient Care Record (PCR) of Mayo Clinic Ambulance. It was deemed exempt from review by the Mayo Clinic Institutional Review Board as it involved analysis of de-identified patient data. The study was conducted and is reported in accordance with STROBE guidelines for observational cohort studies. [18]

Study Population and Setting

We used Mayo Clinic Ambulance PCR to identify all EMS encounters between January 1, 2015 and December 31, 2020. EMS encounters included 911 activation, patient presentation to an EMS station (i.e, "walk-ups"), and requests for service from other public safety agencies such as law enforcement and fire agencies. The period before 2020 was considered to be the "pre-COVID-19 period", while the time after was considered the "COVID-19 period". Non-emergent requests for service (i.e., interfacility transports) were excluded.

Mayo Clinic Ambulance is an ALS provider and the primary response, treatment, and transport service for 14 locations throughout Minnesota and Western Wisconsin, covering 6,894 square miles of urban, suburban, and rural areas. Mayo Clinic Ambulance is staffed by paramedics and emergency medical technicians, and responds to approximately 100,000 requests for service annually, including 75,000 emergent 911 calls, excluding calls for inter-facility transport.

Outcome Variables

EMS activations were categorized based on outcome, severity, primary impression, and location using structured data in the PCR. Each call had two possible outcomes: transport to the ED vs. no transport. If the patient was transported, the urgency of transport was also categorized, with lights and sirens use as one measure of perceived urgency. To assess severity, calls were categorized as (1) no transport, which includes both 'treat, no transport' and 'no treatment or transport needed' as in some situations these two categories can be used interchangeably; (2) refusal of transport against medical advice (AMA); (3) treat, routine transport; (4) treat, transport with lights and sirens; and (5) any call with death prior to ED arrival. High call severity was also gauged by requirement for cardiopulmonary resuscitation (CPR) while on scene or during transport.

The decision to use lights and sirens is made by the EMS provider based on a combination the patient care guideline (PCG) developed and maintained by Mayo Clinic Ambulance medical direction, as well as the EMS provider's clinical judgement. The PCG advises that, at the discretion of the ambulance crew, transport with emergency lights and sirens may be considered if the following clinical conditions or circumstances exist: (1) difficulty in addressing issues related to airway, breathing or circulation; (2) severe trauma; (3) severe neurological or cardiac conditions; (4) obstetrical emergencies; or (5) for patients who pose a safety threat to themselves or the crew after reasonable attempts to control the situation or the patient have been attempted and failed. Providers are encouraged to minimize use of lights and sirens to enhance safety for the patient, caregivers, passengers, and general community, and are required to document the rationale for using lights and sirens in the PCR when they have done so. Thus, the decision to use lights and sirens is influenced by the patient's clinical situation, distance to the ED and traffic conditions while en route, and the EMS providers' experience and resources available at the time of the call.

We also queried the primary impression of the call as documented by the EMS provider in the PCR at the conclusion of the call. Our primary analyses considered all calls, while secondary analyses focused specifically on calls with the primary impressions of motor vehicle collision, overdose or intoxication, and behavioral health. These subgroup analyses were chosen on the basis of emerging evidence that these COVID-19-unrelated events as well as deaths for these conditions may have been strongly influenced by the COVID-19 pandemic.

Independent Variables

Patient demographics were ascertained from the PCR at the time of each call and included patient age, sex, and address of the pick-up location (to assign state and determine rurality). Call location was categorized as rural vs. urban based on the pick-up location documented in the PCR. Rural status was categorized as rural vs. urban using rural-urban commuting area (RUCA) codes, where metropolitan areas were classified as urban, while micropolitan areas, small towns, and rural areas were classified as rural. [19-21] Race and ethnicity data are not routinely collected during calls and were therefore not included. Missing values for each variable are presented as a separate category ('unknown') and included in the analyses; the rate of missing data was <1% for all included variables.

Statistical Analyses

Baseline patient characteristics were descriptively summarized at the call level and compared between the pre-COVID-19 and COVID-19 periods using the Chi Square test or the Wilcoxon two-sample test, as appropriate. Each quarter of 2020 was compared to the same quarter of the combined previous 5 years. Two-sided p-value <0.05 was determined to be significant.

To visualize the geographic distribution of EMS call volumes before and during the pandemic, we graphed the number of calls per county during the pre-COVID-19 and COVID-19 periods using Tableau Software. Call numbers were superimposed over a map of Minnesota and Wisconsin with population estimates based on 2018 American Community Survey data.

Call volume was modeled as a function of time using simple linear regression with call volumes between January 1, 2015 and February 28, 2020. The dependent variable in this model was the number of 911 calls which occurred in a calendar month, and the independent variable was the ordinal number of the month in the progression between the start and finish of this timeframe. Coefficients from this model were used to calculate the expected call volume after March 1, 2020. Goodness of fit was assessed using the R-Square (0.6463), Root MSE (233.64), and ANOVA ($p<0.001$) on model statistics generated in SAS. We then compared expected call volumes with those observed during the COVID-19 period by calculating the absolute difference between expected and observed call numbers (modeled volume minus observed volume) and also relative difference between the two.

Overall and for each calendar year quarter of the pre-COVID-19 and COVID-19 periods, we compared the difference in the distribution of call outcomes, severity, rurality, and primary impressions using the Chi Square test. Bonferroni adjustment for multiple comparisons was used.

All data management and analyses were carried out using SAS 9.4 (SAS Institute Inc. Cary, NC).

Results

There were 262,232 EMS activations during the pre-COVID-19 period and 53,909 during the

COVID-19 period. The mean number of calls per month over the study period was 4,391 (SD, 287.1) Considering the anticipated changes in call volumes over time, this corresponds to an observed relative decrease of 5.3% during the pandemic compared to before the pandemic. This decrease was more pronounced in urban areas (6.8% decrease) compared to rural areas (0.05% decrease) (**Figure 1**). Call volumes declined the most early in the COVID-19 study period, decreasing 28.71% in April 2020 and 14.83% in May 2020. We also observed small, but statistically significant, demographic shifts in patients during the COVID-19 period (**Table 1**). Compared to the pre-COVID-19 period, EMS activations during the COVID-19 period were for patients slightly older (mean age, 59.72 (± 23.71) vs. 59.05 (± 23.71) years; p<0.001) and were more often men (49.57% vs. 47.94%; p<0.001). The geographic distribution of calls overlaid on a population density map of Mayo Clinic Ambulance service areas during the pre-COVID-19 and COVID-19 periods is depicted in **Figure 2**.

Figure 1. EMS Call Volumes: Total, Urban, and Rural. Changes in call volumes per month for all regions included in the study, overall (upper graph) and subset by rural status of the call originating location (bottom graph).

Figure 2. Volumes and Geographic Distributions of EMS Calls Before and During the COVID-19 Pandemic. Population data are mapped by ZIP code as of 2018, while EMS call volume data are shown by county.

Table 1: Study Population. Description of EMS calls included in this study, subset based on study period as occurring before or after COVID-19.

