

Abstract:

This study examines the impact of COVID-19 on homeless mortality in Toronto from January 2017 to June 2023, with a focus on gender disparities. Utilizing a Difference in Differences approach and data from Toronto Public Health, the research analyzed death counts before and after COVID-19, applying regression models with and without gender controls. Results indicate a general increase in deaths post-COVID, with a more pronounced rise in male mortality, though not statistically significant when adjusting for confounders. The study underscores the pandemic's exacerbation of existing vulnerabilities in homeless populations, particularly among males, and highlights the need for targeted public health strategies.

Introduction:

Homelessness is a serious challenge in Canada, drawing attention to the harsh realities faced by the most vulnerable groups among us. In the city of Toronto, the plight of homelessness is manifest nightly with thousands lacking permanent shelter, including those in temporary accommodations and those without any shelter at all. The health vulnerabilities and mortality rates of homeless individuals are alarmingly high when compared to the general population. Within Toronto's male homeless community that uses shelters, the mortality rate for those aged 18-24 is 8.3 times higher, for ages 25-44 it is 3.7 times, and for those 45-64 it is 2.3 times the rate of their housed counterparts. For homeless women aged 18-44, the risk of death is 10-fold compared to the average woman in Toronto (Hwang 2001). Pre-existing burdens of mental illness, substance dependence, various medical conditions, infectious diseases, and physical trauma have been compounded since December 2019 by the advent of COVID-19, further endangering those in communal living situations.

This study aims to explore the impact of the COVID-19 on the difference of the death rate between female and male. Employing the "Difference in Differences" approach, I will analyze homeless death data in Toronto, spanning from January 2017 to June 2023. Death count is the estimand. We will embark on an analysis to validate the hypothesis that the COVID-19 pandemic has led to an increase in the death count among the homeless population. We will present this analysis in two distinct parts: one without controlling for gender, to capture the overall trend, and another with gender control, to discern any differential impact between male and female homeless individuals. Firstly, we will inspect the aggregated data, where we anticipate an observable escalation in death counts following the outbreak, regardless of gender or age group differences. Subsequently, we will refine our analysis with a gender-based perspective. Here, we aim to unravel the nuances of how the pandemic may have disparately affected homeless males and females. This part of the analysis seeks to highlight the intersection of gender with the broader health crisis. In conjunction with these visual comparisons, we will also delve into a more granular analysis by presenting the results of a regression model. This model will quantify the impact of COVID-19 on death counts, first without the inclusion of gender, and then with gender considered. Through this comparative approach, we aim to discern whether the observed increase in death counts post-pandemic holds when we account for gender, as well as other control variables such as the cause of death and age. The conclusions drawn will be critical, not just in understanding the impact of the pandemic but also in informing potential interventions and policy decisions aimed at mitigating the risks faced by homeless populations in such health crises.

The analysis will be conducted in R (R Core Team 2020) and will utilize an array of packages such as tidyverse (Wickham et al. 2019), readr (Wickham, Hester, and Bryan 2024), dplyr (Wickham et al. 2021), and opendatatoronto (Gelfand 2020) for data manipulation and analysis. All visualizations in this report are generated through ggplot2 (Wickham 2016), with tables crafted using kableExtra (Zhu 2021).

Data:

Data Collection

Data for this research were obtained from the City of Toronto Open Data Portal, facilitated by the script “01_downloaddata.R”. The opendatatoronto package (Gelfand 2020) was instrumental in importing the data into the R environment for subsequent processing and analysis. The data, contributed and maintained by Toronto Public Health, is biannually refreshed, with the last update noted on September 29, 2023. Toronto Public Health initiated detailed records of homeless deaths from January 2017, aiming for a precise count and understanding of mortality causes. Data accumulation is a joint effort between Toronto Public Health, Shelter, Support, and Housing Administration (SSHA), various health and social service agencies, with corroborations by the Office of the Chief Coroner of Ontario (OCCO). For this data collection initiative, homelessness is defined as “a situation where an individual or family does not have stable, permanent, appropriate housing, or the immediate prospect, means, and ability to acquire it.

