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# Interrupted time series analysis of drug overdose fatalities in service-related industries versus non-service-related industries during the COVID-19 pandemic, 2018–2021

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## ABSTRACT

**Background** Variation among industries in the association between COVID-19-related closing or reopening orders and drug overdose deaths is unknown. The objectives of this study were to compare drug overdose decedent demographics, annual drug overdose fatality rates and monthly drug overdose fatality rates by specific industry within the service-related industry sector, and to perform an interrupted time series analysis comparing weekly drug overdose mortality counts in service-related and non-service-related industries, examining the COVID-19 pre-pandemic and pandemic phases by Kentucky closing and reopening orders.

**Methods** Kentucky drug overdose death certificate and toxicology testing data for years 2018–2021 were analysed using  $X^2$  and interrupted time series methods.

**Results** Before the pandemic, annual drug overdose fatality rates in service-related industries were higher than in non-service-related industries. However, these trends reversed during the pandemic. Both service-related and non-service-related industry groups experienced increased fatal drug overdoses at change points associated with the gubernatorial business closure orders, although the magnitude of the increase differed between the two groups. Young, female and black workers in service-related industries had higher frequencies of drug overdose deaths compared with decedents in the non-service-related industries.

**Conclusion** Spikes in drug overdose mortality in both service-related and non-service-related industries during the pandemic highlight the need to consider and include industries and occupations, as well as worker populations vulnerable to infectious diseases, as integral stakeholder groups when developing and implementing drug overdose prevention interventions, and implementing infectious disease surveillance systems.

## INTRODUCTION

Stay-at-home and business closure orders were essential public health tools to mitigate virus transmission during the COVID-19 pandemic. However, they had the adverse effect of putting individuals with substance use disorders (SUDs) at elevated risk of drug overdose.<sup>1</sup> Initially, access to SUD treatment was greatly reduced, although subsequent relaxation in personal attendance requirements somewhat mitigated the problem.<sup>2,3</sup> Reduction in work

## WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ Individuals in Food Preparation and Food Service occupations had the second highest rate of drug overdose deaths in 2020 in the USA.
- ⇒ Stay-at-home orders reduced access to recovery support services and increased the number of drug overdose deaths.
- ⇒ At the height of the pandemic, food service establishments were only able to open for take-out orders.

## WHAT THIS STUDY ADDS

- ⇒ Individuals 25–54 years old, women and black service-related industry workers had higher frequencies of drug overdose deaths compared with decedents in the non-service-related industries.
- ⇒ Annual drug overdose fatality rates for the service-related industries were higher than for the non-service-related industry pre-pandemic. During the pandemic phase, the reverse occurred.
- ⇒ Both service-related and non-service-related industry groups experienced increased fatal drug overdoses at points associated with the gubernatorial business closure orders, although the magnitude differed between the two groups.

## HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ Spikes in drug overdose mortality in both service-related and non-service-related industries during the pandemic highlight the need to include high-risk industries and occupations, as well as worker populations vulnerable to infectious diseases, as integral stakeholder groups when developing and implementing drug overdose prevention interventions and implementing infectious disease surveillance systems.

hours or loss of employment increased the risk of using substances alone and as self-medication for stress.<sup>4–6</sup>

At the height of the pandemic, customary gathering places for recovery support services closed, and social distancing was enforced where gathering



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was allowed at all, exacerbating the well-documented role of social isolation in SUDs and overdose.<sup>7–9</sup> The adverse impact was most acute in low-income and minority populations<sup>10</sup> and among those who lost employment at the height of the pandemic lockdown.<sup>10–11</sup> As Hawkins *et al*<sup>12</sup> note, “[o]ccupation groups with high rates of occupational injuries and illnesses, high job insecurity, and low availability of paid sick leave had higher rates of [opioid-related overdose death]”.<sup>12</sup> Most service industry workers such as those in the Arts, Entertainment, and Recreation and Accommodation and Food Services sectors fall squarely within this high-risk group. Thus, for example, individuals employed in the food industry exhibit high levels of substance use.<sup>13</sup> SUDs are associated with drug overdose morbidity and mortality.<sup>14</sup> Individuals in Food Preparation and Food Service occupations had the second highest rate of overdose deaths in 2020 in the USA, followed in third place by those in Personal Care and Service.<sup>15</sup> During the first wave of the COVID-19 pandemic, typical workplaces for service workers, such as bars, restaurants and hotels, were over-represented among the establishments shut down in response to state executive orders.<sup>16</sup> Tourism ground to a halt, and, unlike many in the affected workforce, service workers could not work from home. Although federal aid allowed some establishments to avoid laying off their entire workforce, many financially precarious businesses did not survive the shutdown, and their employees lost their jobs. Even after the stay-at-home orders were lifted, bars and restaurants were limited to a fraction of their normal capacity and thus could not employ their entire pre-pandemic workforce.