	Pre-COVID-19 Period (2015-2019)	COVID-19 Period (2020)	p-value
Total call number	262,232	53,909	
Patient age, years, mean (SD)	59.05 (23.71)	59.72 (22.98)	<0.001
Patient age, years, category, N (%)			
<18	12,416 (4.73%)	2,081 (3.86%)	<0.001
18-29	26,175 (9.98%)	4,896 (9.08%)	<0.001
30-44	32,813 (12.51%)	7,209 (13.37%)	<0.001
45-59	47,534 (18.13%)	9,380 (17.40%)	<0.001
60-74	60,641 (23.12%)	13,369 (24.80%)	<0.001
≥75	81,364 (31.03%)	16,725 (31.02%)	0.96
Unknown	1,289 (0.49%)	249 (0.46%)	
Gender, N (%)			
Women	134,256 (51.20%)	26,780 (49.68%)	<0.001
Men	125,709 (47.94%)	26,724 (47.57%)	
Other or unknown	2,267 (0.86%)	405 (0.75%)	
Rurality of location, N (%)			
Rural	52,342 (19.96%)	11,021 (20.44%)	0.007
Urban	209,451 (79.87%)	42,733 (79.27%)	
Unknown	439 (0.17%)	155 (0.29%)	

While the overall observed number of EMS activations decreased during the COVID-19 pandemic, the proportion of calls requiring transport to the ED increased from 93.77% to 95.33% ($p<0.001$) (**Table 2**). The proportion of calls with AMA refusal of transport decreased during the pandemic, from 1.43% to 1.20% ($p<0.001$). The proportion of calls requiring initiation of CPR also increased from 1.03% to 1.39% ($p<0.001$), while the proportion of calls involving death increased from 1.59% to 1.93% ($p<0.001$). The proportion of observed calls involving death was most increased above expected in Q2 (from 1.53% to 2.08%, $p<0.001$) and Q4 (from 1.65% to 2.08%, $p<0.001$) of the COVID-19 period, which correspond to April through June 2020 (Q2) and October through December 2020 (Q4). Notably, a greater than expected proportion of activations were transported to the ED without lights and sirens, with lights and siren use decreasing from 4.15% to 3.01% ($p<0.001$).

Table 2: Severity and Characteristics of Calls during the Pre-COVID-19 (2015-2019) and COVID-19 (2020) Periods. All values, except for p-values, are listed as percentages of the total call volume during that quarter. Quarter 2 of 2020 (April through June, 2020) corresponds to the beginning of the COVID-19 pandemic in Minnesota and Wisconsin, U.S.A. AMA, against medical advice. CPR, cardiopulmonary resuscitation. ED, emergency department.

	Q_1			**Q_2**			**Q_3**			**Q_4**			**Total Q_1-Q_4**		
	Pre-2020	2020	*P*[4]	Pre-2020	2020	*P*[4]	Pre-2020	2020	*P*[4]	Pre-2020	2020	*P*[4]	Pre-2020	2020	*P*
Transport Category															
Transport (vs. no transport)	93.99%	94.96%	<0.001	93.40%	95.46%	<0.001	93.59%	95.20%	<0.001	94.11%	95.73%	<0.001	93.77%	95.33%	<0.001
Lights & sirens (vs. without)[1]	3.67%	3.00%	<0.001	4.18%	2.97%	<0.001	4.48%	3.29%	<0.001	4.26%	2.79%	<0.001	4.15%	3.01%	<0.001
Call Outcome															
Treat, no transport	4.60%	3.83%	<0.001	5.10%	3.18%	<0.001	4.76%	3.08%	<0.001	3.97%	3.02%	<0.001	4.6%	3.28%	<0.001
AMA Treat, no transport	1.23%	1.02%	.04	1.31%	1.17%	.02	1.44%	1.52%	.47	1.74%	1.08%	<0.001	1.43%	1.20%	<0.001
Treat, routine transport	89.49%	90.92%	<0.001	88.56%	91.17%	<0.001	88.46%	90.92%	<0.001	89.07%	91.55%	<0.001	88.90%	91.14%	<0.001
Treat, transport with lights & sirens[2]	3.07%	2.43%	<0.001	3.50%	2.40%	<0.001	3.75%	2.70%	<0.001	3.58%	2.27%	<0.001	3.48%	2.45%	<0.001
Call with death prior to ED arrival	1.60%	1.79%	0.10	1.53%	2.08%	<0.001	1.59%	1.78%	0.12	1.65%	2.08%	<0.001	1.59%	1.93%	<0.001
Need for CPR															
CPR (vs. No CPR)	1.01%	1.29%	<0.001	1.00%	1.40%	<0.001	1.04%	1.26%	0.02	1.08%	1.62%	<0.001	1.03%	1.39%	<0.001
CPR (in rural areas)	1.41%	1.87%	0.07	1.27%	1.63%	0.14	1.40%	1.89%	0.05	1.47%	2.04%	0.02	1.39%	1.87%	<0.001
CPR (in urban areas)	0.90%	1.15%	0.01	0.93%	1.34%	<0.001	0.95%	1.10%	0.14	0.99%	1.51%	<0.001	0.94%	1.27%	<0.001
Location of the Call															
Urban (vs. rural areas)[3]	79.74%	80.88%	0.002	80.07%	78.29%	<0.001	80.06%	79.75%	0.40	80.15%	78.90%	<0.001	80.01%	79.50%	0.007
Reason for Call (as a proportion of all calls)															
Overdose/intoxication (total)	4.13%	4.51%	0.04	5.03%	6.83%	<0.001	5.52%	6.08%	0.01	4.67%	4.66%	0.98	4.84%	5.46%	<0.001

Overdose/intoxication (in rural areas)	2.91%	3.15%	0.50	4.12%	5.17%	0.02	4.01%	4.86%	0.04	3.23%	3.05%	0.62	3.56%	4.03%	0.02
Overdose/intoxication (in urban areas)	4.44%	4.83%	0.07	5.27%	7.27%	<0.001	5.90%	6.39%	0.05	5.02%	5.08%	0.78	5.16%	5.83%	<0.001
Behavioral (total)	10.62%	10.49%	0.64	11.99%	12.40%	0.20	12.42%	12.56%	0.65	11.21%	9.73%	<0.001	11.56%	11.24%	0.03
Behavioral (in rural areas)	9.39%	9.41%	0.98	11.08%	11.71%	0.36	11.38%	11.83%	0.50	10.01%	8.08%	0.001	10.46%	10.20%	0.41
Behavioral (in urban areas)	10.94%	10.73%	0.52	12.21%	12.57%	0.33	12.68%	12.75%	0.85	11.51%	10.21%	<0.001	11.84%	11.52%	0.06
Motor vehicle collision (total)	3.32%	2.18%	<0.001	4.13%	3.27%	<0.001	4.29%	3.66%	<0.001	3.91%	2.94%	<0.001	3.91%	3.00%	<0.001
Motor vehicle collision (in rural areas)	4.05%	2.62%	<0.001	5.02%	4.43%	0.21	5.34%	4.57%	0.10	5.11%	3.65%	0.001	4.88%	3.82%	<0.001
Motor vehicle collision (in urban areas)	3.10%	2.03%	<0.001	3.68%	2.93%	<0.001	3.99%	3.42%	0.005	3.58%	2.77%	<0.001	3.63%	2.78%	<0.001

[1] Denominator is the total number of transports
[2] Denominator is total number of calls in the specified time frame.
[3] Rurality was missing in fewer than 0.2% calls, and was not taken into consideration when running chi-square test
[4] P-values are as-reported, but are compared to a Bonferroni-corrected critical p-value for each category

The proportion of calls for overdose or intoxication increased during the COVID-19 period (5.46%) when compared to pre-COVID-19 period (4.84%); $p<0.001$ (**Table 2; Figure 3**). This increase was significant in both urban and rural areas, though rates were higher in urban areas during both time periods. In contrast, the proportion of calls for motor vehicle collisions decreased significantly, from 3.91% during the pre-COVID-19 period to 3.00% during the COVID-19 period; $p<0.001$ (**Table 2; Figure 2**). This change was larger in urban than rural areas, though motor vehicle collisions made up a higher proportion of calls in rural than urban areas.