We utilize two datasets titled “Homeless deaths by month.csv” and “Homeless deaths by cause.csv”. The dataset “Homeless deaths by cause.csv” comprises six variables: “_id”, “Year of death”, “Cause_of_death”, “Age_group”, “Gender”, and “Count”. The “_id” variable enumerates from 1 to 253, representing the recorded number of homeless individuals who died between 2017 and 2023. The “Year of death” spans from 2017 to 2023. “Cause_of_death” includes various categories such as “Accident”, “Cancer”, “Cardiovascular Disease”, “COVID-19”, “Drug Toxicity”, “Homicide”, “Other”, “Pneumonia”, “Suicide”, and “Unknown/Pending”. The “Age_group” is categorized as “< 20”, “20-39”, “40-59”, “60+”, and “Unknown”. The “Gender” variable includes “Male”, “Female”, and “Unknown”. The “Count” represents the number of deaths. The “Homeless deaths by month.csv” dataset contains four variables: “_id”, “Year of death”, “Month of death”, and “Count”. The “Month of death” ranges from January to December. Given the onset of COVID-19 in December 2019, we will use this event as a pivotal point to compare the gender-specific death rates from two periods: 2017-2020 and 2020-2023. We will hold constant the variables “Age_group” and “Cause_of_death”, considering them as controls in our analysis. The treatments will be defined as “X1 = time period” and “X2 = gender”. We will encode the time periods as a binary variable, with “0” indicating the period from 2017-2020 and “1” representing 2020-2023. The dependent variable, denoted as Y, is the count of deaths.

Table 1: Homeless Deaths in Toronto

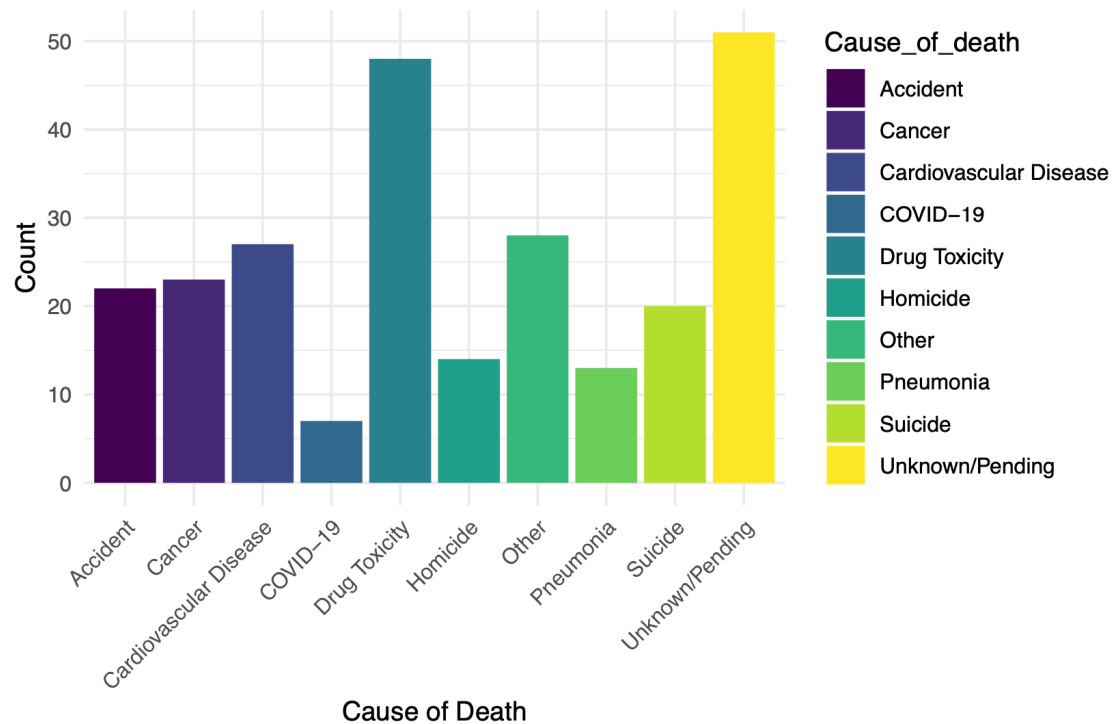
_id	Year of death	Cause_of_death	Age_group	Gender	Count
1	2017	Accident	40-59	Male	2
2	2017	Accident	60+	Male	3
3	2017	Cancer	60+	Female	1
4	2017	Cancer	40-59	Female	2
5	2017	Cancer	40-59	Male	2
6	2017	Cancer	60+	Male	4

