Premature and Avoidable Mortality by Neighbourhood Income in Urban Canada

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ABSTRACT

Background: Canadians are among the healthiest people in the world. Policy initiatives, such as implementing universal healthcare, have been employed to distribute this health equally among different groups of people in the country. Yet, health inequalities still exist and, in some cases, are growing across Canada. A key step to address health inequalities is to improve the measurement, monitoring, and reporting of social determinants of health, population health status, and the extent of health disparities.

Purpose: The underlying purpose of this study is to provide evidence on health inequalities and how these inequalities are related to income disparities in urban Canada, at the municipal, provincial, and national levels, to empower policymakers in evidence-based decision-making to implement policies to tackle health disparity in Canada.

Methods: This study was conducted in two phases. The first phase was a scoping review on application of the concept 'avoidable mortality' in socioeconomic-related health inequality research. The second phase of this study was a retrospective population-based analysis, conducted in two parts; first, the Canadian Vital Statistics - Death Database (CVSD) from 2011 to 2015 and Canadian Censuses 2011 and 2016 were used to calculate all-cause, premature, avoidable, preventable, and treatable mortality rates at municipal, provincial, and national levels; then, the National Household Survey (NHS) 2011 was used to measure income inequality in mortality by calculating concentration index, at municipal, provincial, and national levels.

Results: Findings spanning the period of 2011 to 2015 suggest that overall, income inequality in mortality exists at every level of geography in Canada. This study found a higher inequality in preventable mortality as compared to the inequality in all-cause, premature, avoidable, and treatable mortality, at all geographic levels in Canada. Another finding of this study shows that, at the provincial level, Saskatchewan was the only province with an inequality higher than national level inequality in all the mortality indicators. At the Census Metropolitan Area (CMA) level, Winnipeg was the most unequal CMA in premature, avoidable, preventable, and treatable mortality indicators over the study period.

Conclusion: Findings of this study highlight the need for an improvement in policies whose primary purpose is prevention, to curb the preventive mortality burden and reduce disparity in mortality. Additionally, the geographic variation in inequality found in this study points to the need for future research on identifying the factors leading to this difference in inequality across jurisdictions.

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LIST OF ABBREVIATIONS

OPHLA:	Ontario Public Health Libraries Association
UPHN:	Urban Public Health Network
DA:	Dissemination Area
NHS:	National Household Survey
RDC:	Research Data Center
PCCF+:	Postal CodeOM Conversion File Plus
CMA:	Census Metropolitan Area
CA:	Census Agglomeration
SAC:	Statistical Area Classification
POPCTR:	Population Centre
APHEO:	Association of Public Health Epidemiologists
CIMD:	The Canadian Index of Multiple Deprivation
PRISMA:	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
LSOA:	Lower Super Output Area
CT:	Census Tract
LGA:	Local Government Area
SLA:	Statistical Local Area
IMD:	Index of Multiple Deprivation
Swiss-SEP:	Swiss-SEP is an area-based index of Swiss socioeconomic position
LGA:	Local Government Area
IRSD:	Index of Relative Socioeconomic Disadvantage
SLA:	Statistical Local Area
MLHU:	Middlesex-London Health Unit
CAEC:	Concerted Action of the European Community on Avoidable Mortality
SII:	Slope Index of Inequality
RII:	Relative Index of Inequality
SEYLL:	Standard Expected Years of Life Lost
FCT:	Fundamental Cause Theory
ASMR:	Age-Standardized Mortality Rate
SE:	Standard Error
95% CI:	95% Confidence Interval

1. INTRODUCTION

Every human being has the right to live a healthy life; whether she is poor or rich, whether she is born in a remote region or in a big city. However, many people are experiencing ill-health due to reasons they are not responsible for. This is unjust and should not happen. Although this unfairness in health is avoidable, the problem persists and is even worsening in some cases, around the world (1–7). This should be a concern of a moral mind, and doing research in the area of health inequality is part of the solution in addressing this phenomenon.

This chapter, first, discusses the definition of health inequality and why it is critical to address it, and then, outlines the steps that should be taken in tackling health inequality. Finally, I explain the conceptual framework for action on social determinants of health which was adopted for doing this thesis.

1.1 What is health inequality?

The publication of the Black Report in 1980 is known to be a turning point in health inequality research. This report depicted the inequality in ill-health and mortality which existed between different 'social classes.' The Black Report attracted attention because it showed that the introduction of a free National Health Service in 1948 did not result in reducing health inequality, and furthermore, the health gap between different social classes had even widened from 1951 to 1971 in England and Wales (8).

Health inequality is a generic term referring to any difference in health outcomes between individuals or groups of populations (9,10). The health outcome is most often measured by life expectancy, mortality rates, and rates of diseases. While some health inequalities are amenable to policy interventions, there are adverse health consequences that are not. For example, diseases due to genetic dispositions are not avoidable, or deaths resulting from aging or freely recreational choices could not be prevented by governments' actions (9,11). In reality, an overwhelming proportion of health inequalities are avoidable. These kinds of unjust inequalities in health are called 'health inequity.' That is, 'health inequity' is defined as systematic differences in health status between individuals and groups of people, which are unjust, unfair, and avoidable (9,11,12).

There are different lines of thought as to what kinds of inequalities in health are unjust (10,11,13). For the sake of this project, I consider health inequities as disparities in health due to reasons other than biological factors. One such factor, socioeconomic status (SES) or social class, is widely known to be the reason for many inequities in health (11,12). Socioeconomic status is mainly measured by education attainment, occupation and employment, and income. In this thesis, income is used as a proxy for socioeconomic status and further measuring health inequality.

1.2 Why is tackling health inequality important?

The first but not most important justification for tackling health inequality is to reduce the unnecessary and avoidable suffering experienced by individuals. Reducing health inequality leads to improved population health, which has been identified as a goal of many health systems (14).

The Health Disparities Task Group in Canada discusses the costs of health inequality; they portray the potential economic benefits of addressing health disparities. Amongst the most important consequences of health inequality are: avoidable mortality; morbidity; distress and discomfort. From an economic perspective, inequality in health can lead to unnecessary costs for the health care system and society as a whole; approximately 20% of the cost incurred by the health care system in Canada is due to health disparity (15). It should be also noted that healthy people are more economically productive and therefore can contribute to the economic growth of a country (15).

Ultimately, one should emphasize the moral imperative of tackling health inequalities in society. The World Health Organization (WHO) and a number of international human rights treaties such as the International Covenant on Economic Social and Cultural Rights (ICESCR) recognize health as a right for every human being (9,16). Canada is a signatory to many international covenants which attest to health as a human right, one of which is the ICESCR (9). Article 12 of ICESCR states that parties recognize “the rights of everyone to the enjoyment of the highest attainable standard of physical and mental health” (17). Thus, Canada is committed to tackling health inequalities and is required to periodically report to the United Nations on their adherence to the covenants (9).

Canadian authorities have long recognized the importance of tackling health disparities (9). In 2008, the Chief Public Health Officer of Canada, Dr. David Butler Jones, identified addressing health inequalities as a priority for public health in the country (18). Nevertheless, the issue of health inequality not only did not resolve but is even worsening in some cases (9,18).

1.3 How to tackle health inequality?

Understanding the underlying causes of health inequality is imperative to devise policies to combat these inequalities. It is well documented in the literature that health inequalities result from different conditions in which one grows, works, and lives (11–13,19). Wealthy individuals, for example, live and work in better circumstances, and therefore enjoy better health compared to low-income individuals. These circumstances have come to be known as the social determinants of health, and include income and wealth, educational attainment, employment, race and ethnicity, gender, social and physical environment among others (9,12).

