Deciphering Mortality in Alberta: A Multifaceted Analysis*

A Quantitative Approach on Demographics, Behaviors, Policies, and Environment

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This study focuses on the mortality trends in Alberta, emphasizing the broader public health implications. It offers a panoramic view of the health challenges and demographic shifts influencing the province's mortality rates. The findings highlight an increase in mortality in recent years, with implications extending beyond individual health conditions to encompass wider societal and environmental factors. This paper underscores the importance of data-driven approaches in shaping effective public health strategies and policies.

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*Code and data are available at: https://github.com/iJustinn/Alberta_Mortality_Rate.git

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1 Introduction

Alberta, celebrated for its vibrant culture and robust economy, faces public health challenges that impact its diverse population. Mortality rates, as a key metric of economic level (Preston 2007), influenced by a complex mix of socioeconomic conditions, environmental factors, and healthcare system performance. These rates reflect the community's collective well-being and gauge the effectiveness of public health policies and interventions.

Exploring mortality trends in Alberta is crucial, given the global healthcare challenges posed by new threats and chronic conditions. This paper aims to analyze Alberta's mortality statistics, highlighting both longstanding and emerging causes of death. Our goal is to understand these trends within Alberta's dynamic public health context, rather than pinpoint direct causality.

Our analysis delves into the factors influencing mortality rates, including demographic shifts, health-related behaviors (Wingard 1982), government policies (Rajmil and Fernández de Sanmamed 2019), and environmental changes (Näyhä 2005). By examining data on mortality causes, we aim to offer a nuanced perspective that could guide the province's healthcare policy towards more informed and strategic decisions. This study sets the stage for a quantitative assessment, seeking to reveal the underlying forces shaping health outcomes in Alberta.

The subsequent sections of this paper are organized to facilitate a comprehensive understanding of the study and its implications. After this introduction, Section 2 outlines the methodology used in the analysis, emphasizing transparency and replicability. Section 3 presents the findings in detail, charting the trends in Alberta's mortality. Section 4 discusses these findings from various perspectives as mentioned earlier. Finally, Section 5 concludes the paper, summarizing the key insights and findings of this research.

2 Data

Data used in this paper was cleaned, processed and tested with the programming language R (R Core Team 2022). Also with support of additional packages in R: `tidyverse` (Wickham et al. 2019), `ggplot2` (Wickham 2016), `janitor` (Firke 2023), `readr` (Wickham, Hester, and Bryan 2023), `knitr` (Xie 2014), `rstanarm` (Goodrich et al. 2023), `modelsummary` (Arel-Bundock 2023), `tidybayes` (Kay 2023), `loo` (Vehtari et al. 2023), `testthat` (Wickham Year of publication).

Table 1: top 8 major causes in 2019

Year	Cause	Ranking	Deaths	Years
2019	Organic dementia	1	1,997	22
2019	All other forms of chronic ...	2	1,886	22
2019	Malignant neoplasms of trac...	3	1,523	22
2019	Other chronic obstructive p...	4	1,159	22
2019	Acute myocardial infarction	5	1,061	22
2019	Atherosclerotic cardiovascu...	6	678	22
2019	Accidental poisoning by and...	7	677	10
2019	Stroke, not specified as he...	8	602	22

2.1 Source

Our study delves into Alberta's mortality trends using the "Leading Causes of Death" dataset from the Alberta Open Government Portal (Alberta Open Government Portal 2023). This dataset provides a comprehensive overview of mortality statistics throughout the province, organized by cause of death. As a cornerstone of transparency and public engagement, the Alberta Open Government Portal hosts this dataset at open.alberta.ca, offering open access to crucial health data.

The dataset includes detailed death counts and mortality rates over several years, with breakdowns by age, sex, and specific causes, from chronic diseases to accidents and new health threats. This detail enables a nuanced analysis of mortality trends and the identification of key health challenges, guiding potential public health interventions.

We selected this dataset for its reliability, depth, and alignment with our study's goals. As an official government source, it provides accurate and trustworthy data essential for our analysis. Its comprehensive demographic and cause-specific details allow for an in-depth examination of mortality influences in Alberta. Additionally, the dataset's structure supports efficient analysis and modeling of mortality trends.