The connection between COVID-19 and increased mortality is clear. Homeless individuals, often living in communal settings or without the ability to isolate, are at higher risk of transmission, which can lead to higher mortality rates. This risk is compounded by the fact that homeless individuals often have pre-existing health conditions that make them more susceptible to severe outcomes from COVID-19. Age is a crucial factor when looking at mortality rates because vulnerability to death often increases with age due to a natural decline in physical health. However, in the homeless population, younger individuals might also face significant risks due to hazardous living conditions, lack of healthcare, and potentially dangerous survival behaviors. The progression of years reflects changes over time that might affect mortality rates. For example, the advent of COVID-19 marked an increase in deaths among the homeless, not only due to the virus itself but possibly due to compounded risks associated with the pandemic, such as reduced access to services or increased substance use. The relationship between gender and mortality rates can be complex. Men might be at higher risk in some contexts due to different social behaviors, health status, or utilization of services. The COVID-19 pandemic might have changed these dynamics, for example, by altering the types of available services or the ways that individuals interact with these services.

To explore these relationships, we can use statistical models to examine the data while controlling for confounding factors, allowing us to estimate the unique impact of each variable. For instance, by including both age and gender in the same model, we can see whether the impact of COVID-19 on mortality is different for different age groups or genders, and by how much. Additionally, by looking at data from before and after the pandemic began, we can attempt to isolate the effect of the pandemic from other time-related factors that might influence mortality.