In the 20th century, different research groups put forward theories to explain the relationship between biology and social structure (9,10,13). One of these explanations, known as the ‘material’ pathway, indicates that low income and deprivation from material goods could result in ill health. That is, health inequalities among individuals are driven by differences in material advantage or disadvantage (9,13). The ‘psychosocial’ pathway, on the other hand, emphasizes the stress resulting from material deprivation, explaining that high stress, from lack of resources and comparing oneself to higher social classes, could lead to adverse health consequences (9,13). Another explanation is the ‘cultural behavioural’ approach which indicates that different cultures are more prevalent in different levels of income or social classes; health-threatening behaviours, such as smoking and having an unhealthy diet, are more prevalent in low-income people from lower social classes (13). Accordingly, one should note that having high stress and being materially deprived, individuals in lower levels of the SES ladder are more prone to adopt unhealthy behaviours as coping mechanisms, such as smoking tobacco or consuming alcohol (9,13). All of these theories underpin the critical role that social determinants of health play in the emergence of health inequalities.

A key step to address health inequalities is to improve the measurement, monitoring, and reporting of social determinants of health, population health status, and the extent of health disparities (12,15,20). Good data are crucial for evidence-based policymaking; providing quantitative information to support decision making and evaluating interventions to address health inequalities (12). In health inequality research, health outcome is mostly measured by mortality and morbidity, and SES is one of the leading indicators for measuring social determinants of health (20). Measuring social group differences in health is a common approach to assess health inequality (10). A large body of research indicates that SES is associated with health outcomes, such as hospitalization rates, chronic and acute health conditions, and mortality rates (1,8,19–23).

Mortality outcomes are an important summary measure of overall population health status. Premature mortality rate, which reflects deaths at younger ages, is an indicator commonly used to inform policymakers concerning health promotion, disease prevention, and mortality reduction (24). Recently, the concept of avoidable mortality, a subset of premature mortality, has been introduced as an outcome useful in informing policymakers regarding healthcare system performance (24,25). Additionally, the literature suggests avoidable mortality as a good health equity indicator to inform political decisions trying to address inequity in health (26,27).

After the introduction of the avoidable mortality concept for the first time in 1976 (28), researchers refined and updated the list of avoidable causes of death and related methodology according to their context of research (25,29–32). In Canada, there was no consensus on how to detect and calculate avoidable mortality, until 2012. In the past, due to the lack of a standard methodology, Canadian researchers used lists of avoidable mortality developed for other research or prepared a list for their own studies to identify and track avoidable deaths (33–38). In 2012, the Canadian Institute for Health Information (CIHI) developed the first version of the list of conditions for potentially avoidable mortality in Canada, including two subtypes of preventable and treatable deaths (24). This list was updated in 2018 (39).

1.4 Conceptual Framework for Action on the Social Determinants of Health

The theoretical foundation of this study was based on a conceptual framework developed by the World Health Organization (WHO) Commission on Social Determinants of Health (CSDH) (Figure 1.1). This framework identifies social determinants of health that are amenable to interventions in order to take action to tackle health inequalities. The CSDH framework is a comprehensive and dynamic model, underpinning the significant impact the social and physical conditions in which individuals are born, live, work, and learn have on one's health (40).

This framework shows how *socioeconomic and political context* is interrelated with *socioeconomic position* in a society, whereby individuals are stratified according to their social class, gender, ethnicity, education, occupation, and income. The context and socioeconomic position form the *structural determinants*, which in turn influence health equity through material, behaviours and biological, and psychosocial pathways. These pathways, called *intermediate determinants*, are the same as the previously explained trajectories between social determinants of health and health status. The CSDH framework explains how *structural determinants* affect health status and equity in health mediated by *intermediary determinants*, and how health status can "feed back" on *context* and *socioeconomic position (40)*. More details on the CSDH framework could be found in the 2010 report by WHO (40).

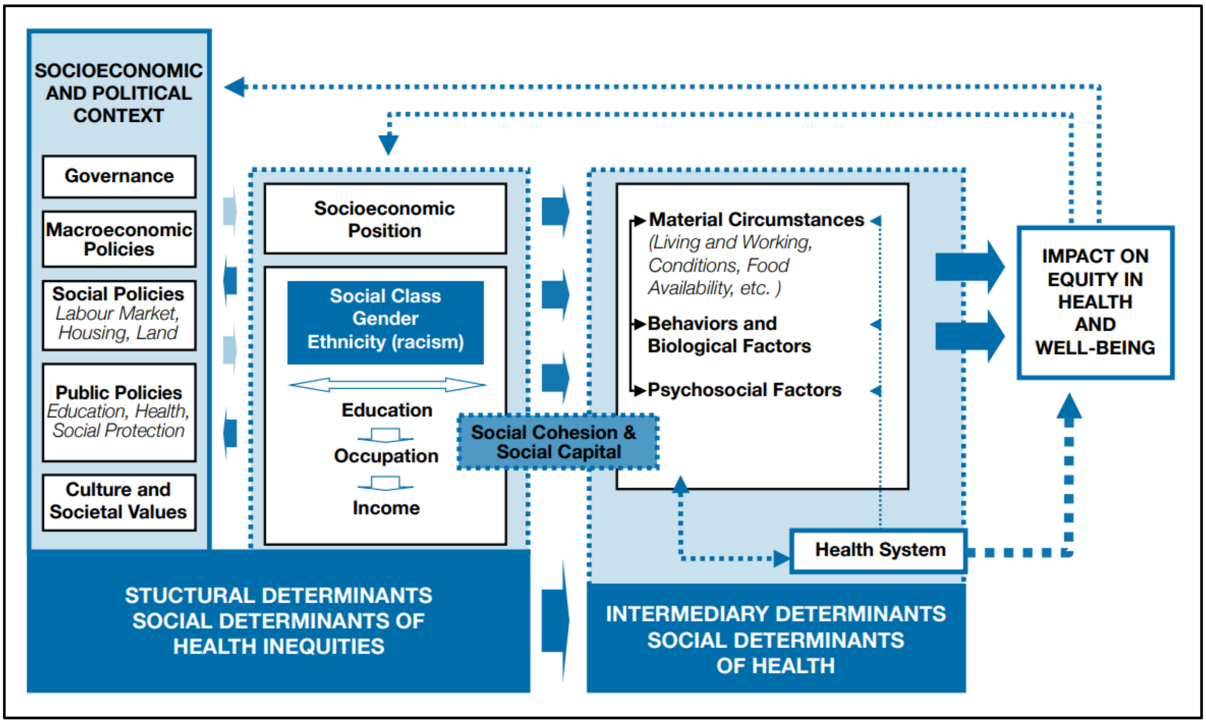


Figure 1.1: Conceptual framework for action on the social determinants of health by WHO (40)

Further on, the CSDH emphasizes the importance of evidence-based policymaking in addressing health inequalities. This begs for up-to-date data on social determinants, among which socioeconomic indicators are of great importance (12).

Having adopted the CSDH framework, this thesis intends to provide evidence on neighbourhood income inequalities in mortality outcomes in Canada, while acknowledging that there are many other factors with an impact on the health outcome of interest (i.e., mortality rates), which are missed in the current analysis. Therefore, the purpose of this study is to see if, in the Canadian urban context, income has the potential to be targeted by actionable interventions with a goal of tackling health inequalities.

It should be noted that as Statistics Canada does not disseminate data by neighbourhood (i.e., what people living in a city would describe as a city neighbourhood), researchers usually use Census Tract, Dissemination Area, or other standard geographic areas to investigate health inequalities at the neighbourhood level. Accordingly, in this thesis, the terms “neighbourhood” and “dissemination area” were used interchangeably. This was followed by the work of other Canadian researchers in this field of research; for example, Zygmunt and colleagues used the term “neighbourhood” in their research, while using the Marg-index to account for neighbourhood SES (41,42). The Marg-index uses the dissemination area as its source of SES (43). Another example is the CIHI Health Indicators 2012 report, in which Postal Code Conversion File Plus was used to map the patient’s postal code to the dissemination area in the 2006 Canadian census, “and the corresponding neighbourhood income quintile of that DA was assigned to the patient.” (24) James et al. used “census tract” as their basis for determining neighbourhood income in their study of avoidable mortality by neighbourhood income in Canada (33). Additionally, it should be acknowledged that there is a large body of literature on neighbourhood effects on health (44–47), and while it is an important area of research, it is not the focus of this thesis.