Figure 3. EMS Calls for Overdose/Intoxication: Total, Urban, and Rural. Changes in call volumes per month for all regions included in the study, overall (upper graph) and subset by rural status of the call originating location (bottom graph).

Discussion

Analysis of nearly 54,000 EMS calls made in 2020 in the U.S. Upper Midwest, compared to over 262,000 calls made between 2015 and 2019, revealed that while EMS call volumes were lower in 2020 than expected based on historic trends, the severity of calls increased, including the proportion of calls with a fatal outcome. The decrease in call volumes was greater in urban than rural areas. Additionally, the proportion of calls for overdose or intoxication increased, while the proportion of calls for motor vehicle collisions decreased, reflecting the impact of the COVID-19 pandemic on different aspects of society.

Recent studies of hospital use during the COVID-19 pandemic found that hospital admissions decreased by up to 50% during the early months of the pandemic, especially during the April 2020 peak in case incidence in the Northeast region of the U.S [4, 5]. In Minnesota, all-cause mortality increased 11.8% in 2020 relative to prior years, with greatest increases in deaths from assault by firearms (68% increase), overdose (49% increase), alcoholic liver disease (26% increase), cirrhosis (28% increase), and malnutrition (48%) increase; COVID-19 comprised 9.9% of all deaths in the state. Our findings build on this emerging body of evidence by examining the impact of the pandemic on pre-hospital emergency care. We hypothesize that there are several potential explanations for the observed decline in EMS activation and the concurrent increases in patient severity and adverse outcome. Early in the pandemic, corresponding to Q2 of 2020, rates of COVID-19 infection were low in Minnesota and Wisconsin (Minnesota positive test rates did not exceed 5% until the week of May 10th, 2020) [22]. Nevertheless, facing an emergence of a poorly understood virus and rising death rates in other areas of the U.S., hospitals suspended elective surgeries and procedures, while clinics deferred preventive visits and transitioned many other encounters to virtual platforms. Fewer surgeries, procedures, and other interventions may have resulted in fewer acute health events that could have prompted an EMS call. Worried about the risk of exposure and heeding social distancing guidelines, people may have deferred seeking both routine and urgent care for lower acuity conditions. Thus, while there were fewer EMS activations overall, those that did occur were more likely to be for more serious conditions requiring ED transport, with some of the deferred activations being for lower acuity conditions that would not have required transport. Simultaneously, the higher proportion of activations with death as an outcome during the pandemic also suggests that at least some of the deferred calls should have been made earlier but were deferred with a fatal outcome.

Compared to urban areas, rural areas saw a smaller impact on EMS activation volume and severity. There are several potential explanations for this. It has been reported that in the beginning of the pandemic, COVID-19 impacted rural communities less than urban centers due to the virus arriving in cities first and the challenges to social distancing posed by high population density in urban areas. [16, 23] The difference in population-adjusted COVID-19 cases and mortality rates shifted as the pandemic progressed, with both fatality and incidence in rural areas surpassing those in urban areas by the end of 2020. [24-26] Rural communities were found to be less likely to change their behavior, such as wearing masks, abiding by stay-at-home orders, or practicing social distancing, in response to the COVID-19 pandemic. [26, 27] Lack of nearby care and distance from definitive care necessitates the use of EMS for many patients in rural communities. [19, 28] Therefore, patients in rural areas may have been less likely to change their healthcare utilization patterns. It will be important to build upon our findings to examine differences in ED and hospital utilization in rural as compared to urban areas throughout the pandemic. EMS is also more utilized in urban areas. [29] with potential for a greater proportion of low acuity activations that could have been eliminated while rationing care in the setting of COVID-19. In contrast, rural areas rely more heavily on EMS for transportation to the ED and as a source of medical care than do urban populations, ensuring that EMS utilization does not decline despite potential external pressures. [16, 17]

We also observed a significant decrease in EMS activations related to motor vehicle collisions. This observation is consistent with previous reports of decreased automobile traffic and accidents during the pandemic, as people were less likely to travel. [30-33] On the other hand, we observed an overall increase in overdose or intoxication-related EMS activations during the COVID-19 pandemic, also consistent with emerging literature from other settings. [34, 35] Possible explanations include stress from lockdown restrictions, loss of employment, and uncertainties regarding the pandemic's course, all of which can lead to increased alcohol and substance use. [36] The increase in overdose or intoxication-related EMS activations was more pronounced in urban areas, reflecting the profound impact of the pandemic and associated economic and social changes on urban residents.

This study is strengthened by the availability of granular activation-level data from a multi-state ALS ambulance agency that serves both rural and urban areas. However, limitations do exist. Mayo Clinic Ambulance Service serves communities in the U.S. Upper Midwest, and our findings may not generalize to other areas of the U.S. While included service areas represent both rural and urban populations, the largest included cities have fewer than 120,000 residents. The impact of COVID-19 on EMS utilization in larger metropolitan areas may not be generalizable from these findings. However, data on the pandemic's impact on healthcare delivery in smaller, Midwest, and rural areas have been scarce, increasing the impact and significance of our findings. The collected data are limited to what is available in EMS patient care records and lacks patient-level clinical information and outcomes data, as would be available within a health system, because these data and services are outside the scope of EMS. Nevertheless, the use of activation-level EMS data of a sole ALS ambulance provider in the covered geographic areas ensures complete capture of EMS utilization by people living in this geography; such capture may not be possible if relying on health system electronic health record data. There is no gold standard for categorizing EMS activation severity, and we relied on the use of lights and sirens during transport to indicate EMS activations as higher acuity. However, the decision to use lights and sirens is influenced both by the objective severity of the patient's illness as well as by subjective factors such as the EMS providers' experience and comfort level managing the patient, resources available on scene, distance to the ED, and traffic conditions en route. Finally, EMS activation volumes presented here are not population-adjusted, but we accounted for this by considering temporal trends from the previous five-year period to compare EMS utilization trends from the same population.

Conclusion

EMS activation volume and severity were affected by the COVID-19 pandemic. EMS activation volume decreased, particularly in urban areas, while severity of activations increased, suggesting deferral of lower acuity care and potentially delayed EMS activation. We observed a disproportionate increase in activations for overdose or intoxication, reflecting the increase in drug-related morbidity and mortality observed during the COVID-19 period. We also observed a decrease in motor vehicle accidents, reflecting the decreased travel amongst stay-at-home orders during the COVID-19 period. Further research is needed to fully understand the impact of deferred EMS care on patient outcomes.

Acknowledgements

Author contributions: MS and BB drafted the manuscript. MCR collected and analyzed the data and reviewed/revised the manuscript. LAM designed the study and reviewed/revised the manuscript. RGM designed the study, reviewed/revised the manuscript, supervised the study, and secured funding.

Funding source: This effort was funded by the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) of the National Institute of Health (NIH) National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) grant number R03DK127010.

Conflicts of interest: The authors have no conflicts of interest to disclose. In the last 36 months, RGM has received unrelated research support from NIDDK, National Institute on Aging (NIA) of the NIH, Patient Centered Outcomes Research Institute (PCORI), and the National Center for Advancing Translational Sciences (NCATS). She also serves as a consultant to Emmi® (Wolters Kluwer) on developing patient education materials related to diabetes.

Role of the sponsor: Study contents are the sole responsibility of the authors and do not necessarily represent the official views of NIH.