An emergency order from Kentucky’s governor closed indoor dining, bars and other hospitality venues on 18 March 2020 (Executive Order 2020-215); the order was lifted effective 22 May 2020, for indoor seating at one-third of a food service facility’s capacity. Service industry-specific association between such orders and partial reopening of restaurants and drug overdose deaths has not been examined, to our knowledge. The objectives of this study therefore were to (1) compare the demographic characteristics of drug overdose decedents in service-related industries and non-service-related industries; (2) compare annual drug overdose fatality rates in service-related industries and non-service-related industries over the pandemic phases; (3) examine monthly drug overdose fatality rates by specific industry within the service-related industry sector; and (4) perform an interrupted time series analysis of the weekly drug overdose mortality counts in service-related and non-service-related industries, examining the COVID-19 pre-pandemic (2018–2019) and pandemic (2020–2021) phases during Kentucky resident stay-at-home orders and partial restaurant reopenings.

## METHODS

### Data sources

All Kentucky resident death certificates, including those for drug overdoses, are filed electronically with the Kentucky Electronic Death Registration System. Drug overdose deaths are identified in Kentucky death certificates by drug categories and intent. Kentucky’s completeness of demographic fields, and contributing and underlying cause of death data fields on drug overdose death certificates averaged 99.2% in 2019.<sup>17</sup> The Kentucky death certificate also includes information to be completed by the certifier, usually an elected coroner, on usual occupation and business/industry. The usual occupation is defined by the National Institute for Occupational Safety and Health (NIOSH) as the ‘type of job the individual performed during most of his or her life, or the job held for the longest time’ and the

business/industry as ‘the type of business or industry that the decedent worked in during most of his or her life, or for the longest time’.<sup>18</sup> NIOSH guidance to capture the industry and occupation for decedents also directs certifiers to complete the ‘usual’ occupation field on the death certificate using the decedent’s longest-held occupation and expressly discourages the use of ‘unemployed’. There was no further guidance to identify whether the decedent was working or not (eg, laid off) at the time of death.<sup>18</sup>

Kentucky drug overdose death certificate data for the years 2018–2021 were obtained from the Kentucky Office of Vital Statistics. Toxicology testing results were accessed through the Kentucky Drug Overdose Fatality Surveillance System (DOFSS).<sup>19</sup> To identify North American Industry Classification System (NAICS) industry and Standard Occupational Classification System occupation codes, the dataset was coded for industry and occupation by using the NIOSH’s Industry and Occupation Computerized Coding System (<https://csams.cdc.gov/nioccs/>). Data on Kentucky industry employment denominator numbers for calculation of the industry-specific fatality rates by month were obtained from the US Bureau of Labor Statistics (BLS) ‘Economy at a Glance’ data series (<https://www.bls.gov/eag/eag.us.htm>).

### Definitions

Drug overdose deaths were identified from death certificates using underlying cause of death codes X40–X44, X60–X64, X85 or Y10–Y14. Specific drug types were identified through toxicology testing results from blood, urine and/or vitreous fluids in DOFSS data.

### Study populations

Study inclusion criteria comprised all Kentucky residents who (1) died as a result of a drug overdose from 1 January 2018 to 31 December 2021; (2) were usually employed in service-related or non-service-related industries; and (3) were 16 years of age and older at the time of death.

The following industry sectors were included in the service-related industries classification: Education and Health Services (NAICS 61, 62), Professional and Business Services (NAICS 54, 55, 56), Leisure and Hospitality (NAICS 71, 72), and Other Services (NAICS, 81). Industry sectors classified as non-service-related industries included: Mining and Logging (NAICS 21, 11), Construction (NAICS 23), Manufacturing (NAICS 31–33), Trade, Transportation and Utilities (NAICS 42, 44–45, 48–49, 22), Information (NAICS 51), Financial Activities (NAICS 52, 53) and Government (NAICS 92, 99). Based on these criteria, 6788 drug overdose fatality records were selected for potential inclusion.