2.2 Method

Our analysis commenced with the essential task of refining the raw dataset. The initial phase involved cleaning and standardizing the dataset's variable names to enhance readability and analytical efficiency. We also aggregated the data to quantify the prevalence of each cause of death, thereby streamlining the dataset for more focused analysis. A critical aspect of our methodology was the isolation of data from the year 2019. This strategic choice was made to examine mortality trends immediately before the onset of the COVID-19 pandemic. By focusing on this specific year, we aimed to establish a baseline understanding of mortality patterns unaffected by the pandemic's impact. Within this scope, as showing in Table 1, we identified and prioritized the top 8 causes of mortality, based on their significance and prevalence.

Building on the refined dataset, our analysis further narrowed to investigate the top 5 causes of mortality in 2019. This deliberate focus allowed us to concentrate our efforts on the most impactful health challenges faced by Alberta before the pandemic. We applied statistical models to fit these mortality trends, seeking to identify underlying patterns and determinants. This approach was aimed at uncovering insights that could inform public health strategies and interventions, contributing to a more nuanced understanding of mortality dynamics in the province.

The choice of models for our analysis was the Poisson and Negative Binomial. These models are particularly suited for mortality data analysis, aligning well with the characteristics of count data. Mortality counts, which represent the number of deaths over specific periods, naturally follow the discrete distribution assumed by the Poisson model. This model assumes equal mean and variance, a condition that typically applies to independent events occurring at a constant rate. The Poisson model is valued for the interpretability of its parameters; its exponential coefficients reflect the change in mortality rate per unit change in a predictor, providing clear insights into factors influencing mortality rates. This clarity is crucial for deriving actionable insights from the data. However, mortality data often exhibit overdispersion—where the variance exceeds the mean—challenging the Poisson model's assumption. The Negative Binomial model addresses this by introducing an extra parameter to handle overdispersion, making it a more adaptable choice for analyzing data with greater variability.

3 Results

3.1 Data Trend

Results in the Figure 1 displays the annual number of deaths in Alberta for the top five causes in 2019 unveils distinct trends for each cause over approximately two decades. The data suggest a relatively stable trend in deaths from acute myocardial infarction, with a small rise that may indicate a steady prevalence of risk factors or an equilibrium between advancing medical interventions and demographic shifts. Conversely, the increasing trajectory seen in deaths due to chronic diseases points to a potential escalation in lifestyle-related health issues or could reflect the demographic realities of an aging population.

Particularly notable is the sharp increase in deaths attributed to organic dementia, surging upwards more markedly in the latter half of the time span. This trend could signify heightened awareness and improved diagnostic capabilities, alongside the impact of an aging society. Meanwhile, deaths from malignant neoplasms related to the respiratory system display minor fluctuations, hinting at persistent challenges in cancer prevention, detection, and treatment. The upward trend in chronic obstructive pulmonary disease-related mortality could be linked to

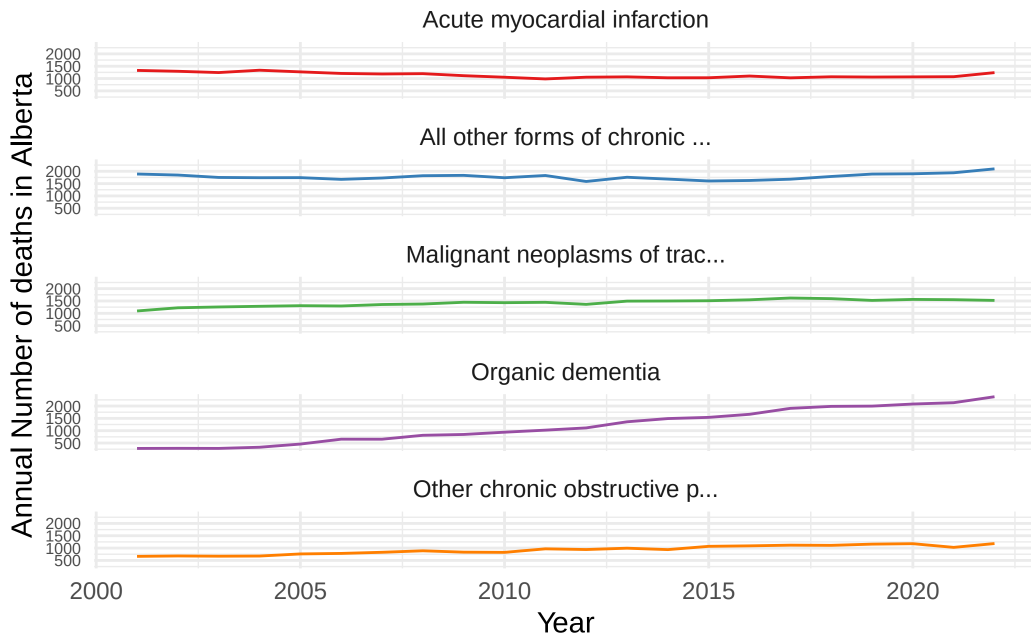


Figure 1: Trend for Alberta Mortality-Top 5 Causes

environmental factors or historic smoking patterns, underscoring the pressing need for robust public health policies and effective healthcare strategies.