1.5 Statement of the Problem

Canadians are among the healthiest people in the world. One of the goals of implementing universal healthcare in Canada is to distribute this health equally among different groups of people through centering patients' needs rather than their ability to pay in providing health care services (48). Yet, health inequalities still exist and, in some cases, are growing across the country (15,20). As we are in the midst of the COVID-19 crisis, understanding and deconstructing inequalities in health seems more important than ever, for there is a growing body of literature indicating that the pandemic is taking greater tolls on people with lower socioeconomic status (21,49–52).

It is well-established that one of the consequences of inequality is avoidable deaths (37). Currently, there is a gap in the literature concerning avoidable mortality evidence in different SES groups across Canadian provinces and cities using the list of avoidable mortality conditions prepared by CIHI (24,27). Particularly, there is a need for rigorous assessment, by using standard methods (24), of the association between neighbourhood income and avoidable mortality rates in urban Canada at the municipal, provincial, and national level; these types of research could inform evidence-based policymaking and provide evidence for comparing different jurisdictions in terms of their performance in implementing public policies to tackle health inequalities.

1.6 Purpose of the Study

The underlying purpose of this study is to provide evidence on health inequalities in urban Canada, at the municipal, provincial, and national levels, to empower policymakers in evidence-based decision-making to implement policies to tackle health disparity in Canada. This will be done by filling the gap in knowledge concerning evidence for income inequalities in different mortality indicators in urban Canada. Furthermore, as previous studies indicated that there is a gender gap in avoidable mortality (24,34,41,42,53), this thesis also examined if mortality rates differed significantly between males and females.

To do so, this study will, first, conduct a scoping review to provide a comprehensive background on characteristics of the studies done to capture SES inequalities in avoidable mortality across the world. Secondly, this study will describe all-cause, premature, avoidable, preventable, and treatable mortality rates at the national, provincial, and municipal levels. Finally, this study will use dissemination area level median after-tax household income and mortality rates in urban areas to quantify inequalities in health in Canada overall, its provinces and territories, and the eight most populous Canadian cities.

1.7 Research Questions/Hypotheses

The research questions are as follows;

1. How is the concept ‘Avoidable Mortality’ applied in SES-related health inequality research?
2. How does the rate of mortality indicators differ in provinces and cities in Canada, and between males and females?
3. How does neighbourhood income-related inequality in mortality indicators compare between Canadian provinces, in urban areas?
4. How does neighbourhood income-related inequality in mortality indicators compare between cities with more than 800'000 population (in 2016) in Canada?

This thesis will test the following hypotheses;

1. There is a neighbourhood income gradient in mortality indicators in urban Canada, with higher avoidable mortality rates in lower-income neighbourhoods.
2. There is a neighbourhood income gradient in mortality indicators in cities with more than 800'000 population (in 2016) in Canada, with higher avoidable mortality rates in lower-income neighbourhoods.
3. There is a neighbourhood income gradient in mortality indicators in Canadian provinces, with higher avoidable mortality rates in lower-income neighbourhoods.

2. LITERATURE REVIEW

This chapter, first, describes the history of the introduction and further adaptation of the 'avoidable mortality' concept. It outlines different definitions and methodologies proposed for tracking avoidable causes of death in a population. Next, the standard methodology proposed for use in the Canadian context is discussed. Finally, a review of the current Canadian literature surrounding avoidable mortality is provided. A scoping review on the use of the avoidable mortality concept in SES-related inequality research was also conducted as a part of this thesis, whose result is reported in the fourth chapter.

2.1 The Concept of 'Avoidable Mortality'

In 1976, the Working Group on Preventable and Manageable Diseases, chaired by David D. Rutstein, introduced the new concept of 'unnecessary untimely deaths' as a health outcome indicator to measure the quality of medical care. They proposed a list of causes of death that could be prevented in the presence of timely effective medical care, which was defined as prevention, care, and cure. Using this broad definition, Rutstein et al. listed over 90 conditions, along with the 8th revision of International Classification of Diseases (ICD) codes, and categorized them into 'unnecessary disease' and/or 'unnecessary disability' and/or 'unnecessary untimely death', while identifying whether they were preventable and/or treatable at the time (28). Subsequently, when the 9th revision of ICD was introduced, the Working Group revised the list of conditions according to the latest revision of ICD in 1977 and 1980, while taking into account certain advances in health care (54,55).

In 1978, Alder et al. applied this concept empirically for the first time to "demonstrate the usefulness of this approach" as a measure of healthcare quality, by evaluating preventable mortality in the U.S during the years 1974 to 1978 (56).

Charlton et al. were the first research group to apply this concept at the population level, by analyzing regional variation in mortality in England and Wales from 1974 to 1978, introducing the terms "avoidable mortality" and "conditions amenable to medical interventions." They prepared a list of conditions based on the one developed by Rutstein et al. and excluded conditions whose avoidance was considered to be outside the scope of medical care. They also set lower and upper age limits for each condition, within which death due to the condition was deemed potentially avoidable (57,58). Revising and modifying their original list of avoidable causes of death, Charlton and colleagues extended their work to investigate trends in mortality due to causes amenable to medical interventions at the national and international levels (59,60). Since then, different research groups around the world used this concept in their area of interest and revised and extended it accordingly.

Poikolainen and Eskola examined trends of mortality amenable to health care in Finland, and estimated the impact of health services on mortality by comparing the decrease in rates of amenable mortality and non-amenable mortality between the years 1969 to 1981 (61). In their research, they listed 22 conditions (or groups of conditions), including five causes of perinatal death, tuberculosis, cervical cancer, hypertensive disease, and asthma as amenable to medical care, based on the list of "unnecessary untimely mortality" by Rutstein and colleagues. Similar to Charlton et al. (58), Poikolainen and Eskola excluded lung cancer from their list of amenable causes of death, arguing that its prevention depended mainly on efforts outside the health services (62). Additionally, they identified 7 categories of causes as "partly amenable" to medical care that had become amenable during the study period. These causes included ischemic heart disease, non-melanoma skin cancer, and meningitis. Poikolainen and Eskola defined an age limit of 0-64 for most of the mortalities, with some exceptions such as diabetes or asthma for which this limit was 0-50 (61). Two years later, in a cross-national study, Poikolainen and Eskola extended their list of amenable mortality to cover more than 70 amenable conditions and another 20 partly amenable causes, which in turn led to a substantial expansion of the “avoidable mortality” concept. In their work, Poikolainen and Eskola also developed an explicit list of “non-amenable deaths”, which included cerebrovascular diseases (61,62).