References

1. Prevention CfDCa. COVID Data Tracker Internet: Centers for Disease Control and Prevention; 2020 [cited 2023]. Available from: https://covid.cdc.gov/covid-data-tracker/#datatracker-home.
2. Mohammed AH, Blebil A, Dujaili J, Rasool-Hassan BA. The Risk and Impact of COVID-19 Pandemic on Immunosuppressed Patients: Cancer, HIV, and Solid Organ Transplant Recipients. AIDS Rev. 2020;22(3):151-7. doi: 10.24875/AIDSRev.20000052. PubMed PMID: 33118527.
3. Nicola M, Alsafi Z, Sohrabi C, Kerwan A, Al-Jabir A, Iosifidis C, et al. The socio-economic implications of the coronavirus pandemic (COVID-19): A review. Int J Surg. 2020;78:185-93. Epub 20200417. doi: 10.1016/j.ijsu.2020.04.018. PubMed PMID: 32305533; PubMed Central PMCID: PMCPMC7162753.
4. Birkmeyer JD, Barnato A, Birkmeyer N, Bessler R, Skinner J. The Impact Of The COVID-19 Pandemic On Hospital Admissions In The United States. Health Aff (Millwood). 2020;39(11):2010-7. Epub 20200924. doi: 10.1377/hlthaff.2020.00980. PubMed PMID: 32970495; PubMed Central PMCID: PMCPMC7769002.
5. Blecker S, Jones SA, Petrilli CM, Admon AJ, Weerahandi H, Francois F, Horwitz LI. Hospitalizations for Chronic Disease and Acute Conditions in the Time of COVID-19. JAMA Intern Med. 2021;181(2):269-71. doi: 10.1001/jamainternmed.2020.3978. PubMed PMID: 33104158; PubMed Central PMCID: PMCPMC7589070.
6. Portela MC, de Aguiar Pereira CC, Lima SML, de Andrade CLT, Martins M. Patterns of hospital utilization in the Unified Health System in six Brazilian capitals: comparison between the year before and the first six first months of the COVID-19 pandemic. BMC Health Serv Res. 2021;21(1):976. Epub 20210917. doi: 10.1186/s12913-021-07006-x. PubMed PMID: 34535135; PubMed Central PMCID: PMCPMC8445784.
7. McCoy RG, Campbell RL, Mullan AF, Bucks CM, Clements CM, Reichard RR, Jeffery MM. Changes in all-cause and cause-specific mortality during the first year of the COVID-19 pandemic in Minnesota: population-based study. BMC Public Health. 2022;22(1):2291. Epub 20221207. doi: 10.1186/s12889-022-14743-z. PubMed PMID: 36474190; PubMed Central PMCID: PMCPMC9727873.

8. Alabdali A, Yousif S, Alsaleem A, Aldhubayb M, Aljerian N. Can Emergency Medical Services (EMS) Shorten the Time to Stroke Team Activation, Computed Tomography (CT), and the Time to Receiving Antithrombotic Therapy? A Prospective Cohort Study. Prehosp Disaster Med. 2020;35(2):148-51. Epub 20200214. doi: 10.1017/s1049023x20000126. PubMed PMID: 32054556.
9. Alrawashdeh A, Nehme Z, Williams B, Stub D. Emergency medical service delays in ST-elevation myocardial infarction: a meta-analysis. Heart. 2020;106(5):365-73. Epub 20190628. doi: 10.1136/heartjnl-2019-315034. PubMed PMID: 31253694.
10. De Luca G, Suryapranata H, Ottervanger JP, Antman EM. Time delay to treatment and mortality in primary angioplasty for acute myocardial infarction: every minute of delay counts. Circulation. 2004;109(10):1223-5. Epub 20040308. doi: 10.1161/01.Cir.0000121424.76486.20. PubMed PMID: 15007008.
11. Harmsen AM, Giannakopoulos GF, Moerbeek PR, Jansma EP, Bonjer HJ, Bloemers FW. The influence of prehospital time on trauma patients outcome: a systematic review. Injury. 2015;46(4):602-9. Epub 20150116. doi: 10.1016/j.injury.2015.01.008. PubMed PMID: 25627482.
12. Kobayashi A, Misumida N, Aoi S, Steinberg E, Kearney K, Fox JT, Kanei Y. STEMI notification by EMS predicts shorter door-to-balloon time and smaller infarct size. Am J Emerg Med. 2016;34(8):1610-3. Epub 20160607. doi: 10.1016/j.ajem.2016.06.022. PubMed PMID: 27317481.
13. Nielsen VM, DeJoie-Stanton C, Song G, Christie A, Guo J, Zachrison KS. The Association between Presentation by EMS and EMS Prenotification with Receipt of Intravenous Tissue-Type Plasminogen Activator in a State Implementing Stroke Systems of Care. Prehosp Emerg Care. 2020;24(3):319-25. Epub 20191002. doi: 10.1080/10903127.2019.1662862. PubMed PMID: 31490714; PubMed Central PMCID: PMCPMC7113086.
14. Penverne Y, Jenvrin J, Montassier E. EMS dispatch center activity during the COVID-19 containment. Am J Emerg Med. 2021;46:654-5. Epub 20200805. doi: 10.1016/j.ajem.2020.07.083. PubMed PMID: 32826107; PubMed Central PMCID: PMCPMC7403864.
15. Satty T, Ramgopal S, Elmer J, Mosesso VN, Martin-Gill C. EMS responses and non-transports during the COVID-19 pandemic. Am J Emerg Med. 2021;42:1-8. Epub 20201231. doi: 10.1016/j.ajem.2020.12.078. PubMed PMID: 33429185; PubMed Central PMCID: PMCPMC7836527.
16. Karim SA, Chen HF. Deaths From COVID-19 in Rural, Micropolitan, and Metropolitan Areas: A County-Level Comparison. J Rural Health. 2021;37(1):124-32. Epub 20201106. doi: 10.1111/jrh.12533. PubMed PMID: 33155723.
17. Kitchener S. Rural-related epidemiology of COVID-19 cases in Queensland. Aust J Rural Health. 2020;28(6):634-5. doi: 10.1111/ajr.12681. PubMed PMID: 33382476.
18. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Ann Intern Med. 2007;147(8):573-7. doi: 10.7326/0003-4819-147-8-200710160-00010. PubMed PMID: 17938396.
19. Uva JL, Wagner VL, Gesten FC. Emergency department reliance among rural children in Medicaid in New York State. J Rural Health. 2012;28(2):152-61. Epub 20110427. doi: 10.1111/j.1748-0361.2011.00377.x. PubMed PMID: 22458316.

20. Center WRHR. Rural Urban Commuting Area Codes Data WWAMI Rural Health Research Center; 2020 [cited 2023]. Available from: https://depts.washington.edu/uwruca/ruca-uses.php.

21. Morrill R, Cromartie J, Hart G. METROPOLITAN, URBAN, AND RURAL COMMUTING AREAS: TOWARD A BETTER DEPICTION OF THE UNITED STATES SETTLEMENT SYSTEM. Urban Geography. 1999;20(8):727-48. doi: 10.2747/0272-3638.20.8.727.

22. Health MDo. Situation Update for Coronavirus Disease 2019 (COVID-19) Internet: Minnesota Department of Health; 2020 [cited 2023]. Available from: https://www.health.state.mn.us/diseases/coronavirus/situation.html.

23. S.J. Goetz ZT, C. Schmidt, D. Meadowcroft. Rural COVID-19 Cases Lag Urban Areas but Are Growing Much More Rapidly Internet: Northeast Regional Center for Rural Development; 2020 [cited 2023]. Available from: https://aese.psu.edu/nercrd/publications/covid-19-issues-briefs/rural-covid-19-cases-lag-urban-areas-but-are-growing-much-more-rapidly.