The graph presented in Figure 2 illustrates a clear upward trajectory in the total number of deaths from 2001 to 2022. This trend, while indicative of a rising mortality rate, necessitates a nuanced interpretation. The increasing death toll may not necessarily be attributed to the lethality or prevalence of specific causes alone. Instead, it potentially reflects broader demographic changes, such as the growth of the overall population, particularly within older age groups who are statistically more vulnerable to various health-related fatalities.

3.2 Modeling

Then the Table 2 summarizes the coefficients of both models built to fit the mortality trend in Alberta, offering a comparison of their estimations for the top causes of mortality. In both models, “other chronic” conditions and “neoplasms” exhibit positive coefficients, suggesting these causes of death have an increasing trend over time. Meanwhile, “obstructive pulmonary” diseases show a negative relationship in both models, indicating a decreasing trend in mortality rates. The consistency across both models reinforces the reliability of our findings.

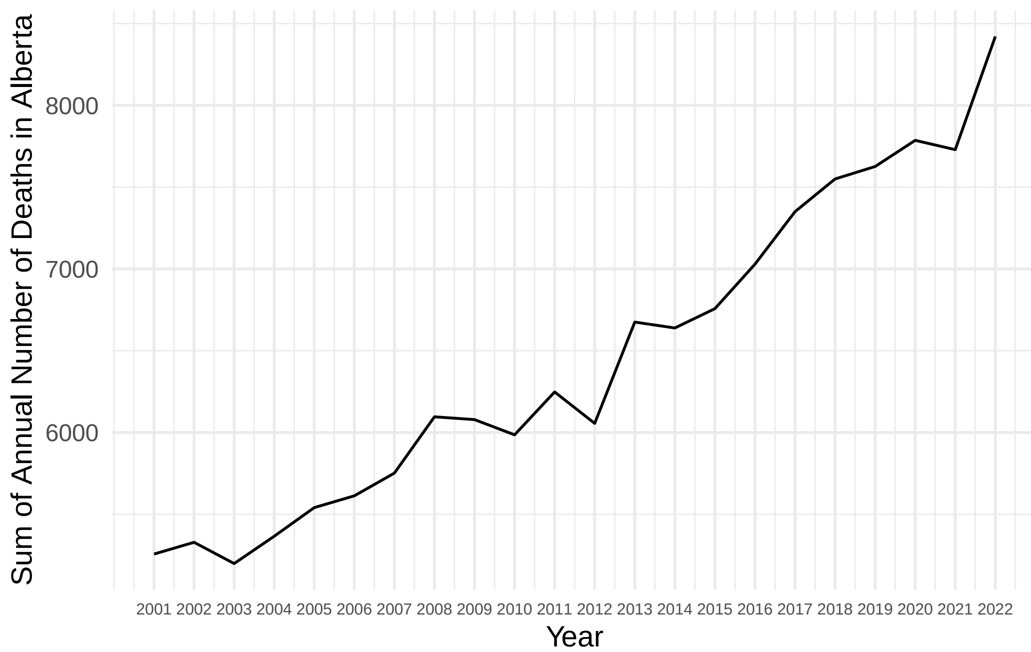


Figure 2: Trend for Alberta Mortality-Sum of Causes

For the Poisson model, the expected log count is defined as:

$$\log(\mu_i) = \beta_0 + 0.447 \times (\text{other chronic})_i + 0.223 \times (\text{neoplasms})_i + 0.046 \times (\text{dementia})_i - 0.205 \times (\text{obstructive pulmonary})_i$$

For the Negative Binomial model, the expected log count is defined as:

$$\log(\mu_i) = \beta_0 + 0.449 \times (\text{other chronic})_i + 0.226 \times (\text{neoplasms})_i + 0.048 \times (\text{dementia})_i - 0.203 \times (\text{obstructive pulmonary})_i$$

Then, to see how well the two models fit the original data, we can refer to the values in the lower half of Table 2. However, it's always clearer to see this visually, as depicted by the graphs for the Poisson (Figure 3a) and Negative Binomial models (Figure 3b). The diagnostic plots further elucidate the fits of the models. The spread of the simulated lines (y_rep) around the predicted data (y) suggests that the Negative Binomial model may better accommodate the overdispersion present in the data, which is a common characteristic of count data such as mortality rates.