In 1988, building on Charlton et al. 's work (58), the European Community Concerted Action Project on Health Services and ‘Avoidable Deaths’ (ECCAP), directed by Walter W. Holland, adopted and modified the concept of ‘avoidable mortality’ which led to the publication of the European Community Atlas of ‘Avoidable Mortality’ (29,63). Initially, the atlas included 17 groups of conditions that were considered to be wholly or substantially preventable or treatable by health care services, while health care services was defined as primary care, hospital care, and collective health services such as screening and public health programs (e.g., immunization). Unlike its precedents, ECCAP considered health policy measures (primary prevention) effective in preventing mortalities such as lung cancer, liver cirrhosis, and motor vehicle accidents, and included them in their list of avoidable deaths. Out of the 17 groups of diseases, three were considered ‘primary prevention indicators,’ and fourteen were considered amenable to effective treatment or secondary prevention. The European Community Atlas of ‘Avoidable Mortality’ was followed by other editions; volume 2 of the second edition, published in 1996, contained further eight conditions which were argued to be ‘partly avoidable’ through health services. Similar to the ‘partly amenable’ list by Poikolainen and Eskola (61), this supplementary list of conditions included ischemic heart disease and skin cancer. The ECCAP atlas also set an age limit for each condition, mostly 0 to 64, to improve the “validity of mortality as an indicator of health service outcome.” (29,63,64)

These efforts gave rise to a number of explanatory analyses in the 1980s, occurring mostly in developed countries in which national death data was available at the time. Further, in 1990, Mckenbach and colleagues reviewed to date published works reporting mortality from conditions amenable to medical intervention and categorized them into two groups based on the type of analysis carried out in their investigations (65); the first group of studies, conducted in England and Wales (60), Netherlands (66), and Finland (61), examined ‘time trends’ in avoidable mortality, attributing the decline in mortality from amenable causes to improvement in medical care; and the second category included studies analyzing ‘geographical variation’ within or between countries, relating mortality or the availability of health care services and other factors. The second group of studies occurred in England and Wales (58,67,68), Belgium (69), France (70), Netherlands (71,72), and Finland (62). In their review, Mackenbach and co-workers noted a great inconsistency in how avoidable mortality was defined across the 11 reviewed papers. This variation in what conditions are considered amenable to death was observed across studies in spite of sharing Rutstein’s original lists as the base of their work. Mackenbach et al argued that this variation is mainly rooted in local circumstances in terms of availability of mortality data and, in part, due to the regional context as differences in the frequency of death due to certain conditions in certain countries. That is, some studies excluded certain conditions from their list of avoidable causes due to the low frequency of that condition in the respective study region. An example of this is the exclusion of hypertension and asthma in a study conducted in Greenland (73).

Later on, researchers started to differentiate between ‘treatable’ mortality (deaths amenable to medical intervention, through secondary prevention and treatment) and ‘preventable’ mortality (deaths amenable to interventions that are usually outside the control of health care services, through health policies). Westerling was the first to apply this approach empirically to data from Sweden, splitting avoidable mortality into ‘medical care’ indicators and ‘health policy’ indicators (74–76), Similarly, Benavides and colleagues examined avoidable mortality in Valencia, Spain, while using the ECCAP list of conditions as the basis of their study and dividing the causes of death into ‘primary prevention’ indicators which included lung cancer, liver cirrhosis, and motor vehicle injuries, and ‘secondary prevention’ indicators, including the remained 14 causes of death (77). This approach was subsequently applied in a number of studies on avoidable mortality (78–81).

Following that focusing on avoidable mortality indicators gained attention among the scholars, Simonato et al. applied a slightly different approach by dividing avoidable causes into three groups, namely, ‘causes avoidable through primary prevention,’ ‘causes avoidable through early detection and treatment,’ and ‘causes avoidable through improved treatment and medical care.’ The list of avoidable causes prepared by Simonato and colleagues included 24 causes or groups of causes, and was based upon Rutstein’s and Charleton’s original list and European Community Atlas of Avoidable Deaths, and also included some causes of death not frequently seen in previous lists, such as tumors of the upper airways and digestive tract, liver, bladder, and female breast, leukemias, and injury or poisoning. A description for the classification along with some examples of the avoidable causes of death developed by Simonato et al. is provided in table 2.1. In an attempt to describe avoidable mortality rates in 21 European countries, Simonato and co-workers set an age limit of 5-64, and age-standardized the rates using the world population, ages 5-64, as the standard (30).

Causes amenable to	Description	Etiology/avoidable through	Examples of causes of death
Primary prevention	Death due to this group of causes could be avoided by reducing the incidence of disease.	lifestyle, most importantly consuming alcohol and tobacco	circulatory disturbances of the brain, chronic liver diseases, tumors of the upper digestive and respiratory tract, lung, and bladder
		occupational	several tumors (lung, bladder, and liver)
		legal and societal measures such as traffic safety (speed manufacture of safer vehicles), and crime reduction policies.	injury and poisoning
Secondary prevention	Death due to this group of causes could be avoided through early detection and treatment.	established screening modalities	tumors of the breast and cervix
		early detection combined with adequate treatment	melanoma of the skin
Improved treatment and medical care	Death due to this group of causes could be avoided through improved treatment and medical care.	antibiotic treatments and vaccinations as well as cleaner water and food supplies	infection diseases
		complex interactions within the health care system, such as accurate diagnoses, transport to hospital, adequate medical and surgical care	hypertension, ulcers, complications of pregnancy, appendicitis, hernia, cholelithiasis

Table 2.1: Simonato and colleagues’ classification of avoidable causes of death

Tobias and Jackson adapted Simonato’s approach by subcategorizing avoidable mortality into ‘primary avoidable mortality (PAM),’ ‘secondary avoidable mortality (SAM),’ and ‘tertiary avoidable mortality (TAM),’ and using an ‘expert consensus’ method to partition causes among these subcategories. Thereby, each avoidable cause of death was assigned to a proportion (weight) that reflected the scale of its potential preventability within each subcategory. For example, the relative weights of preventability through primary, secondary, and tertiary prevention measures assigned to asthma were 0.1, 0.7, and 0.2 respectively, which means that asthma is mainly preventable through secondary prevention interventions. Tobias and Jackson also substantially broaden the list of avoidable causes of death by updating Charlton’s original list via considering advances in health care technology, increasing the upper age limit from 65 to 75 to account for the improvements in life expectancy, and extending the concept of avoidability to not only cover conditions amenable to therapeutic intervention, but also those amenable to preventive interventions. Their final list included 56 causes or groups of causes of death (25).

At the same time, Nolte et al. amended Rutstein's original list based on the European Community Atlas of 'Avoidable Death'(29) and the list proposed by Mackenbach et al. (66), and employed Albert et al.'s (79) approach, separating conditions amenable to medical intervention from those responsive to intersectoral health policies. They explain that conditions included in their proposed list of avoidable causes of death do not cover all causes possibly preventable and/or treatable. "Rather, it was assumed that while not all deaths from these causes would be 'avoidable', health services could contribute substantially to minimizing mortality." In their work, they categorized mortalities in four groups: 1) conditions responsive to health policy, considered as indicators for the impact of health policy (i.e., primary prevention), and thus 'preventable' conditions; 2) conditions responsive to medical care, considered as indicators for the impact of medical care (i.e., secondary prevention or medical treatment), and therefore, 'amenable' or 'treatable' conditions; 3) ischemic heart disease (IHD); and 4) non-avoidable causes. Nolte and colleagues raise three reasons why IHD was treated separately: 1) the unknown contribution of medical care to the reduction in deaths due to IHD; 2) both health policy and medical care have impacts on deaths due to IHD; 3) the large number of deaths due to IHD might conceal the impact of health care on deaths due to other conditions. Similar to some other scholars, Nolte and co-workers set the upper age limit at 75 years, while specifying several conditions to have different age limits, providing rationale behind choosing the age limits. For example, the age limit for diabetes mellitus was set to less than 50 years of age because the avoidability of death at older ages was controversial at the time (82).

Further in 2004, Nolte and McKee conducted a comprehensive literature review on avoidable mortality with the goal of bringing the definitions up to date. In the *Does Healthcare Save Lives? Avoidable Mortality Revisited* report, Nolte and McKee assessed the impact of health care on population health status in industrialized countries, and confirmed that health care actually did contribute to the improved population health in the countries investigated. In this report, they also clarified the terms 'treatable,' 'preventable,' and 'amenable' causes of death. According to their explanation, deaths due to 'preventable' causes can be averted through prevention. That is, 'preventable' conditions are those for which there are measures to prevent the condition from occurring. On the other hand, deaths due to 'treatable' or 'amenable' conditions can be avoided through treatment. That is, 'amenable' or 'treatable' causes of death are those from which death can be averted even after the condition has developed. Examples of such conditions include appendicitis and hypertension. This category of death also includes conditions susceptible to secondary prevention through early detection and effective treatment. For example, deaths due to cervical cancer could be avoided through effective screening programs, and mortality due to tuberculosis could be prevented by timely treatment (31).