24. Cuadros DF, Branscum AJ, Mukandavire Z, Miller FD, MacKinnon N. Dynamics of the COVID-19 epidemic in urban and rural areas in the United States. Ann Epidemiol. 2021;59:16-20. Epub 20210422. doi: 10.1016/j.annepidem.2021.04.007. PubMed PMID: 33894385; PubMed Central PMCID: PMCPMC8061094.

25. Pro G, Hubach R, Wheeler D, Camplain R, Haberstroh S, Giano Z, et al. Differences in US COVID-19 case rates and case fatality rates across the urban-rural continuum. Rural Remote Health. 2020;20(3):6074. Epub 20200819. doi: 10.22605/rrh6074. PubMed PMID: 32811154; PubMed Central PMCID: PMCPMC7583661.

26. Jiang DH, Roy DJ, Pollock BD, Shah ND, McCoy RG. Association of stay-at-home orders and COVID-19 incidence and mortality in rural and urban United States: a population-based study. BMJ Open. 2022;12(4):e055791. Epub 20220407. doi: 10.1136/bmjopen-2021-055791. PubMed PMID: 35393311; PubMed Central PMCID: PMCPMC8990263.

27. Callaghan T, Lueck JA, Trujillo KL, Ferdinand AO. Rural and Urban Differences in COVID-19 Prevention Behaviors. J Rural Health. 2021;37(2):287-95. Epub 20210222. doi: 10.1111/jrh.12556. PubMed PMID: 33619836; PubMed Central PMCID: PMCPMC8013340.

28. Morrisey MA, Ohsfeldt RL, Johnson V, Treat R. Rural emergency medical services: patients, destinations, times, and services. J Rural Health. 1995;11(4):286-94. doi: 10.1111/j.1748-0361.1995.tb00426.x. PubMed PMID: 10153688.

29. Hegenberg K, Trentzsch H, Gross S, Prückner S. Use of pre-hospital emergency medical services in urban and rural municipalities over a 10 year period: an observational study based on routinely collected dispatch data. Scand J Trauma Resusc Emerg Med. 2019;27(1):35. Epub 20190402. doi: 10.1186/s13049-019-0607-5. PubMed PMID: 30940157; PubMed Central PMCID: PMCPMC6444540.

30. Keays G, Friedman D, Gagnon I. Injuries in the time of COVID-19. Health Promot Chronic Dis Prev Can. 2020;40(11-12):336-41. Epub 20200911. doi: 10.24095/hpcdp.40.11/12.02. PubMed PMID: 32924925; PubMed Central PMCID: PMCPMC7745832.

31. Levin MW, Shang M, Stern R. Effects of short-term travel on COVID-19 spread: A novel SEIR model and case study in Minnesota. PLoS One. 2021;16(1):e0245919. Epub 20210122. doi: 10.1371/journal.pone.0245919. PubMed PMID: 33481956; PubMed Central PMCID: PMCPMC7822539.

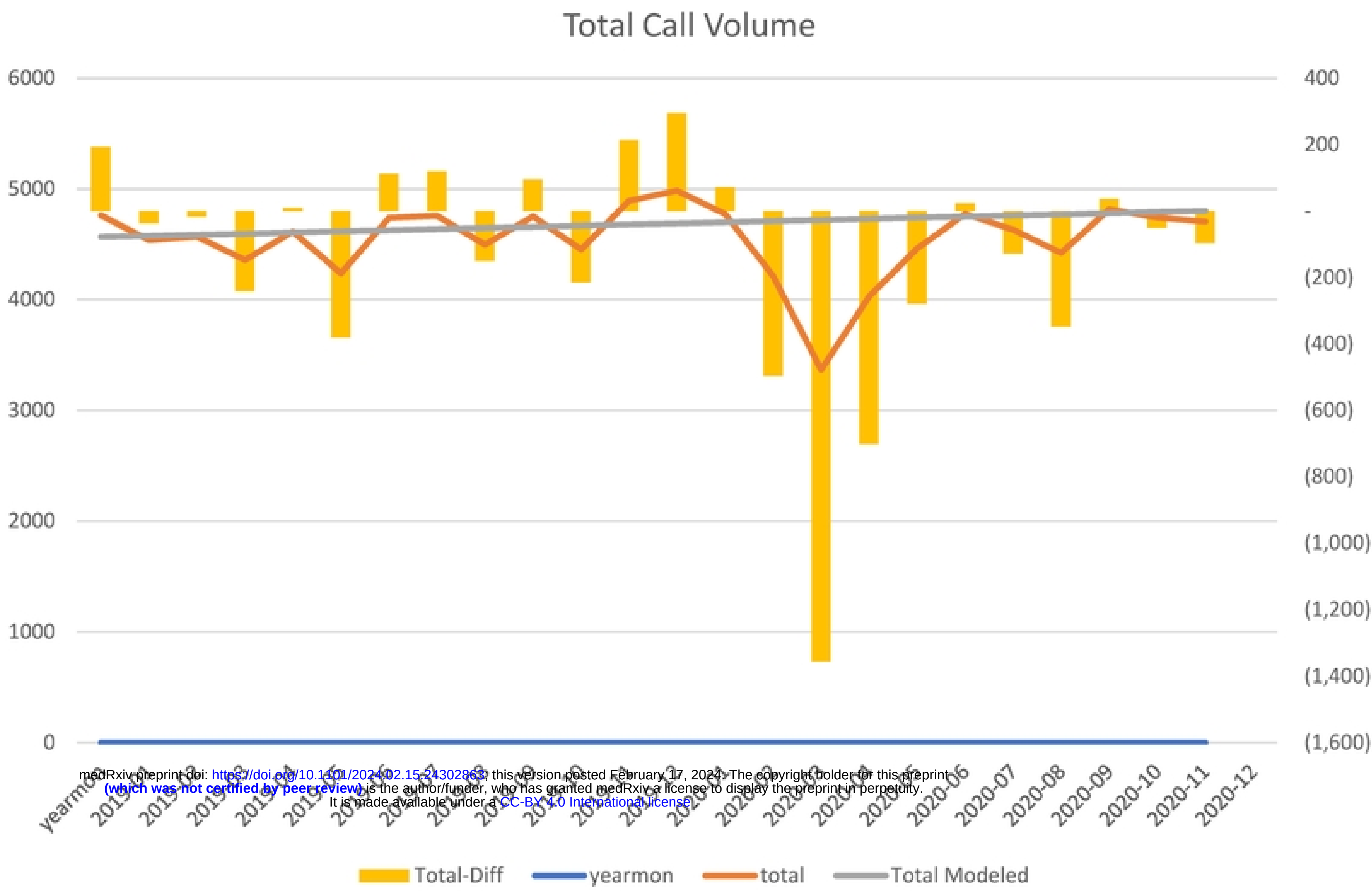
32. Xiang J, Austin E, Gould T, Larson T, Shirai J, Liu Y, et al. Impacts of the COVID-19 responses on traffic-related air pollution in a Northwestern US city. Sci Total Environ. 2020;747:141325. Epub 20200728. doi: 10.1016/j.scitotenv.2020.141325. PubMed PMID: 32771792; PubMed Central PMCID: PMCPMC7386255.

33. Yasin YJ, Grivna M, Abu-Zidan FM. Global impact of COVID-19 pandemic on road traffic collisions. World J Emerg Surg. 2021;16(1):51. Epub 20210928. doi: 10.1186/s13017-021-00395-8. PubMed PMID: 34583713; PubMed Central PMCID: PMCPMC8478263.