Drug overdose decedents were excluded from analysis if they were under 16 years old at time of death (n=10), were NAICS industry coded as retired/unpaid/unemployed (n=1969); had insufficient industry and occupational information (n=96); or were employed in the Agriculture, Fishing and Hunting industry (n=86); the latter exclusion was due to lack of accurate monthly employment denominator numbers for calculation of fatality rates. Based on the inclusion and exclusion criteria, the final dataset contained 1789 drug overdose fatality records for the service-related industries and 2838 drug overdose fatality records for the non-service-related industries.

### Statistical analysis

Statistical analysis was conducted using Statistical Analysis System (SAS) Enterprise Guide V.8.2<sup>20</sup> as well as Microsoft Excel.

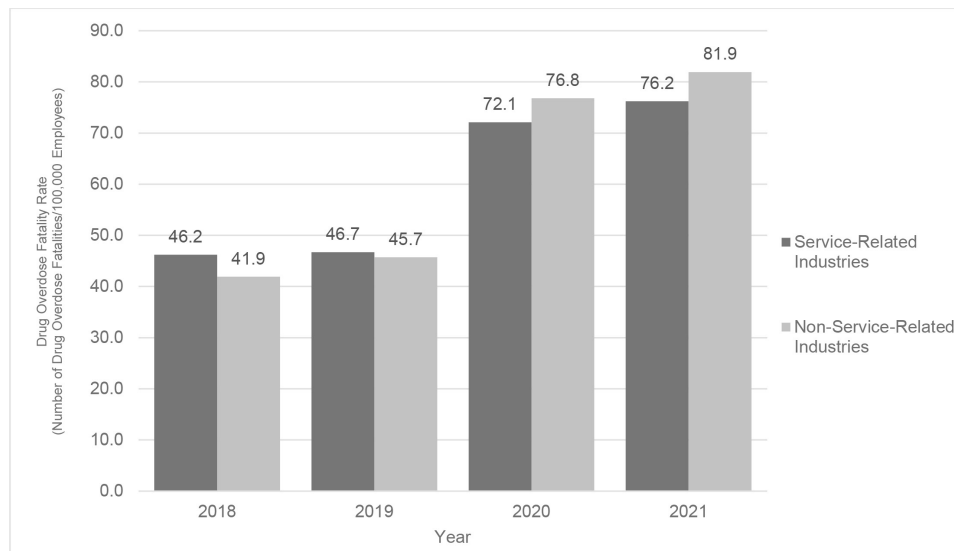
**Table 1** Demographics of Kentucky resident drug overdose fatalities in service-related industries versus non-service-related industries, 2018–2021

Demographic characteristic	Service-related industries (n=1789)	Non-service-related industries (n=2839)	X <sup>2</sup> test of association p value
Age group	(n=1789)	(n=2838)	
16–24	106 (6%)	149 (5%)	0.0013
25–54	1387 (78%)	2098 (74%)	
55+	296 (17%)	591 (21%)	
Gender	(n=1789)	(n=2838)	
Female	823 (46%)	393 (14%)	<0.0001
Male	966 (54%)	2445 (86%)	
Race	(n=1789)	(n=2838)	
Black	205 (11%)	211 (7%)	<0.0001
White	1554 (87%)	2594 (91%)	
Other	30 (2%)	33 (1%)	
Ethnicity	(n=1786)	(n=2838)	
Hispanic	30 (2%)	41 (1%)	0.0757
Non-Hispanic	1756 (98%)	2797 (99%)	
Occupation			
Service-related industries	(n=1789)		
Waiters and waitresses	176 (10%)		
Cooks, restaurants	131 (7%)		
Landscaping and groundskeeping workers	113 (6%)		
Automotive service technicians and mechanics	100 (6%)		
Registered nurses	72 (4%)		
Janitors and cleaners, except maids and housekeeping cleaners	67 (4%)		
Nursing assistants	66 (4%)		
Food service managers	56 (3%)		
Maids and housekeeping cleaners	50 (3%)		
Chefs and head cooks	46 (3%)		
Other	912 (51%)		
Non-service-related industries		(n=2838)	
Construction labourers		427 (15%)	
Carpenters		196 (7%)	
Labourers and freight, stock, and material movers, hand		192 (7%)	
Production workers, all other		163 (6%)	
Retail salespersons		124 (4%)	
Heavy and tractor trailer truck drivers		116 (4%)	
Painters, construction and maintenance		92 (3%)	
Assemblers and fabricators, all other		88 (3%)	
Electricians		73 (3%)	
Roofers		59 (2%)	
Other		1308 (46%)	
Top drugs identified in worker drug overdose decedents*	(n=1787)	(n=2838)	
Fentanyl	787 (44%)	1363 (48%)	
Methamphetamine	430 (24%)	804 (28%)	
Amphetamine	366 (20%)	689 (24%)	
Gabapentin	233 (13%)	373 (13%)	
Morphine	194 (11%)	349 (12%)	
Acetylfentanyl	196 (11%)	342 (12%)	
THC	224 (13%)	318 (11%)	
Ethanol	172 (10%)	313 (11%)	
Cocaine	155 (9%)	237 (8%)	