2.2 The Concept of 'Avoidable Mortality' in Canada

After the introduction of the avoidable mortality concept, several studies employed different applications of this indicator in Canada. However, there was no agreed-upon approach to identify avoidable mortalities and calculate the rates in Canada. In 2012, CIHI proposed the first and only definition for avoidable mortality developed specifically to be used in Canadian research, providing a comprehensive list of avoidable causes of death (24). This list was updated later in 2018 (39).

The CIHI's list was built upon three decades of research on avoidable mortality, particularly, the Australian Potentially Avoidable Deaths indicator (83) and a list proposed by the Office of National Statistics in the U.K (84). Figure 2.1 illustrates how CIHI categorizes mortality into premature mortality, which is deaths occurring before the age of 75, and those occurring at 75 years of age or later. While some premature deaths cannot be averted, others can be potentially avoided through public health policies, early detection, and timely and effective treatment. According to the CIHI proposed definition, avoidable mortality is any death that either can be avoided by preventing disease onset (i.e., incidence reduction) or can be averted or delayed after a condition has developed (i.e., case-fatality reduction) (24).

With the goal of making the avoidable mortality indicator more actionable for policymakers in the health sector, this indicator is divided into mortality from ‘preventable’ causes, which will inform primary prevention efforts, and from ‘treatable’ causes, which will inform secondary and tertiary prevention efforts. Based on the *Health Indicators 2012* report, mortality from preventable causes include deaths from conditions considerably related to modifiable factors, such as lifestyle (e.g., smoking for lung cancer and excessive alcohol consumption for liver cirrhosis), as well as those linked to public health interventions, such as vaccinations, or traffic safety legislation (e.g., speed limits, seat belts and motorcycle helmets). This subset of avoidable mortality informs efforts for incidence reduction. The second subset of avoidable mortalities (i.e., treatable mortality) includes causes of death that could have been potentially prevented or significantly delayed by screening, early detection of diseases, and timely and effective treatments and health interventions. Treatable mortality informs efforts for case-fatality reduction (24).

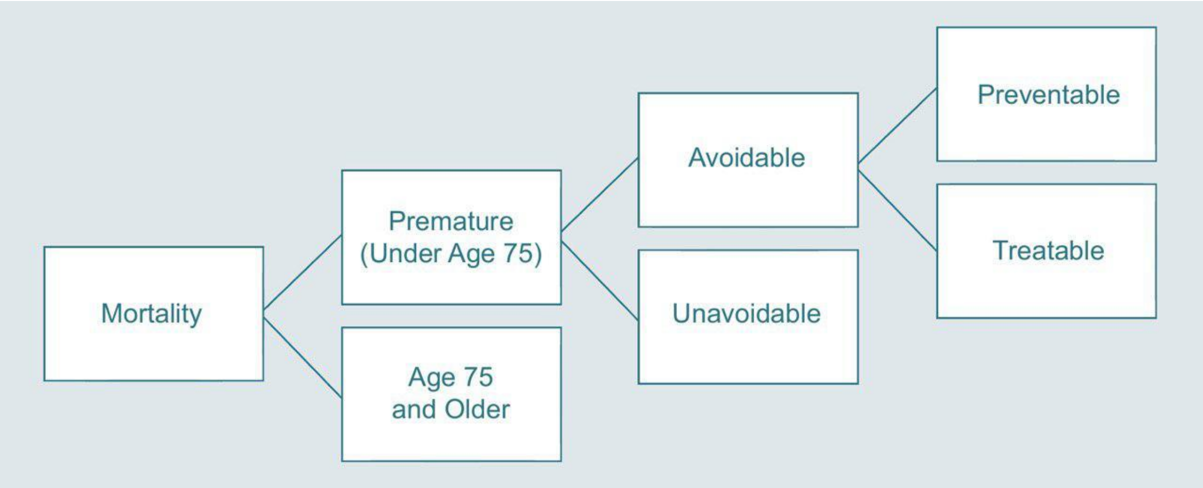


Figure 2.1: Mortality classification (24)

In developing the CIHI’s list of avoidable causes (provided in Appendix B), each cause of death was carefully reviewed by experts to determine if it is avoidable or not. The identified conditions for potentially avoidable mortality were further assigned to one of the two categories of ‘preventable’ or ‘treatable’ “according to the two main mechanisms of mortality reduction (incidence and case-fatality reduction).” (24) Given the complex nature of the etiology of death, however, it should be fully acknowledged that causes of death cannot always be easily separated into preventable and treatable conditions. In cases conditions could not be easily assigned to preventable or treatable categories; if there were clear arguments for a cause of death to be both preventable and treatable, CIHI’s strategy was to prioritize the preventability of that condition, and therefore the condition would be categorized as preventable. However, where a precedent in literature existed, exceptions were made; for example, deaths due to ischemic heart disease, stroke, and diabetes were split into 50% preventable and 50% treatable (24).

The avoidable mortality indicators are great measures for assessing the quality and performance of health systems and tracking changes over time, to estimate gains in population health, and to identify gaps in health care delivery (24).

Within the scope of this thesis, avoidable mortality and the related indicators are defined in the same manner as in the *Health Indicators 2012 (24)*.

2.3 Empirical Studies of Avoidable Mortality in Canada

In Canada, there have been several studies employing different applications of the avoidable mortality concept. While some studies investigated the temporal trends and regional variation in avoidable mortality in Canada, others explored trends in social determinants of health in avoidable mortality rates to assess inequality in this respect. Nolte and McKee elucidate that studying avoidable mortality variation between social groups leads to examining the contribution of health care to the difference in health status among social groups. This will, in turn, demonstrate the extent to which inequality in health is attributable to access to health care (31).

A scoping review on worldwide empirical studies on SES-related inequality in avoidable mortality was conducted as a part of this thesis, and the results are reported in the fourth chapter. The following is a review of Canadian literature on studies of avoidable mortality.

Pampalon was one of the first researchers who used the avoidable mortality concept in Canada and investigated its temporal and regional variations in Quebec (85). Findings of his research indicated that avoidable mortality has dropped considerably between two time periods of 1969-73 and 1982-90. He found significant regional variations for only three causes of death, including tuberculosis, hypertensive and cerebrovascular diseases, and perinatal mortality. Pampalon argues that these variations are primarily associated with socioeconomic status, but they are also related to health services (85).

Manuel and Mao investigated differences between age-standardized avoidable mortality rates in Canada and the United States from 1980 to 1996 (36). Having found that the United States has higher mortality rates in most of the disease groups, Manuel and Mao suggest that further investigations should be done to unpack underlying reasons for health care shortcomings in the United States (36). Several years later, Manuel and Mao together with James examined national and regional age-standardized avoidable mortality rates in five geographic regions in Canada from 1975 to 1999. During this period of time, overall, the avoidable mortality rate decreased by 46.9%, while all-cause mortality rate decreased by only 24.9%. James et al. also found regional differences in avoidable mortality rate, with consistently lower rates in Ontario and British Columbia compared to the Atlantic, Quebec, and Prairies regions (34).

Wood et al. extracted samples for occupational data from 1981, 1986, and 1991 censuses to examine mortality rates due to causes of death amenable to medical intervention among different social classes and socioeconomic groups of British Columbian males (37). Their findings indicated a persistent gradient in avoidable mortality rates, observing higher mortality rates in lower social and socioeconomic classes (37). A cohort study with a similar interest was conducted by Mustard et al., investigating age-standardized mortality rates for causes amenable to medical care among occupation groups in Canada over the period of 1991 to 2001 (35). Mustard et al. found an occupational gradient in mortality rates, which was consistent with the results of the Wood et al. study (35,37).