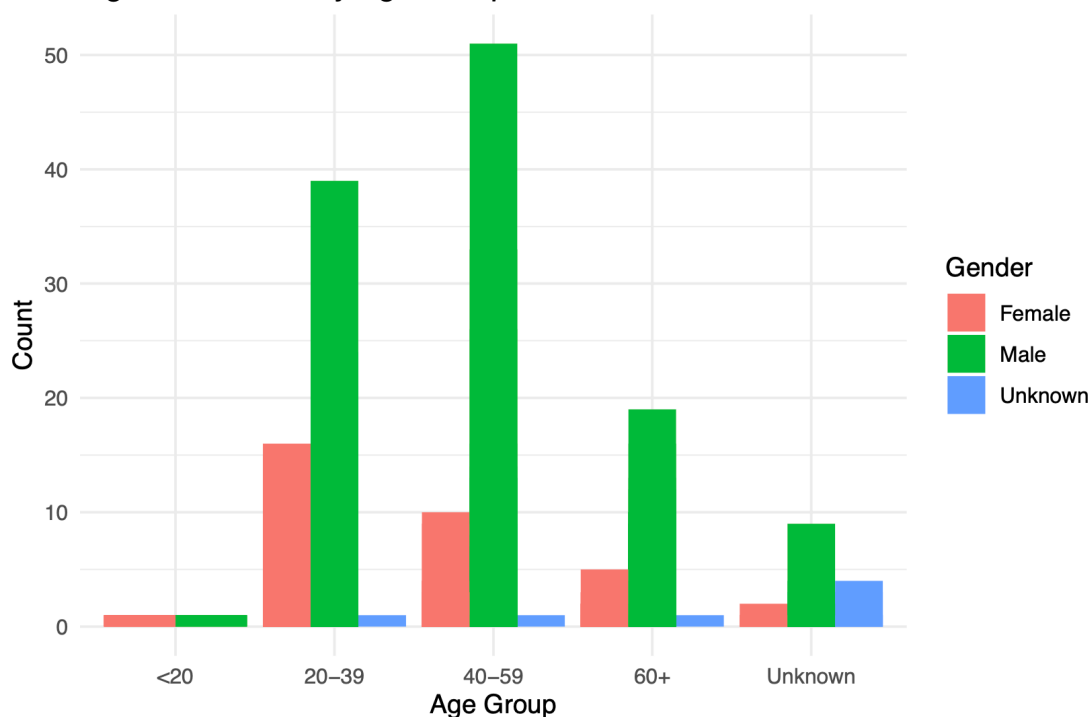
Variable analysis

Figure 1: Distribution of Deaths by Cause



This bar plot provides us with a stark visualization of the tragic endpoints faced by Toronto's homeless population. Each bar, colored distinctly to represent a different cause of death, stands as a reminder of the varied threats to life that disproportionately affect those without a home. Upon examining the graph, it becomes evident that certain causes of death are particularly prevalent within the homeless community. For instance, a noticeably higher bar for causes like Drug Toxicity or Cardiovascular Disease suggests that these are significant contributors to mortality and thus warrant specific attention from healthcare providers and policymakers. Contrastingly, the data shows that the least number of homeless deaths were attributed to COVID-19. This finding could potentially reflect the success of public health interventions or the underreporting of COVID-19 deaths due to challenges in post-mortem viral testing. It may also bring attention to the effectiveness of rapid response measures taken to protect this vulnerable group during the pandemic.

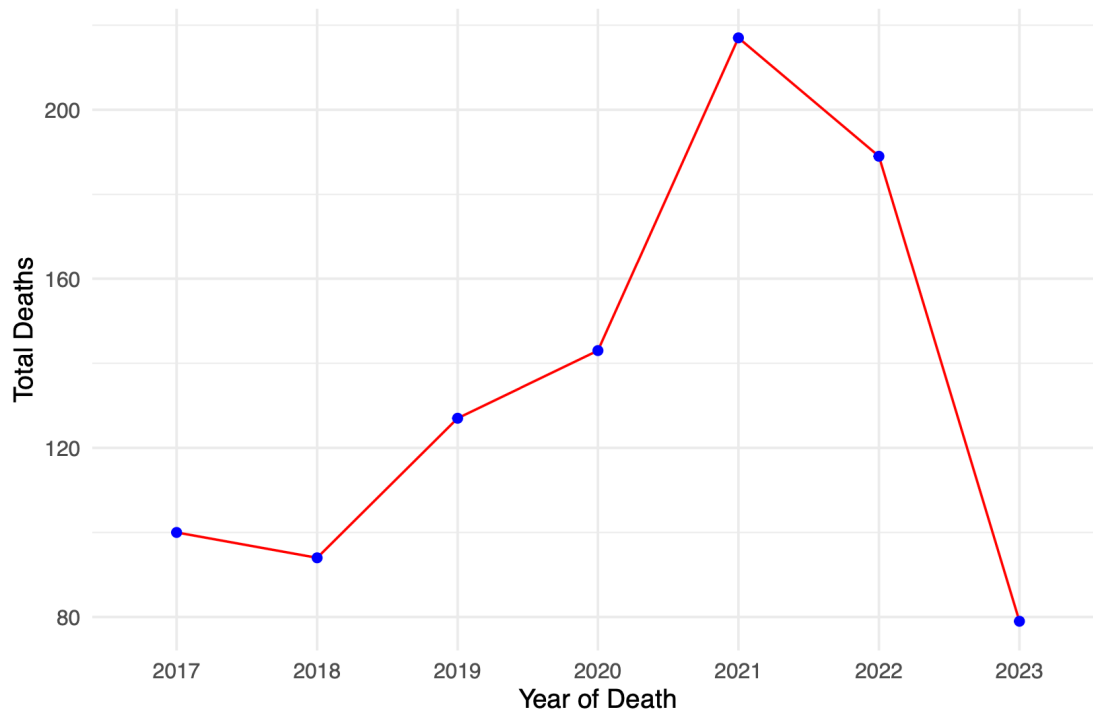
Figure 2: Deaths by Age Group and Gender