\*Most deaths have more than two substances in the postmortem toxicology results. Therefore, drug categories are not mutually exclusive. THC, tetrahydrocannabinol.

Frequencies and percentages were calculated for each categorical variable including age, gender, race, ethnicity, occupation and drug type. The continuous variable ‘age at time of death’ was split into terciles for comparison purposes. The 10 most

frequent drug overdose decedent occupations were reported for the service-related and non-service-related industries. An ‘Other’ category was created to combine low frequency-number occupations categorised under each industry grouping. The 10



**Figure 1** Annual Kentucky resident drug overdose fatality rates in service-related industries versus non-service-related industries, 2018–2021.

most frequently detected substances in toxicology results were reported by industry grouping.

The  $\chi^2$  test of association was used to compare the variables of age group, sex, ethnicity and race to examine the relationship between demographic characteristics and usual industry employment. Crude drug overdose fatality rates were calculated for the service-related and non-service-related industry groupings, and for the service-related industry subsectors. BLS employment estimates by week were not available, so weekly drug overdose fatality rates could not be calculated. Thus, service-related and non-service-related industry fatality rates were calculated by month. In order to calculate the monthly fatality rate for each industry grouping, the monthly average number of persons who died as a result of a drug overdose was divided by the monthly average number of workers employed in each industry grouping; this value was then multiplied by 100 000 to calculate the monthly drug overdose fatality rates for each industry grouping.

To assess temporal changes to fatal drug overdoses in each industry grouping over the course of the COVID-19 pandemic, an interrupted time series analysis design with segmented regression with autoregressive error<sup>1 21 22</sup> was performed using weekly drug overdose fatality numbers. The regression model was designed with three segments of the study period defined by two change points.

The Kentucky stay-at-home order was issued on 25 March 2020, and took effect on 26 March 2020. The reopening of businesses started on 11 May 2020, and effectively concluded on 29 June 2020. Therefore, the first change point was specified as the week of 22 March 2020 (22–28 March 2020), since the emergency order took effect on 26 March 2020.<sup>1</sup> To identify the second change point, we tested each week between the week of 10 May 2020 (10–16 May 2020) and the week of 28 June 2020 (28 June–4 July 2020) and selected the model with the best fit based on the maximum likelihood estimates using Akaike's Information Criteria (AIC). The model with the lowest AIC was considered the best fit. Each model examined autoregressive parameters up to order 53 and dropped autocorrelation terms using backward selection when significance fell below 0.05 to account for possible temporal autocorrelation. Parameter estimates and 95% CIs are reported.