A 25-year long study conducted by James et al. examined neighbourhood income differences in mortality amenable to medical care and public health in urban Canada, from 1971 to 1996. James and colleagues found that for causes amenable to medical intervention, differences between the richest and poorest quintiles in age-standardized expected years of life lost diminished 60% in men and 78% in women, and for causes amenable to public health, the disparity increased 0.7% in men and 20% in women. Based on their findings, changes in the age-standardized expected years of life lost disparity for deaths amenable to medical care were significantly larger from other causes of death (33).

In 2015, Omariba used national mortality data, from 1991 to 2006, to shed light on how avoidable mortality rates differ based on immigration status, and further, assessed the impact of sociodemographic and socioeconomic factors on the observed differences by the duration of residence (86). Adopting the CIHI's definition for avoidable causes of death (24), Omariba found that foreign-born persons had lower age-standardized avoidable mortality rates compared to Canadian-born residents, with an exception of high rates of mortality due to ischemic heart diseases among South Asian Women. The results of the hazard regression analysis indicated that there was a lower risk for avoidable mortality among immigrants, irrespective of duration of their settlement in Canada, compared to nonimmigrants. Omariba argues that these findings suggest differential access to and use of health services, differences in protective health-related behavior, and the healthy immigrant effect (86).

In 2017, Khan et al. examined socioeconomic gradients in premature and avoidable mortality among immigrants and long-term residents of Ontario, over the period of 2002 to 2012. In their study, deaths amenable to medical care, public health intervention, or both were tracked and used as an indicator of health system functioning. To do so, they developed a list of amenable conditions based on established classification lists, including Nolte and McKee's (87) and James et al.'s (33,34). In line with findings from previous studies, Khan and colleagues also observed a downward gradient in age-adjusted avoidable mortality rates with increasing income quintiles (38).

In another study conducted in 2019, using the level of attained education, employment, and personal income as indicators for socioeconomic status, Young et al. found a strong influence of socioeconomic conditions on age-standardized potentially avoidable mortality rates in Canada's 18 northern regions for the period of 2010 to 2014 (88). The potentially avoidable mortality data used in this study were retrieved from Statistics Canada's compendium of health indicators (89), which are based upon the avoidable mortality definition proposed by CIHI (24). Their findings demonstrated a less strong correlation for potentially avoidable mortality with income rather than with the level of attained education and employment status (88).

The authors of a report published by Statistics Canada examined if the remoteness index is a statistically significant predictor of avoidable mortality rates in Canada. In this report, Subedi et al. extracted data from the Canadian Vital Statistics Death Database (CVSD) for the years 2011 to 2015 and identified and calculated age-standardized avoidable death rates using the methodology proposed by CIHI (24). Performing descriptive and multivariate analysis, they found a geographic gradient in avoidable mortality rates by remoteness, with higher rates in very remote areas compared to easily accessible areas. They concluded that remoteness is a good predictor of preventable and treatable mortality for low-Aboriginal census subdivisions but not for high-Aboriginal census subdivisions in Canada (90).

Another report published by Statistics Canada looked at differences in avoidable mortality rates between First Nations and non-Aboriginal adults, during the years 1991 to 2006. In this study, Park et al. used CIHI's definition of avoidable mortality to calculate age-standardized unavoidable, avoidable, preventable, and treatable mortality rates. They found that during the study period, First Nations individuals had more than twice the risk of dying from avoidable conditions compared with non-Aboriginal peoples aged 25 to 74. They also found that the observed disparity is of greater extent in younger ages, and education and income accounted for a considerable share of the existing disparity between First Nations and non-Aboriginal persons (91).

Zygmunt and colleagues used the CIHI's definition of avoidable mortality (24) to examine the avoidable mortality trends by neighbourhood-level marginalization in Ontario, from 1993 to 2014. They used the Ontario Marginalization (ON-Marg) Index, which includes four dimensions of material deprivation, residential instability, dependency, and ethnic concentration, to stratify residents of Ontario in quintiles within each dimension. The avoidable mortality rates were then calculated in quintiles, and rate ratios between the highest and lowest quintiles for each ON-Marg dimension were calculated. They found that although avoidable mortality rates decreased between the years 1993 to 2014, the inequity gaps widened for marginalized neighbourhoods. In a further analysis, they also found different ON-Marg dimensions have distinctive associations with avoidable mortality (41,42).

Recently, Shahidi et al. used the CIHI's list of avoidable conditions to examine socioeconomic inequalities in Canadian adults aged 25 to 74 years (53). Using household income and education as proxies for SES, their findings suggest declines in premature and avoidable mortality between the years 1991 to 2016. However, relative socioeconomic inequalities in premature and avoidable mortality widened progressively during the study period, among men and women (53).

Besides peer-reviewed journal articles, several national and provincial organizations developed and distributed reports, including information on avoidable mortality rate and its relationship with socioeconomic status, to assist and support decision-makers in the health sector at all levels.

The *Health Indicators 2012* report, developed by CIHI, provides a detailed description of the concept of avoidable mortality and its sub-indicators. This report also examined income data along with death data for the years 2005 to 2007 and found a gradient in both preventable and treatable mortality by socioeconomic group, as measured by neighbourhood income quintile. In addition to the income inequality, CIHI also found a geographic variation with regard to different avoidable mortality indicators (24).

In 2019, British Columbia Centre for Disease Control published a report with the goal of introducing premature mortality indicators, including preventable and treatable premature mortality, as health equity indicators. This report indicates declines in preventable and treatable premature mortality as socioeconomic conditions improve by analyzing the rates of income, education, employment, social deprivation, and material deprivation for the years 2009 to 2013 (26).

In accordance with the findings of other reports and studies, Winnipeg Regional Health Authority also observed a strong relationship between income and potentially avoidable death rates in two time periods of 2007- 2011 and 2012- 2016, in the province of Manitoba (92).

As shown above, a substantial body of literature exists on avoidable mortality in Canada; however, only a few studies used the CIHI algorithm to identify avoidable mortality and its sub-indicators. Additionally, there is a gap in the literature concerning income inequality in avoidable mortality across Canadian provinces and CMAs; these types of research could inform evidence-based policymaking and provide evidence for comparing different jurisdictions in terms of their performance in implementing public policies to tackle health inequalities. Consequently, this study tried to fill this gap in the literature by using CIHI's proposed algorithm on avoidable mortality and by using a more robust summary measure (concentration index), as compared to previous studies, to quantify income inequality in mortality. Furthermore, since previous studies demonstrated that there is a gender gap in avoidable mortality (24,34,41,42,53), this study also examined if mortality rates differed significantly between males and females in urban Canada. Finally, it should be taken into account that avoidable mortality indicators and their associated inequality should be tracked and reported continuously to be able to provide more meaningful recommendations to support evidence-based decision making.

3. METHODS

This research was conducted in two phases. The first phase was a scoping review on application of the concept 'avoidable mortality' in socioeconomic status (SES)-related health inequality research. In the second phase, first, the Canadian Vital Statistics Death Database (CVSD) and Canadian Censuses were used to calculate mortality indicators at municipal, provincial, and national levels in Canada. Then, income inequality in mortality rates was measured using the National Household Survey at municipal, provincial, and national levels.

3.1 Phase 1: Conducting a scoping review

Before measuring health inequality in Canada, a literature review was conducted on the application of the concept 'avoidable mortality' in the assessment of SES inequality around the world. The primary goal of this scoping review is to provide information on how ‘avoidable mortality’ is defined and operationalized in the literature.

3.1.1 Arksey and O'Malley methodological framework for scoping review

Scoping review is a relatively new type of literature review. Considering this lack of knowledge, Arksey and O'Malley developed a methodological framework to guide researchers conducting scoping reviews, proposing thorough direction in six stages (93). Five years later, Levac et al. provided recommendations on each stage to further clarify and enhance the use of this framework (94). Table 3.1 summarizes these six stages.