34. Imtiaz S, Nafeh F, Russell C, Ali F, Elton-Marshall T, Rehm J. The impact of the novel coronavirus disease (COVID-19) pandemic on drug overdose-related deaths in the United States and Canada: a systematic review of observational studies and analysis of public health surveillance data. Subst Abuse Treat Prev Policy. 2021;16(1):87. Epub 20211129. doi: 10.1186/s13011-021-00423-5. PubMed PMID: 34844624; PubMed Central PMCID: PMCPMC8628272.

35. Slavova S, Rock P, Bush HM, Quesinberry D, Walsh SL. Signal of increased opioid overdose during COVID-19 from emergency medical services data. Drug Alcohol Depend. 2020;214:108176. Epub 20200710. doi: 10.1016/j.drugalcdep.2020.108176. PubMed PMID: 32717504; PubMed Central PMCID: PMCPMC7351024.

36. Killgore WDS, Cloonan SA, Taylor EC, Lucas DA, Dailey NS. Alcohol dependence during COVID-19 lockdowns. Psychiatry Res. 2021;296:113676. Epub 20201225. doi: 10.1016/j.psychres.2020.113676. PubMed PMID: 33385782; PubMed Central PMCID: PMCPMC9754813.


Total Call Volume
6000
5000
4000
3000
2000
1000
0
400
200
-
(200)
(400)
(600)
(800)
(1,000)
(1,200)
(1,400)
(1,600)
2020-07
2020-08
2020-09
2020-10
2020-11
2020-12
Total-Diff
yearmon
total
Total Modeled

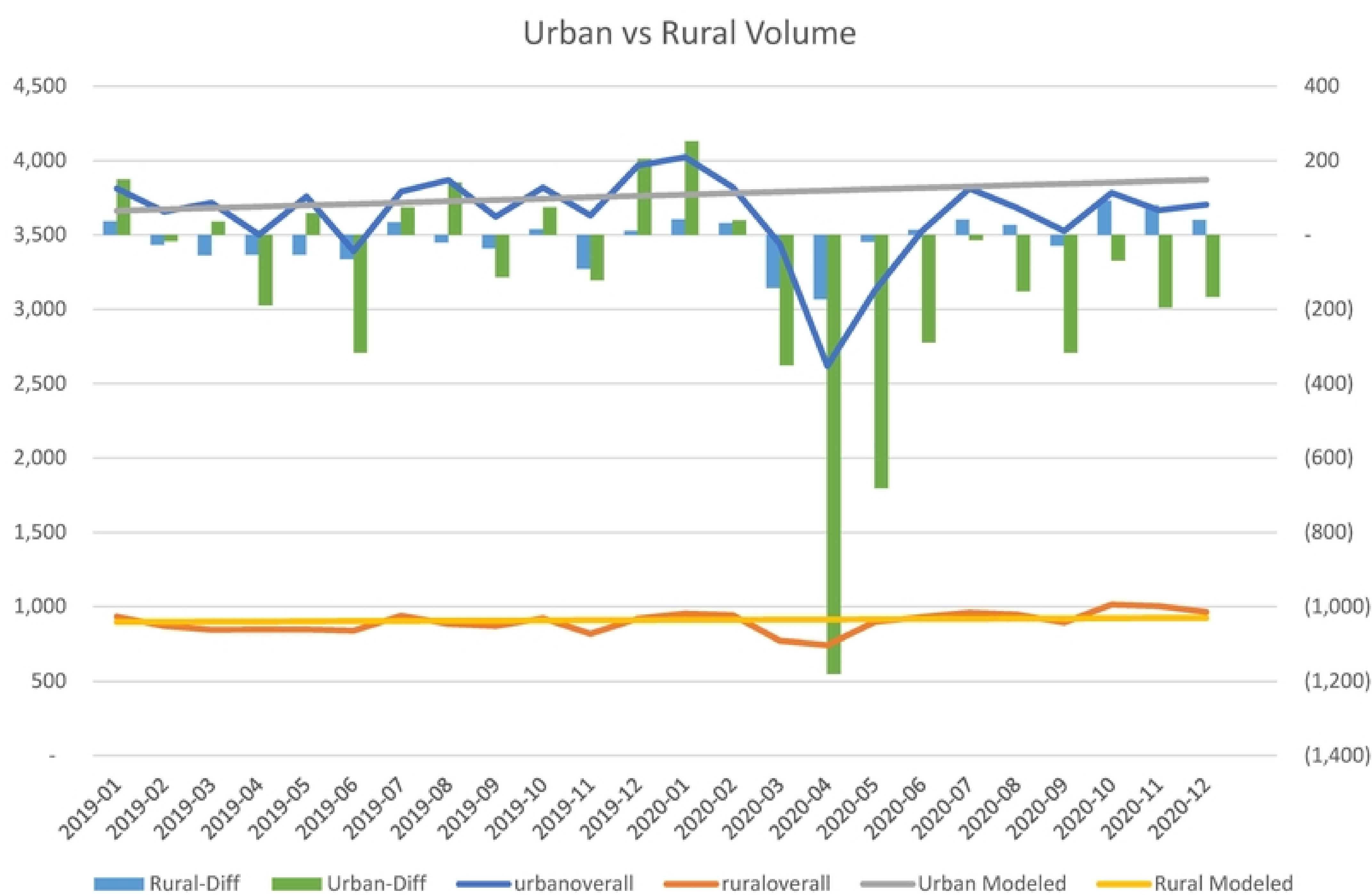
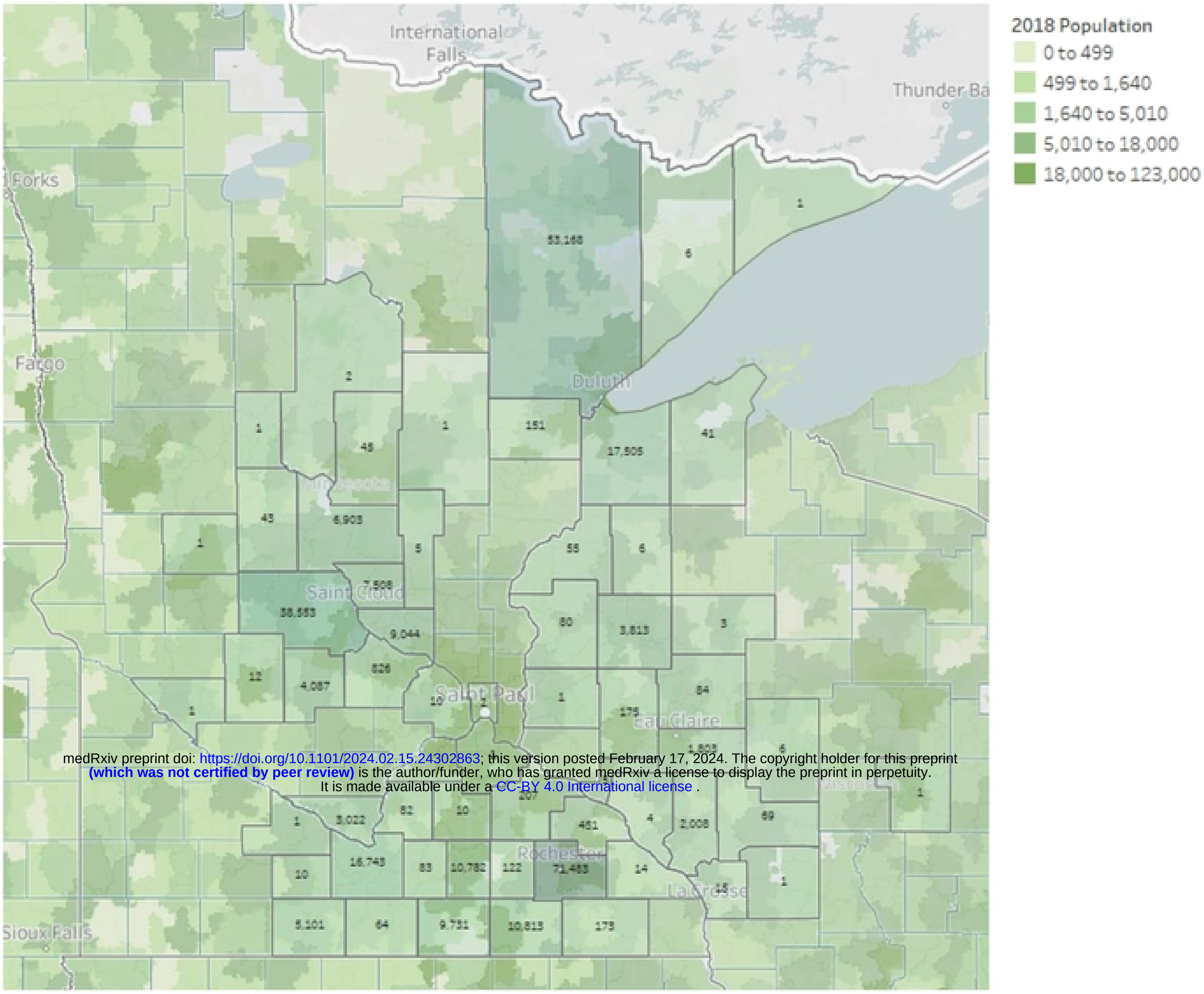