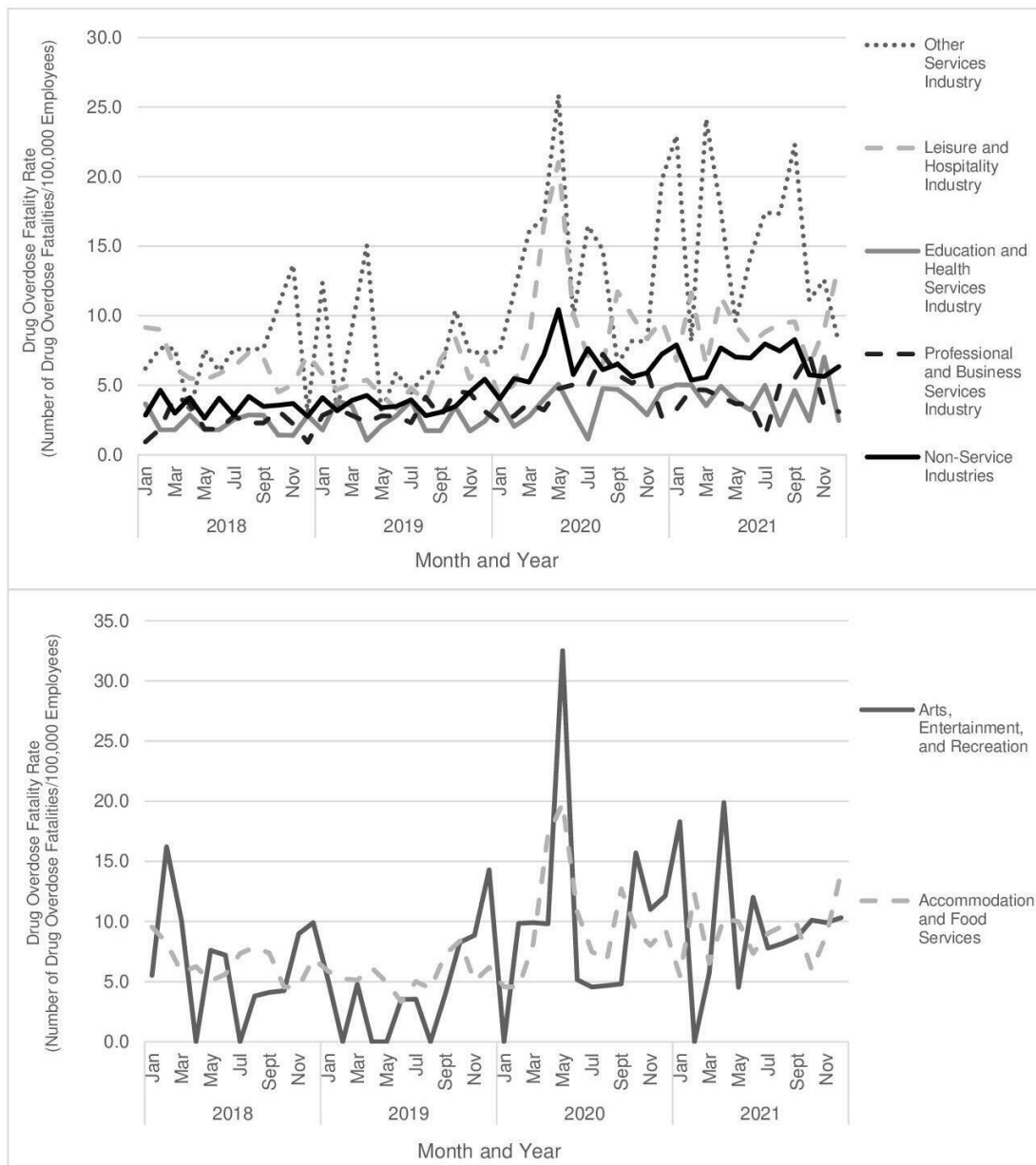
The first change point was the week of 22 March 2020, when the stay-at-home order became effective. The regression model

with the second change point on 24 May 2020 displayed a minimum value of AIC for service-related industries, indicating that this model best described the trend of weekly Kentucky resident drug overdose fatality numbers in service-related industries during the COVID-19 pandemic. For the trend in non-service-related industries, the second change point was the week of 31 May 2020.