This plot illustrates the distribution of homeless deaths across different age groups, further categorized by gender (Female, Male, Unknown). The age groups are less than 20 years old, 20 to 39 years old, 40 to 59 years old, greater than 60 years old, and unknown. The x-axis represents the age groups, the y-axis shows the count of deaths, and the color coding differentiates between genders.

The plot highlights the prevalence of homeless deaths across age and gender lines, with a stark contrast between male and female mortality rates. Notably, the mortality rate of male is obviously higher than female. Males, particularly in the 40 to 59 age group, show the highest death counts, suggesting acute vulnerabilities. Females tend to die at a younger age, potentially due to gender-specific health issues and risks such as gynecological diseases or sexual violence. This underscores the need for gender-sensitive and age-specific interventions in addressing homelessness and associated mortality.

Figure 3: Yearly Trends in Homeless Deaths

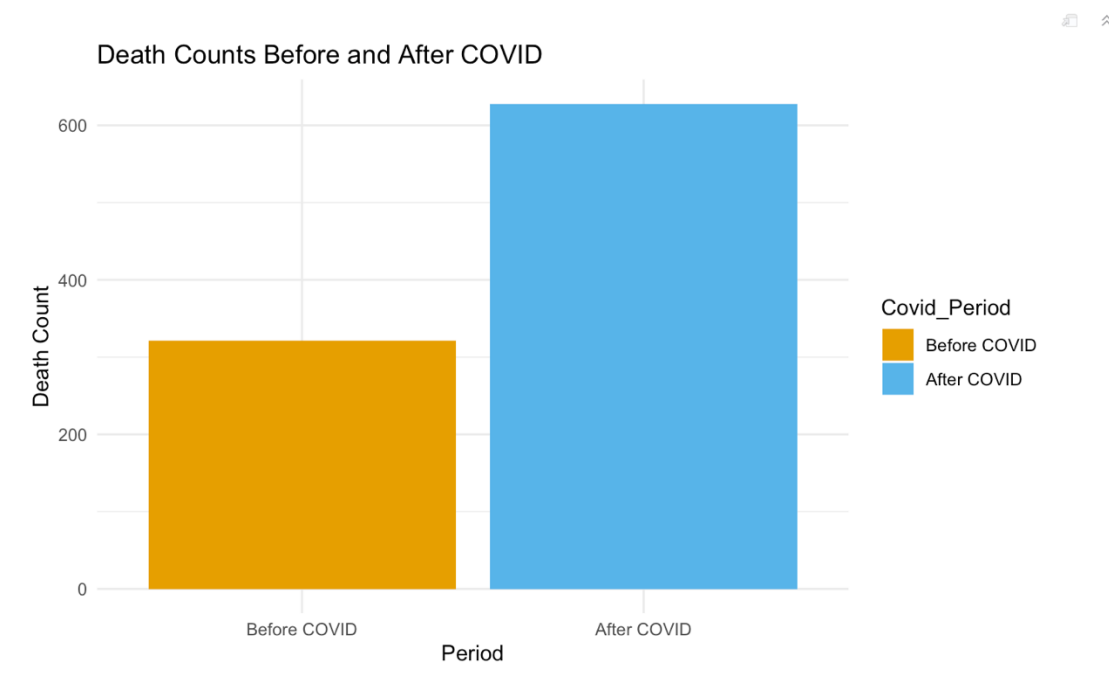


This line plot shows the total number of homeless deaths per year. The x-axis represents the years (from 2017 to 2023), and the y-axis indicates the total count of deaths for each year. The red line, marked with circular points, illustrates the trend over the years. The overall trend from 2017 to 2021 is upward that indicates an increase in mortality. It suggests the worsening conditions or increased vulnerabilities within the homeless population. The peak in 2021 marks the highest mortality, but the subsequent sharp decrease in 2022 signals a significant shift. This sudden decline may reflect successful policy implementation, altered data gathering methods, or other influential variables.