Urban vs Rural Volume
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
-
400
200
-
(200)
(400)
(600)
(800)
(1,000)
(1,200)
(1,400)
2019-01
2019-02
2019-03
2019-04
2019-05
2019-06
2019-07
2019-08
2019-09
2019-10
2019-11
2019-12
2020-01
2020-02
2020-03
2020-04
2020-05
2020-06
2020-07
2020-08
2020-09
2020-10
2020-11
2020-12
Rural-Diff
Urban-Diff
urbanoverall
ruraloverall
Urban Modeled
Rural Modeled

Figure 1

A. EMS Call Volumes and Geographic Distribution Prior to COVID-19.



B. EMS Call Volumes and Geographic Distribution During COVID-19.

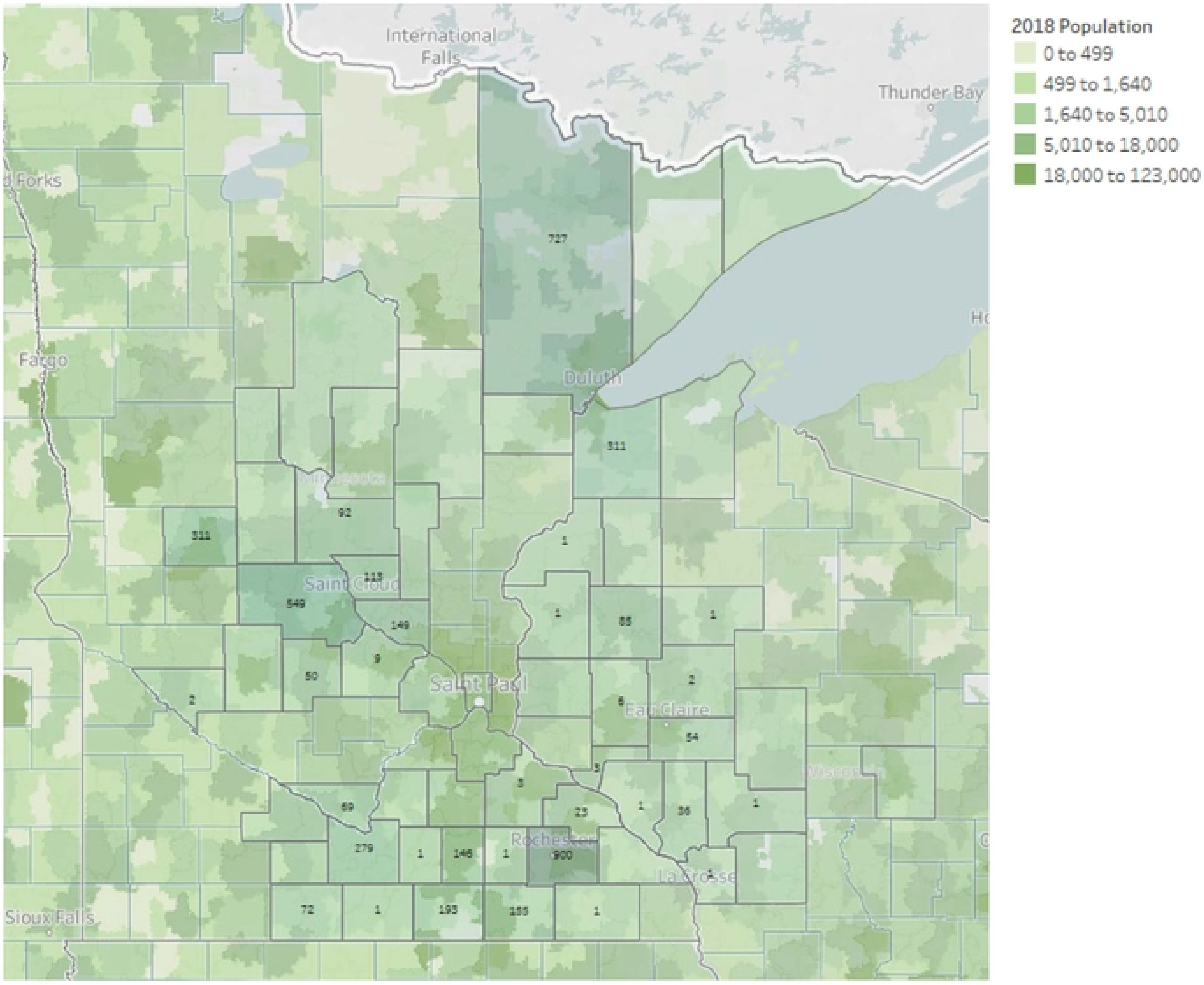
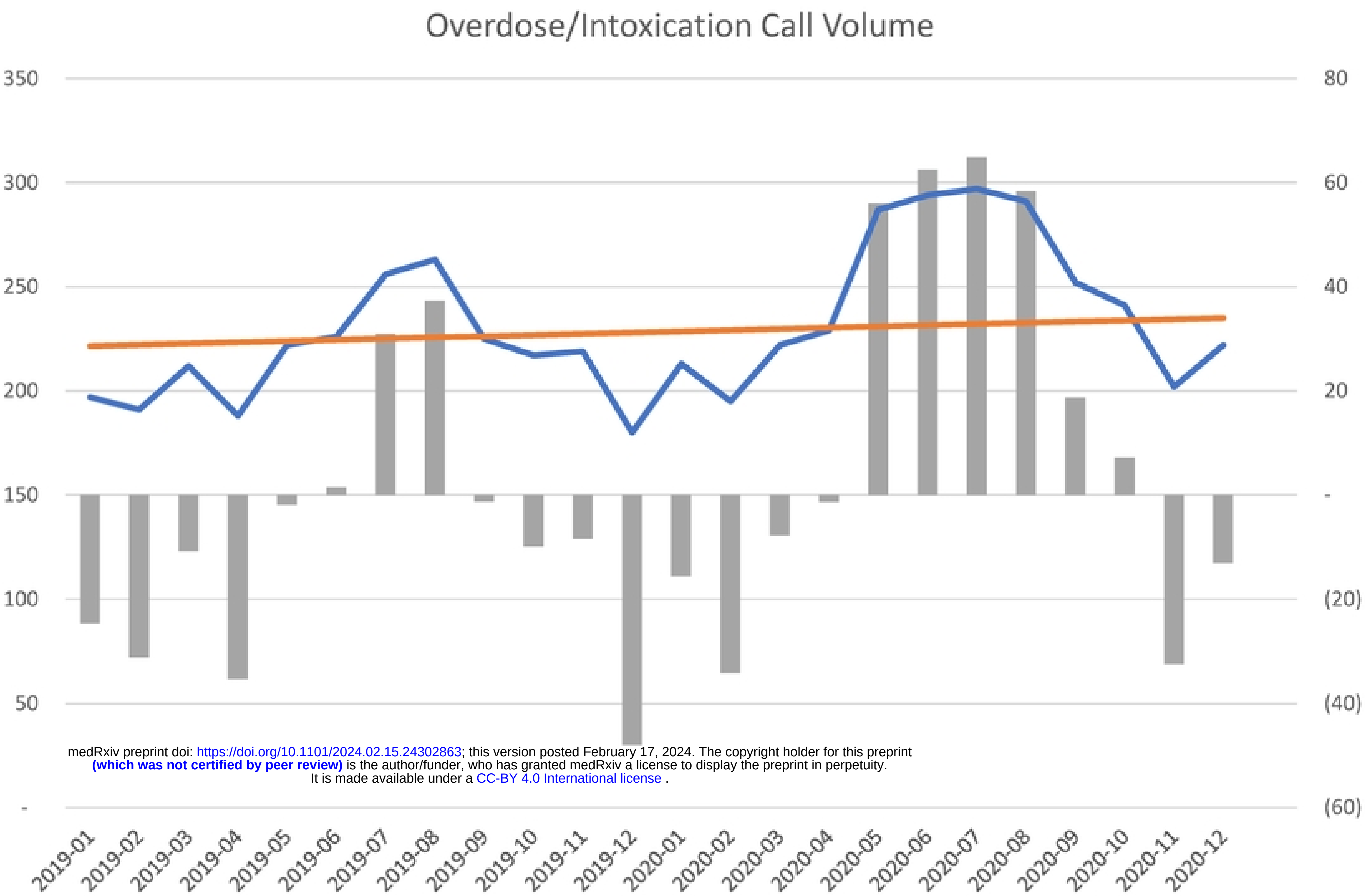