## RESULTS

Individuals aged 25–54, women and black service-related industry workers had higher frequencies of drug overdose deaths compared with decedents in the non-service-related industries (table 1). Similarly, the highest frequency of drug overdose decedents in the non-service-related industries was also in the 25–54 years age group; however, elevated frequencies were also observed in the 55+ age group, and in the male and white groups. The highest frequencies of usual occupations within the service-related industry drug overdose death group were waiters and waitresses (10%), restaurant cooks (7%), and landscaping and groundskeeping workers, and automotive service technicians and mechanics (6% each). Non-service-related industry drug overdose fatalities occurred more often among construction labourers (15%), carpenters (7%), and labourers and freight, stock, and material movers and hand occupations (7%). The top drug identified in drug overdose decedents in both industry groupings was fentanyl, a highly potent synthetic opioid (44% of identified substances among service-related industry deaths and 48% of identified substances among non-service-related deaths). The second drug with elevated frequencies detected in drug overdose decedents was methamphetamine, with 24% of identified substances among service-related industry deaths and 28% of substances identified among non-service-related industry deaths. Tetrahydrocannabinol was detected in 13% of the identified substances among service-related industry deaths compared with 11% of identified substances among non-service-related industry deaths. Differences in the proportion of identified drugs between the two groups were not statistically significant, and differences from year to year were also not statistically significant (data not shown).

Annual drug overdose fatality rates were higher for the service-related industries than the non-service-related industry fatality



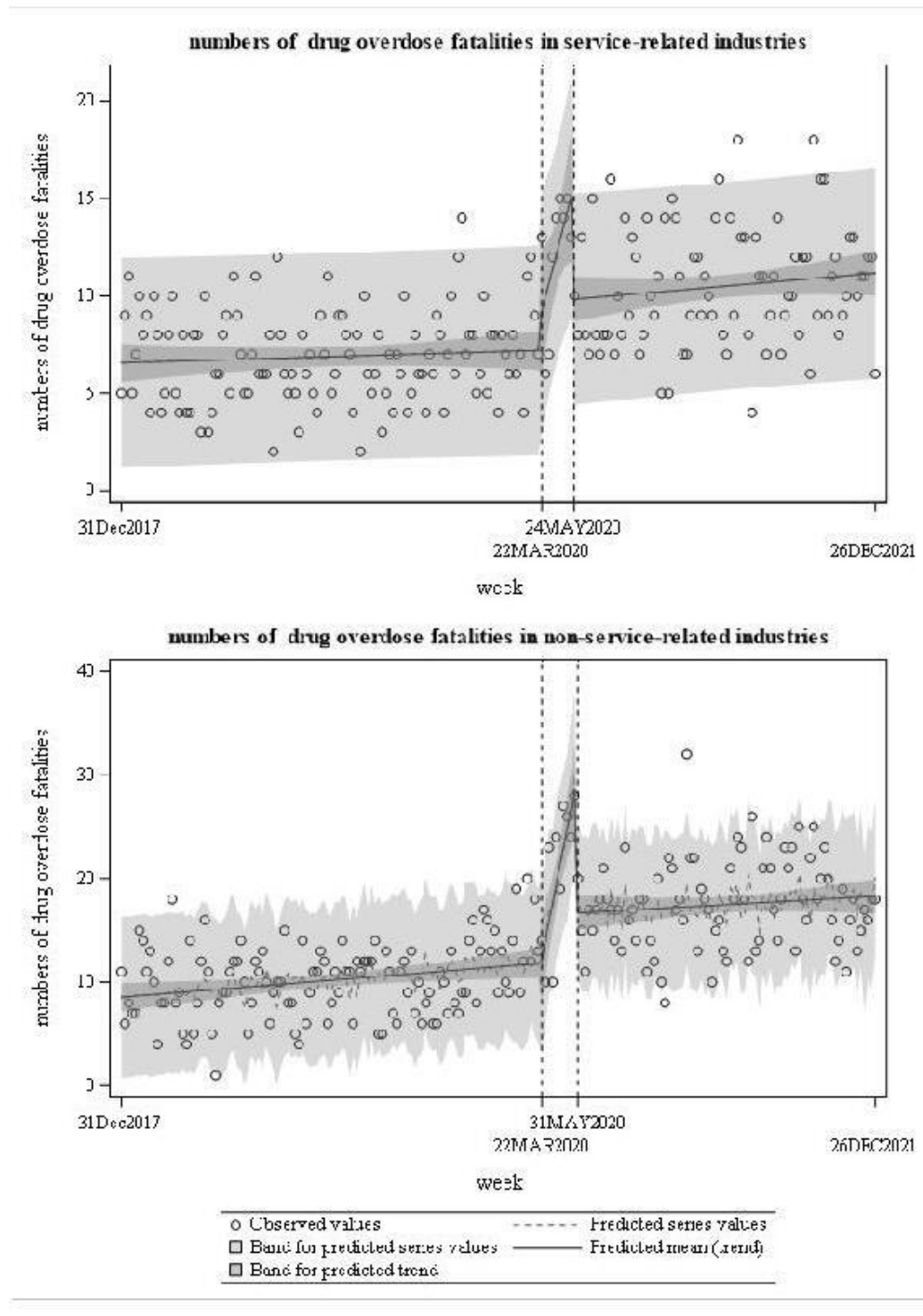
**Figure 2** Monthly Kentucky resident drug overdose fatality rates in service-related industries versus non-service-related industries, 2018–2021.