Table 3.1: Arksey and O'Malley methodological framework (94)

Arksey and O’Malley Framework Stage	Description
1: Identifying the research question	Identifying the research question provides the roadmap for subsequent stages. Relevant aspects of the question must be clearly defined as they have ramifications for search strategies. Research questions are broad in nature as they seek to provide breadth of coverage.
2: Identifying relevant studies	This stage involves identifying the relevant studies and developing a decision plan for where to search, which terms to use, which sources are to be searched, time span, and language. Comprehensiveness and breadth is important in the search. Sources include electronic databases, reference lists, hand searching of key journals, and organizations and conferences. Breadth is important; however, practicalities of the search are as well. Time, budget and personnel resources are potential limiting factors and decisions need to be made upfront about how these will impact the search.
3: Study selection	Study selection involves post hoc inclusion and exclusion criteria. These criteria are based on the specifics of the research question and on new familiarity with the subject matter through reading the studies.
4: Charting the data	A data-charting form is developed and used to extract data from each study. A ‘narrative review’ or ‘descriptive analytical’ method is used to extract contextual or process oriented information from each study.
5: Collating, summarizing, and reporting results	An analytic framework or thematic construction is used to provide an overview of the breadth of the literature but not a synthesis. A numerical analysis of the extent and nature of studies using tables and charts is presented. A thematic analysis is then presented. Clarity and consistency are required when reporting results
6: Consultation (optional)	Provides opportunities for consumer and stakeholder involvement to suggest additional references and provide insights beyond those in the literature.

This framework was adopted to lead a scoping literature review on the topic of socioeconomic inequality in avoidable mortality.

3.1.2 Study design

This was a scoping review conducted in five steps, following Arksey and O'Malley's methodological framework (93):

1. Identification of studies
2. Screening and identifying relevant studies
3. Selecting eligible studies
4. Charting the data
5. Collating, summarizing, and reporting the results

3.1.3 Identification of studies

After determining the research question, which is "What are the main findings of studies investigating socioeconomic inequality in avoidable mortality?", a search plan was developed in order to find relevant articles to answer this question. In doing so, a decision was made to search electronic databases, including Medline, Scopus, and Web of Science, as well as grey literature. For each of these databases, except grey literature, a search strategy was developed (see Appendix C). Using the prepared syntax, including a limitation to the English language and the publication date from 2000 to 2020, databases Medline, Scopus, and Web of Science were searched on June 18th, 2020. The results were extracted and then imported into Rayyan®.

For the grey literature search, due to feasibility reasons and limited time and human resources, the focus was on Canadian websites along with several general international websites. The keywords searched included "avoidable mortality", "avoidable death", "preventable mortality", "preventable death", "amenable mortality", and "amenable death." For this purpose, the following websites were searched: Google; Google Scholar; The World Health Organization (95); United Nations (96); Organisation for Economic Co-operation and Development (OECD) (97); and Public Health Agency of Canada (98) with restrictions to the first five pages, with ten results on each page. Further on, the following websites were searched with no restrictions on page numbers of the search results: Canadian Institute for Health Information (99); National Collaborating Center for Determinants of Health (100); and Ontario Public Health Libraries Association (OPHLA)-Custom Search Engine for Canadian Public Health information (101). Moreover, to make sure that all the research and analysis conducted by local public health units and larger public health agencies in Canada were captured, all the Urban Public Health Network (UPHN) members' websites were searched with no restrictions on page numbers for the search results. The list of UPHN members whose websites were searched is provided in Appendix D.

3.1.4 Screening and identifying relevant studies

All the articles extracted from Medline, Scopus, and Web of Science were imported into Rayyan® for deduplication and title and abstract screening. After deduplication, articles were reviewed by title and abstract to find relevant studies using the inclusion and exclusion criteria as follows:

Inclusion criteria:

1. Articles that quantitatively evaluated socioeconomic inequalities in any type of avoidable mortality, defined as premature mortalities which could have been potentially avoided through primary, secondary, or tertiary prevention measures.
2. Articles whose socioeconomic status of interest are one or more of the following indicators: income, education, and employment/occupation.
3. Articles that use administrative databases to extract mortality data.

Exclusion criteria:

1. Articles investigating a specific cause of death (e.g., cancer mortality).
2. Articles investigating premature mortality without mentioning avoidable/preventable/amenable mortality.
3. Articles investigating a particular group of age (e.g., infant mortality, adults between 25-75 years of age).
4. Articles that only examined mortality in a sub-sample of the population, such as recruitment of participants in a case-control study.
5. Articles investigating a specific sex.

3.1.5 Selecting eligible studies

After the title and abstract screening, all the included articles were extracted from Rayyan® and imported into Paperpile® for full-text screening. In this step, the full texts were reviewed against the inclusion-exclusion criteria, and the final decision was made regarding the inclusion or exclusion of articles. Having decided about all the articles from the searched databases, the reviewer thoroughly assessed the grey literature search results and decided regarding the inclusion of any other documents in the review.

3.1.6 Charting the data

A comprehensive data extraction form was prepared in Google Sheets to chart study characteristics and data for the selected articles and grey literature. Data were extracted on: years in which study took place; study design; region under study; unit of analysis; study population; SES indicator; avoidable mortality definition; upper age limit; method of avoidable mortality measurement; method of analysis of the association between avoidable mortality and SES; outcome (association between SES and avoidable mortality); ICD codes used for identifying avoidable deaths; and the categorization of Ischemic Heart Disease.

3.1.7 Collating, summarizing, and reporting the results

Finally, the extracted information was collated, summarized, and reported in chapter four of the thesis. In particular, a summary is provided on the articles' outcomes on SES inequality in avoidable mortality and the types of SES indicators used. The final report also describes how avoidable mortality was defined across the articles and if Ischemic Heart Disease was accounted as an avoidable cause of death.

3.2 Phase 2: Measuring income inequality in avoidable mortality in urban Canada

The second phase of the thesis was conducted in two parts. In the first part, mortality rates were calculated and reported at municipal, provincial, and national levels. The second part aims to measure dissemination area (DA)-level inequality by calculating concentration index in urban Canada, provinces, and the most populous cities in 2016, which includes: Toronto, Montreal, Vancouver, Calgary, Ottawa-Gatineau, Edmonton, Quebec, and Winnipeg.

Ethics approval was exempt from the University of Saskatchewan Behavioural Research Ethics Board (see Appendix A).

3.2.1 Study design

This was a retrospective population-based analysis using national surveys, Census data, and the Canadian Mortality Database. The first part of the study was a descriptive report of mortality rates at different geographic levels in Canada. In the second part, concentration indices were calculated at the DA level to compare area-based income inequality in mortality rates between the eight most populous cities in Canada, and Canadian provinces. The concentration index was also used to quantify area-based income inequality in mortality rates at the national level.

This study covers the time period from 2011 to 2015. All deaths that occurred between January 1, 2011, to December 31, 2015, were included in the analyses. The income variable was retrieved from the National Household Survey conducted in May 2011.

3.2.2 Data sources

Data for this thesis were collected from the Canadian Vital Statistics Death Database (CVSD), National Household Survey 2011 (NHS), Census 2011 and 2016 that were accessible through Statistics Canada - Research Data Center (RDC). A brief description of these centres (i.e., RDCs) is provided in Appendix E. Postal Code^{OM} Conversion File Plus (PCCF+) version 6d was used to link deaths in the CVSD with socio-economic information contained in the NHS. A description of these data sources and key variables of interest is provided below:

Canadian Vital Statistics Death Database (CVSD): The Canadian Vital Statistics Death Database (CVSD) is a cross-sectional database that collects demographic and medical (e.g., causes of death) information annually and monthly from all provincial and territorial vital statistics registries on all deaths in Canada. In CVSD, decedents' place of residence is available by postal codes (102).