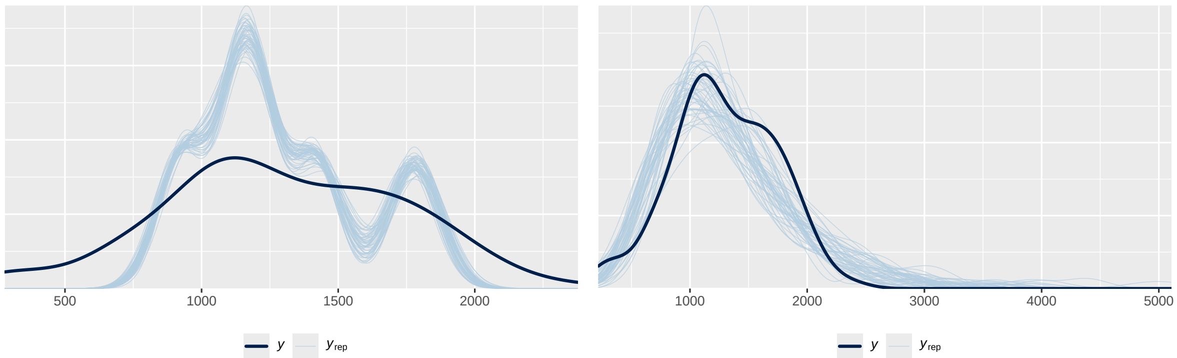
Table 2: summary of modeling

	Poisson	Negative binomial
other chronic	0.447	0.449
		(0.102)
neoplasms	0.223	0.226
		(0.100)
dementia	0.046	0.048
		(0.101)
obstructive pulmonary	−0.205	−0.203
		(0.104)
Num.Obs.	110	110
Log.Lik.	−5718.182	−810.934
ELPD	−5926.8	−815.4
ELPD s.e.	1216.0	10.6
LOOIC	11 853.7	1630.8
LOOIC s.e.	2432.0	21.2
WAIC	11 954.1	1630.8
RMSE	325.38	325.39

Table 3: cross validation of modeling

```
                                 elpd_diff se_diff
cause_of_death_alberta_neg_binomial     0.0       0.0
cause_of_death_alberta_poisson      -5111.5    1205.8
```

The presence of multiple peaks in the simulated data distributions of Figure 3b indicates potential subgroups within the data or non-linearity in the mortality trends that the Poisson model may not be accounting for. Such patterns underscore the importance of considering different model structures when dealing with complex datasets. The Negative Binomial model appears to capture the dispersion in the data more effectively than the Poisson model. This not only evident in the plots, but also by the larger ELPD (Expected Log Pointwise Predictive Density) value showing in Table 3, as a higher ELPD indicates a model with better predictive accuracy. Furthermore, this better prediction by the Negative Binomial model was consistent with the predictions for the two models mentioned in the method section of Section 2.



(a) Poisson Model

(b) Negative Binomial Model

Figure 3: Model Results

4 Discussion

The preceding sections have laid the groundwork for a comprehensive analysis of mortality trends in Alberta, paving the way for this discussion.

4.1 Demographic Shifts

Alberta's demographic landscape has been undergoing significant transformations, predominantly fueled by a steady influx of immigrants from within Canada and across the globe (Government of Alberta 2024b). This diversification of the population not only enriches the province's cultural fabric but also introduces complex dynamics in public health management. Immigrants, adapting to a new environment, might face unique health challenges including climate-related discomfort and exposure to diseases not prevalent in their countries of origin. These factors, coupled with the stressors associated with resettlement, could potentially influence mortality rates in ways that are distinct from the native population.

The demographic shift towards a more diverse population composition also brings into focus the aging demographic. As the overall population grows, so does the proportion of elderly residents, a group inherently at higher risk of mortality due to chronic diseases and other age-related health issues. This aging demographic, compounded by the province's overall population growth, naturally leads to an increase in the number of deaths. However, interpreting these rising death tolls requires careful consideration of the expanding population base (Government of Alberta 2024a); a larger population inherently includes more individuals at risk of mortality, thereby elevating the absolute number of deaths even if the mortality rate (deaths per capita) remains constant or decreases.