rates during the 2018 and 2019 pre-pandemic phase (figure 1). During the pandemic phase, the reverse occurred: non-service-related industry workers had higher annual drug overdose fatality rates in 2020 and 2021 compared with those in service-related

industries. When monthly drug overdose rates were examined, the other services industry had the highest monthly drug overdose fatality rates during the pandemic phase (2020–2021), followed by the Leisure and Hospitality service-related industry

**Table 2** Parameter estimates for interrupted time series regression analysis of weekly Kentucky resident drug overdose fatality numbers in service-related industries versus non-service-related industries, 2018–2021

	Service-related industries		Non-service-related industries	
	Parameter estimate (95% CI)	P value	Parameter estimate (95% CI)	P value
Pre-COVID-19 level	6.57 (5.59 to 7.54)	<0.0001	8.56 (7.21 to 9.90)	<0.0001
Pre-COVID-19 trend	0.0055 (–0.0092 to 0.0202)	0.4646	0.028 (0.0074 to 0.049)	0.0082
Level change after the week of 22 March 2020	1.25 (–2.73 to 5.23)	0.5358	–1.43 (–6.48 to 3.63)	0.5784
Trend change after the week of 22 March 2020	0.73 (0.042 to 1.413)	0.0374	1.80 (1.01 to 2.57)	<0.0001
Level change after business resumed	–5.22 (–8.6 to –1.76)	0.0033	–11.89 (–16.40 to 7.38)	<0.0001
Trend change after business resumed	–0.72 (–1.40 to –0.032)	0.0403	–1.80 (–2.58 to –1.02)	<0.0001



**Figure 3** Interrupted time series analysis of weekly Kentucky resident service-related industry versus non-service-related industry fatality numbers, 2018–2021. Dashed vertical lines indicate first change point and second change point, respectively.

(figure 2). The overall non-service-related industry group had the third highest monthly drug overdose fatality rate during the pandemic phase. The Arts, Entertainment and Recreation industry monthly drug overdose fatality rate spiked and doubled from March 2020 to June 2020 while stay-at-home orders were in effect. The Accommodation and Food Services industry also had an elevated spike in its monthly drug overdose fatality rates during the same time frame.

The interrupted time series analysis of drug overdose fatalities (table 2 and figure 3) showed that at the beginning of the pre-COVID-19 period, the average drug overdose fatality numbers per week for the service-related industries (6.57; 95% CI: 5.59, 7.54) were lower than for the non-service-related industry fatality numbers (8.56; 95% CI: 7.21, 9.90). Before the stay-at-home order was in effect, the fatality numbers significantly increased by 0.028 per week ( $p=0.0082$ ) in non-service-related

industries, but no significant increase ( $p=0.46$ ) was found in service-related industries. There were significant differences in the slopes or trends of weekly drug overdose fatality number lines (figure 3) before and after the week of 22 March 2020 (estimated slope change of 0.73;  $p=0.0374$  for service-related industries; estimated slope change of 1.80;  $p<0.0001$  for non-service-related industries; table 2), but the estimated levels of drug overdose fatality numbers for both service-related and non-service-related industries did not change significantly before and after the week of 22 March 2020.

The estimated level and trend of drug overdose fatality numbers shifted significantly ( $p<0.05$ ) before and after businesses reopened in both the service-related industries (the week of 24 May 2020) and the non-service-related industries (the week of 31 May 2020). In service-related industries, the estimated level of drug overdose fatality numbers decreased by 5.22 before and after the week of 24 May 2020; the estimated trend decreased by 0.72. In non-service-related industries, the estimated level of drug overdose fatality numbers decreased by 11.89 before and after the week of 31 May 2020; the estimated trend decreased by 1.80. There were no significant differences in the trends of drug overdose fatality numbers before the week of 22 March 2020, or after the businesses reopened for both service-related industries ( $p=0.4607$ ) and non-service-related industries ( $p=0.6703$ ).