– Results

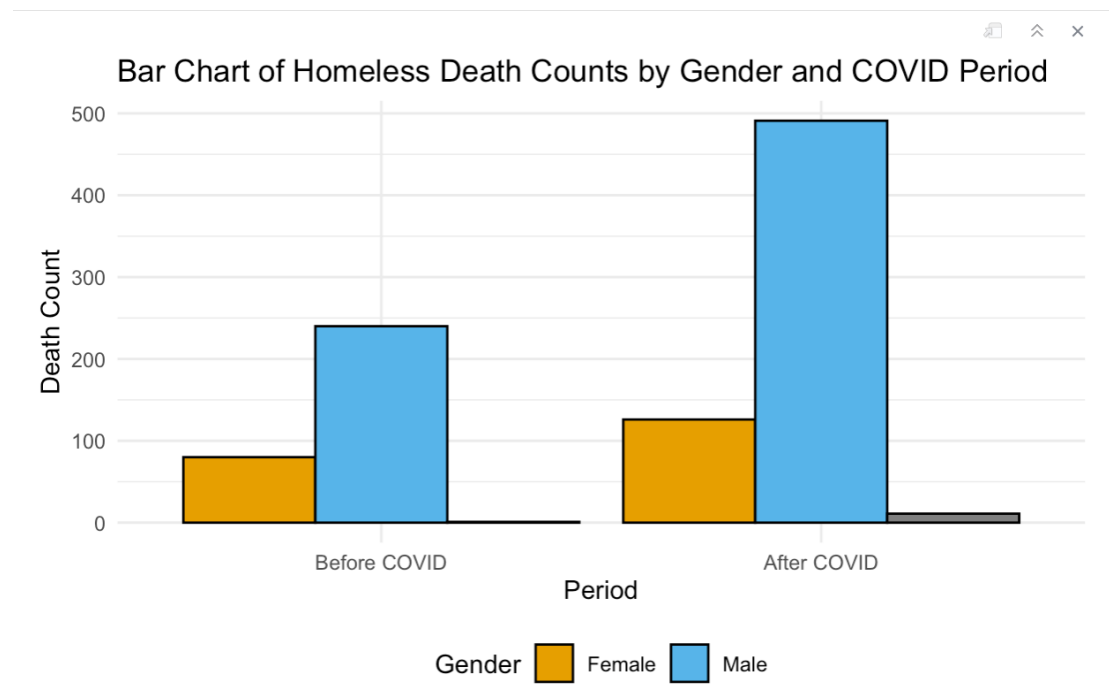
Without Gender Control

验证猜想, after covid-19, death count of homeless increase



The bar graph illustrates the comparison of homeless death counts before and after the outbreak of COVID-19, not controlled by any other variables. The period prior to COVID-19 is represented by a significantly lower bar, indicating a lower death count among the homeless population. In contrast, the bar representing the post-COVID period is substantially higher, suggesting a marked increase in the number of deaths. The visualization of data comparison supports the hypothesis that the death count of homeless individuals has increased after the outbreak of the pandemic. It is worthy to note that this data does not differentiate by other variables, such as gender or aged group, implying that the increase in deaths is a general trend influencing the homeless population as a whole. This trend could be attributed to various pandemic-related factors, including increased vulnerability to the virus due to pre-existing health conditions, the strain of medical resources, and other indirect consequences of the global pandemic crisis.

With Control of Gender



The bar chart visualizes a gender-differentiated comparison of homeless death counts before and after the outbreak of the COVID-19 pandemic. In the post-pandemic period, the recorded death counts for both genders were markedly lower, with the male death count being higher than the female. The impact of the pandemic is evident in the post-pandemic period, where there is substantial rise in the death counts for both genders, This increase suggest that the pandemic has had a considerable effect on the homeless population, which is consistent with the analysis we discussed above, exacerbating the existing vulnerabilities faced by this group.