4.2 Health-related Behaviors

Health-related behaviors, encompassing lifestyle choices such as diet, physical activity, smoking, and alcohol consumption, significantly influence mortality trends in Alberta. These behaviors, often rooted in socio-economic conditions, cultural norms, and individual psychology, have a profound impact on the prevalence and progression of chronic diseases, including heart disease, diabetes, and various forms of cancer. For instance, the high prevalence of sedentary lifestyles coupled with increasing consumption of processed foods contributes to obesity and related health complications, which can elevate mortality rates. Smoking and excessive alcohol consumption continue to be major risk factors for respiratory diseases (Wingard 1982), liver conditions, and cancers, despite public health campaigns aimed at curbing these behaviors.

Refer back to Table 2, the positive coefficients for "other chronic" and "neoplasms" in both models suggest that deaths from these causes have steadily increased, raising questions about the broader factors at play beyond the healthcare system's direct influence. Simultaneously, the negative coefficient for "obstructive pulmonary" diseases suggests a decline in mortality from these conditions, potentially reflecting successful public health initiatives and changing social habits, such as reduced smoking rates.

4.3 Government Policies

Government policies, particularly those related to austerity measures, play a significant role in shaping public health outcomes and mortality rates (Rajmil and Fernández de Sanmamed 2019). Austerity policies, which are often implemented to reduce government debt through spending cuts and increased taxes, can have far-reaching effects on the social determinants of health. For instance, reductions in funding for public healthcare services can limit access to preventive care, screenings, and treatment for chronic diseases, potentially leading to an increase in mortality rates. Additionally, austerity measures that result in cuts to social services can exacerbate poverty, unemployment, and housing instability, further impacting individuals' health and well-being.

In Alberta, where public health policy can significantly influence healthcare delivery and social welfare programs, the implementation of austerity measures may pose challenges to achieving optimal health outcomes. Although there was no implimentation of austerity policies recent years, some past implementation has already proven to have a significant negative impact on society (White 1997). The relationship between such policies and mortality underscores the need for careful consideration of the health impacts of fiscal decisions. Policymakers must balance budgetary constraints with the imperative to protect and enhance public health, ensuring that austerity measures do not disproportionately harm vulnerable populations or erode the quality of healthcare services.

4.4 Environmental Changes

Environmental changes in Alberta, ranging from air and water pollution to climate variability and extreme weather events, significantly influence public health and mortality trends. The province, known for its diverse landscapes and economic reliance on industries such as oil and gas, agriculture, and forestry, faces unique environmental challenges that directly impact the health of its residents. Air pollution (Wang, Kindzierski, and Kaul 2015) , resulting from industrial activities and urban traffic, is linked to respiratory diseases, cardiovascular conditions, and increased mortality rates. Industrial waste issues (Timoney and Lee 2009), such as sand and water, can leading to health complications and diseases. Besides, even seemingly insignificant temperature changes in living environments can have an impact on human health (Näyhä 2005), and such changes are mainly attributed to global warming.

4.5 Possible Improvements

While our study sheds light on Alberta's mortality trends, it's important to recognize its limitations. Our analysis depends on available data, which might not capture every detail affecting mortality rates. The methods we used, although useful for spotting general trends, might oversimplify the complex factors at play, including how policies or environmental changes impact health. Future research should aim to use more detailed data and explore these complexities more deeply. It's also essential to look at the long-term effects of changes in public health policies and the environment. By digging deeper into these areas and using a mix of quantitative and qualitative research, we can better understand and address the factors that influence health outcomes in Alberta.

5 Conclusion

In conclusion, our examination of Alberta's mortality trends over the last two decades has shed light on the province's public health landscape. We've pinpointed key causes of death and trends that demand attention from healthcare providers and policymakers. Our work underscores the necessity of using suitable statistical models to grasp complex health data accurately.

Our study reveals the diverse factors affecting public health in Alberta, including demographic changes, health behaviors, government policies, and environmental challenges. The influx of immigrants has significantly shifted Alberta's demographic makeup, bringing new health issues and diversifying healthcare needs. Lifestyle factors, such as diet, physical activity, and substance use, significantly influence health outcomes, highlighting the importance of targeted public health initiatives. Moreover, government policies and environmental factors, like pollution and climate change, present ongoing challenges to public health.

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