## DISCUSSION

In Kentucky, the effects of COVID-19 business closures on overdose death rates differed between those employed in service-related industries and non-service-related industries. Both service-related and non-service-related workers experienced increased fatal drug overdoses during the effective period of the gubernatorial business closure orders. The closure of restaurants and other businesses was associated with an increase in drug overdose mortality for non-service-related industry workers that was nearly twice the increase among service-related industry workers. Similarly, when restaurants reopened, the decline in drug overdose mortality for non-service-related industry workers was twice that of service-related industry workers. The decline of drug overdose deaths among service-related industry workers occurred nearly a week before that of the non-service workers.

No single explanation accounts for these variations, but several individual and environmental factors are plausible. First, service-related industry employees may be more resilient to employment instability compared with those in non-service-related industries, mitigating the impact of business closures. Second, service-related industries may have been more capable than others of returning to open status and recalling employees. Third, employees in service-related industry jobs tend to be younger and may have been more readily employable in other 'essential' sectors such as grocery providers that remained open during the COVID-19 pandemic because their risk of severe COVID-19 infection was lower than for older workers.

Possible explanations that have been offered for the increase in drug overdoses during the early pandemic period other than the loss of employment include pandemic-associated support payments from the federal government and changes in the drug supply. In March 2020, the Coronavirus Aid, Relief, and Economic Security Act provided financial relief to individuals. The association of specific pandemic payments with the increase in fatal drug overdoses cannot be measured without data reflecting the receipt and timing of such payments by decedents in relation to the time of death.

The presence of drugs in postmortem toxicology results can serve as a limited proxy for the drugs available in the drug supply. In an analysis of changes in drugs involved in fatal drug overdoses between the two groups over time, there were no significant differences in the substances identified between the service and non-service industries during the study period.

Drug overdose deaths were higher among the age group 25–54 years old, among women and among black workers in service-related industries over the study period compared with non-service-related employees. The higher proportions of drug overdose deaths in these groups correspond to employment demographics in service-related industries (BLS Current Population Survey). Necessary interventions include increased access and financial support for recovery services as well as increased awareness of fentanyl-adulterated substances such as cocaine and marijuana through awareness campaigns targeted to industries through worker and employer organisations. Harm reduction and drug overdose prevention interventions targeted to restaurants and construction companies that may be of benefit include distribution of naloxone to reverse drug overdose in the workplace and distribution of fentanyl test strips to test for fentanyl-adulterated substances. In addition, overdose prevention requires dissemination of information to businesses about local community resources for timely linkage to SUD treatment and recovery support services.

## Limitations

Potential limitations to the present study include the lack of monthly denominator data for those employed in the Agriculture, Fishing and Hunting industry, resulting in the exclusion of an important industry in the assessment of drug overdose mortality. Because a decedent's single usual occupation was assessed, our analysis did not consider multiple jobholders and the concurrent implications of COVID-19 policies across these populations.

## CONCLUSIONS

Spikes in drug overdose mortality in both service-related and non-service-related industries during the pandemic highlight the need to consider and to include vulnerable industries and occupations, as well as worker populations vulnerable to related infectious diseases, as integral stakeholder groups when developing and implementing drug overdose prevention interventions and infectious disease surveillance systems.

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**Contributors** TLB conceived the idea, participated in the analysis and undertook the main writing of the manuscript. JFC provided the information on the stay-at-home orders and closing and participated in the writing of the manuscript. MM and LKD performed the overall analysis. DW conducted the time series analysis. DQ provided detailed information on the closing policies and contributed to the analysis. All authors participated in the preparation of the manuscript and reviewed the final manuscript. TB is the guarantor who accepts full responsibility for the conduct of the study, had access to the data, and controlled the decision to publish.

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**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

**Patient consent for publication** Not required.

**Ethics approval** Ethical approval for the current study was conducted by the University of Kentucky Institutional Review Board (IRB approval number 44741). The death certificate data are secondary data and because the study involved the analysis of secondary data with no personal identifiers, informed consent was neither required nor obtained.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** Data may be obtained from a third party and are not publicly available. The study data are available on request to the data owner (Kentucky Office of Vital Statistics).

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