In post-pandemic period, the increase in death counts is significant among males, indicated by the pronounced height of the blue bar, which far exceeds the pre-pandemic figures. The rise in female death counts, represented by the orange bar, experience a less dramatic increase than that of their male counterparts. The chart clearly demonstrates that the pandemic's aftermath has led to a higher incidence of deaths among the homeless, with gender-specific data revealing that the male homeless population has experienced a more severe increase in mortality. This gender-controlled analysis underlines the heightened risks and challenges that the homeless group has encountered during the global pandemic, with the differential impact on the males and females pointing to underlying social, economic and health-related disparities.

Comparison by table

Impact of COVID-19 on Homeless Death Counts by Gender		
	Death Count	
	(1)	(2)
Post-COVID Period	-0.620 (1.212)	0.040 (1.074)
Female	2.884*** (1.016)	3.575*** (0.898)
Post-COVID * Female	-1.199 (1.526)	-1.807 (1.343)
Constant	2.571*** (0.818)	-1.280 (1.577)
Cause of Death Controlled	No	Yes
Age Controlled	No	Yes

Note:

This table compares the difference in death counts between genders before and after the onset of COVID-19, with and without controls for cause of death and age.

*p<0.1; **p<0.05; ***p<0.01

The table presents the results of a regression analysis of the influence of COVID-19 on homeless death counts by gender. The regression model has been run twice: model 1 without controlling by gender, and model 2 with the control. Through the table and data included. We can gain a deeper understanding of the validity and significance of the data, which reveals aspects that visualization of data cannot show.

The coefficient of model 1 for the Post-COVID Period is -0.620, but it's not statistically significant since its p-value is larger than 0.1, suggesting that there is no significant change in the death counts post-COVID when not controlling for other variables. The coefficient for males is significantly positive (2.884) at the 5% levels, suggesting that male death counts are substantially higher than female death counts in the pre-COVID period. However, the interaction term between the post-COVID period and being male is not statistically significant (-1.199), including that the increase in death counts after pandemic is not significantly different for males compared to females.

The second model, which includes controls for the cause of death and age, shows a light substantial increase (0.040) in death counts during the post-COVID period compared to the pre-COVID period, but this increase is not statistically significant enough to provide strong evidence that the death counts have increased after COVID-19 once we account for these additional variables. However, male death counts are significantly higher (3.575) at less than 0.01 level, reinforcing the observations from the first model. The interaction term is negative (-1.807) and not statistically significant, implying that controlling for cause of death and age does not change the relationship between gender and death counts in the post-COVID period.

Summary for Results

In summarizing the outcomes from the regression analysis, the data indicates a persistent association between genders and homeless death counts, implying that males are consistently more represented in these statistics. It is worthy to point out the outbreak of COVID-19 appears to have had little influence on the pre-existing gender difference in death counts among the homeless. This finding indicates that while COVID-19 has undoubtedly had a broad and profound impact on global health and mortality rates, but the analysis does not show that it also has significantly exacerbated the gender gap in mortality among the homeless population in Toronto. It is crucial to note that these results are determined by the accuracy and completeness of the reported death counts and the actual impacts may vary with additional context or data.

Discussion

Exploring the Significance of Our Findings

The analytical significance of examining the death counts among Toronto's homeless population during the pandemic are illustrations of how public health crises can exacerbate the vulnerabilities of already marginalized groups. Especially our findings underscore the association between gender and mortality within the homeless groups. These data and results provide an essential narrative that may inform public health strategies and services, and policymaking to better support the vulnerable homeless community during time of crisis.