Figure 2


Overdose/Intoxication Call Volume
350
300
250
200
150
100
50
-
80
60
40
20
-
(20)
(40)
(60)
2019-01
2019-02
2019-03
2019-04
2019-05
2019-06
2019-07
2019-08
2019-09
2019-10
2019-11
2019-12
2020-01
2020-02
2020-03
2020-04
2020-05
2020-06
2020-07
2020-08
2020-09
2020-10
2020-11
2020-12

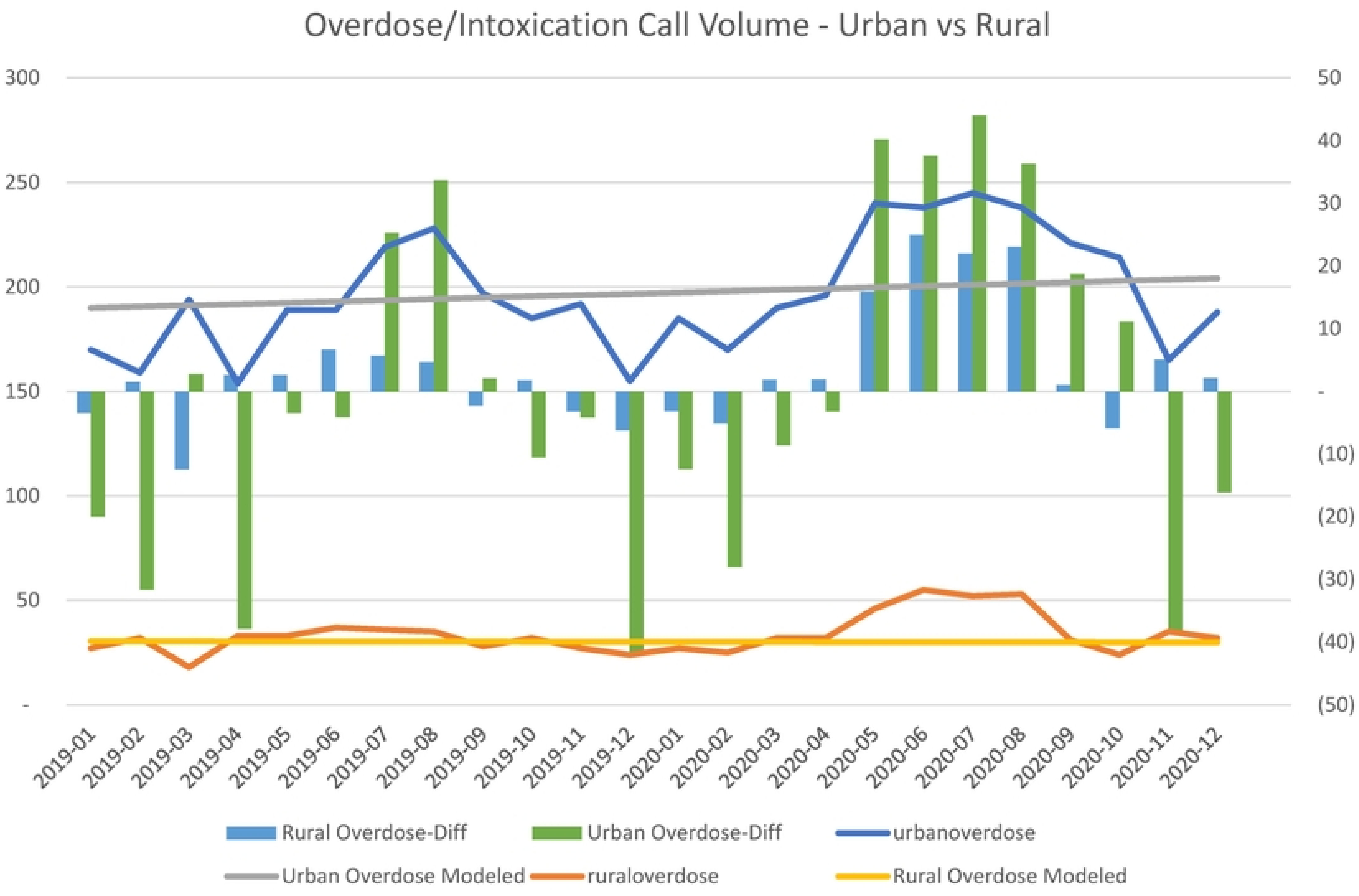

Overdose/Intoxication Call Volume - Urban vs Rural
300
250
200
150
100
50
-
50
40
30
20
10
-
(10)
(20)
(30)
(40)
(50)
2019-01
2019-02
2019-03
2019-04
2019-05
2019-06
2019-07
2019-08
2019-09
2019-10
2019-11
2019-12
2020-01
2020-02
2020-03
2020-04
2020-05
2020-06
2020-07
2020-08
2020-09
2020-10
2020-11
2020-12
Rural Overdose-Diff
Urban Overdose-Diff
urbanoverdose
Urban Overdose Modeled
ruraloverdose
Rural Overdose Modeled

Figure 3