However, our observation related to gender aspects, does not inherently indicate higher individual vulnerability for either gender group, it underscores the need for gender-specific data and targeted resources to address the unique challenges faced by both male and female homeless. In addition, these observations also highlight the importance of considering demographic proportions in public health research. A deeper understanding of the structure of the homeless people by gender could reveal insights into differential access to resources, health care, and exposure to risk factors that contribute to mortality. Further research that accounts for the percentage distribution of gender within the homeless population would provide a more detailed understanding of the gender dynamics and adjust supportive interventions more effectively.

Limitations

While our research provides insights into the death counts of homeless group before and after pandemic, particularly in relation to gender, it is essential to acknowledge several limitations that could influence the results drawn from our analysis.

Firstly, the integrity of our conclusions is related to the quality and accuracy of the data used in the study. If the data on death counts is not comprehensive or if there are inaccuracies in recording the data, this could lead to misinterpretations of the true impact of the pandemic on different genders within the homeless population. Incomplete data might fail to capture all cases of mortality among homeless, potentially underestimating the actual number of deaths.

Secondly, the regression analysis does not account for all possible confounding variables that affect death counts. This is also a limitation of the source data, which does not include all the variables that could affect the death count. Factors such as socio-economic status, access to healthcare, and geographic location are just a few examples of variables that were not controlled for but could significantly affect the outcomes. For example, whether the ratio of male to female among homeless community also counts for a variable in death. The absence of these variables means that we might not fully understand the relationships.

Finally, the local context of the pandemic in Toronto, including specific policy responses, the

capacity of the healthcare systems of different regions, and public health measures implemented, had a significant influence on death counts among the homeless. While our findings focus on Toronto, they may not be directly applicable to other cities or regions due to differences in regional policies, healthcare systems, and public health strategies. It is crucial to note that our results apply only to the specific context of Toronto during the pandemic.

Ethical Concerns and Bias

The research of death counts of homeless community before and after pandemic could raise potential biases and ethical concerns that might have happened and need to be addressed to ensure the applicability of the research. Ensuring that research methods and data interpretation do not include stereotypes or misrepresentations is crucial.

The comparison of pre and post-pandemic period reveals the increase in homeless death counts, ethical concerns cannot be overlooked. The research should extend beyond data representation, advocating for systematic policy change to address the fundamental causes of homelessness, such as poverty, lack of affordable housing, insufficient mental health support, to avoid increase in homeless death counts. While presenting data on the higher mortality rates among male homeless, it is critical not to ignore the struggles faced by female homeless. Additionally, researchers have a duty to handle sensitive information with the respects for the deceased and their families, ensuring that privacy and the dignity of individuals is maintained.

Regarding bias, the potential for data collection to skew the reality must be acknowledged. We must consider if deaths among the homeless accurately reported and attributed, and data fully capture the scope of issue. There is a concern that homeless individuals who die without interaction with medical systems may be not collected and lead to an underestimated of the true death counts. This potential underrepresentation calls for a critical examination of the methodologies employed in data collection and necessitates a vigilant approach to interpreting the results to avoid misinforming policy or public perception.

Future Research Directions

Future research directions stemming from our study topic should aim to deeper understandings of the dynamics of homelessness in relation to health crises. Prospective studies could focus on the constant effects of pandemic and investigate the success of interventions. Particularly, understanding the gender difference in mortality rates, and qualitative research, such as interviews which illuminate the personal experiences of the homeless during such crisis, should be paid more attention. By widening a range of socio-economic variables, future studies could provide more comprehensive insights that are critical to the development of specific policies and support systems to effectively assist the homeless.

Conclusion

In conclusion, this study has quantitatively examined the impact of the COVID-19 pandemic on mortality among Toronto's homeless population, with a focus on gender disparities. The analysis,

which applied a Difference in Differences approach, suggests an overall increase in deaths post-pandemic, with males experiencing a notably higher mortality rate. Although the increase in death counts after COVID-19 was not statistically significant when accounting for confounders such as cause of death and age, the gender gap in mortality persisted. These results highlight the importance of targeted public health interventions and policies to address the needs of homeless populations during health crises. Future research should incorporate a broader set of socio-economic factors to deepen our understanding of the determinants of mortality in this vulnerable group.