The key variable of interest in CVSD is the *cause of death*, which is classified according to the 10th version of the World Health Organization "International Statistical Classification of Diseases and Related Health Problems" (ICD), from 2000 to the present. This variable was used to calculate mortality rates, as explained later in this chapter. The ICD-10 codes were used to detect potentially avoidable deaths according to the CIHI list of avoidable causes of death (see Appendix B) (24). The CIHI list presents the version 9 and 10 ICD codes for all the potentially avoidable causes of death and classifies them into preventable and treatable causes. These indicators are explained in detail in the section *Measuring numerators (number of deaths) and calculating rates*.

To determine the category of a death event (i.e., premature, avoidable, preventable, etc.), the age and sex of the deceased should be known. In CVSD, the age at the time of death is determined by two variables; the first variable is *age_value* indicating the age attained at the last birthday preceding death, and the second variable is *age_code* indicating the unit of *age_value* (i.e., minutes, hours, days, months, or years). In the case of infant deaths, *age_code* takes 1 to 4 meaning that *age_value* represents the completed number of months (or minutes, hours, or days) since birth. To have a harmonized age variable, the *age_value* of any observation with an *age_code* 1 to 4 was replaced with zero, and *age_value* was then used as the age variable in this study. Doing so, infant mortalities were represented by an age of zero in the final dataset.

National Household Survey 2011 (NHS): In 2011, Statistics Canada replaced the mandatory long-form Census with the voluntary National Household Survey, in which approximately 4.5 million households received a questionnaire. This survey was conducted only once, in 2011, and Statistics Canada proceeded with the long-form Census again for the next Censuses, from 2015 onward (103). The NHS provides an extensive number of SES and demographic variables of the Canadian population. Statistics Canada obtains income information from personal income tax and benefits files, and therefore, the NHS is a reliable data source of Canadians' income for policy development and research purposes (104). Consequently, area-based income was calculated and retrieved from the NHS.

Since the NHS and CVSD are not linked by individual identifiers, instead, they must be linked by geography. Thus, an area-based income measure was constructed and used in this study. NHS has several geographical variables including Dissemination Area (DA). Dissemination Area is the smallest geographic unit for which all census data are disseminated. DAs are uniform in terms of population, and 400 to 700 persons reside in each DA (105). Given that DA can be used for linking NHS and CVSD, by using PCCF+ (as described below), the income variable was calculated at the DA level. Accordingly, the median after-tax household income was calculated at the DA level, to be used in the calculation of concentration indices.

After-tax income is an important indicator for measuring income level in health inequality research (40). Since benefits of accumulated income are shared among the household members, the after-tax 'household' income is preferred as compared to after-tax 'individual' income. Hence, the variable of interest in the NHS was *after-tax household income*, which was adjusted for the household size (see section *Measuring median after-tax household income at the dissemination area level* for more information on adjusting income for the household size).

Postal Code^{OM} Conversion File Plus (PCCF+): The Postal Code^{OM} Conversion File Plus is a SAS$^{©}$ control program and a set of associated datasets. The SAS control program automatically assigns a range of geographic identifiers, including Dissemination Area (DA) based on postal codes (106). Each version of PCCF+ is compatible with a specific set of other products, including censuses. The version 6D can be linked to the 2011 census products, and therefore this version was used to assign DA to each observation from CVSD based on postal codes. This assignment of the DAs to CVSD data made the DA-based merging of NHS and CVSD data possible.

Census of Population: The Canadian Census of Population is a cross-sectional survey that occurs every five years, and responding to this survey is mandatory. Census data is mainly collected using a short-form questionnaire and a long-form questionnaire. The short-form questionnaire is designed to collect exhaustive demographic data, while the long-form questionnaire collects high-quality information on demographic and key socioeconomic characteristics of Canadians (107,108). In this study, a sample of 2011 Census (short-form) and 2016 Census (long-form) were used to estimate population counts in years 2011 to 2015 at DA, municipal, provincial, and national levels in Canada. Besides the total population, the number of people younger than 75 years of age was estimated using a methodology explained later in the section *Estimating denominators (population counts)*. The estimated population counts were used as denominators in mortality rate calculations. The age variable that was used here was *age* which refers to the age of a person at their last birthday. Following is a description of the Censuses used in this study:

*Census of Population 2011 (A sample of the short-form questionnaire)***:** The primary purpose of the Census of Population is to determine population counts in Canada at different geographic levels. In 2011, all the Canadian citizens, landed immigrants, and non-permanent residents received the short-form of the questionnaire. RDC provides researchers with a 20% sample of data collected through short-form questionnaires.

Census of Population 2016 (long-form): In 2016, a sample of approximately 25% of Canadian households received the long-form questionnaire. This Census provides information on social and economic characteristics, such as income, education, and housing, within small geographic areas (104). Researchers have access to the full sample in RDC.

3.2.3 Study population

The study population was different in the first and second parts of the study. For the first part of the analysis (i.e., calculating mortality rates), all the records from the Canadian Vital Statistics Death database from 2011 to 2015 were included except non-Canadian residents. For the second part (i.e., measuring income inequality in mortality rates), the study population included Canadian residents living in urban areas, excluding institutional records (reasons for why institutional residents and non-urban areas were excluded is given below in sections *Non-urban areas* and *Institutional residents*.) Table 3.2 presents a summary of the study population in each part of the thesis. Details on the excluded populations are provided below:

Table 3.2: Study population in each part of the thesis

	Study population
First part: Calculating mortality rates	All Canadian residents
Second part: Measuring income inequality in mortality rates	All Canadians residing in urban areas, excluding participants living in institutions

Non-Canadian residents: Deaths whose place of residence were unknown or outside of Canada were excluded. This exclusion was carried out following Statistics Canada's methodology; in calculating mortality counts and rates, Statistics Canada excludes deaths of non-residents of Canada, deaths of residents of Canada whose province or territory of residence is unknown, and deaths with unknown age at the time of death (109).

Unknown age or sex: Any death with corresponding unknown age should be excluded as without the age variable, the mortality category (e.g., premature, avoidable) cannot be determined using CIHI's algorithm. However, there was no missing age or sex in CVSD data as Statistics Canada imputes the missing observations with regards to these two variables. To elaborate, Statistics Canada imputed any missing province or territory of residence, sex, age, and date of birth of the decedent. Starting with 2010, missing data on sex were imputed based on the cause of death and a logistic regression. For missing age values, if the date of birth was provided, they were imputed based on the date of birth, and in case the date of birth was missing, age values were imputed to the median age observed for groups of similar causes of death (102,109).

Non-urban areas: Any participant residing in a non-urban area was excluded for the second part of the analysis (i.e., measuring income inequality in mortality rates), as there are differences in lifestyles between rural areas and urban areas. These differences affect health outcomes and therefore obscure urban health inequality results. To exclude rural areas from the analysis, CIHI developed a systematic method that was adopted in this study (19); areas categorized as Census Metropolitan Area (CMA) or Census Agglomeration (CA) with a population of at least 1,000 and no fewer than 400 persons per square kilometer, were identified and included in the analysis. For this purpose, two variables in the National Household Survey dataset were used:

Statistical Area Classification (SAC): SAC provides unique codes for CMA, CA, and outside CMA and CA areas. Using this variable, observations outside CMA and CA areas were excluded.

Population Centre (POPCTR): A population centre has a population of at least 1,000 and no fewer than 400 persons per square kilometer. POPCTR provides four unique codes for the following areas: rural areas; small population centres, with a population between 1,000 and 29,999; medium population centres, with a population between 30,000 and 99,999; and large urban population centres, with a population of 100,000 or more. Using this variable, any observation coded as a rural area was excluded.

Institutional residents: The institutional records were excluded for the second part of the analysis (i.e., measuring income inequality in mortality rates) since the income indicator in a dissemination area in which the institution is located might be unrelated to its residents' income level. Further, deaths with institutional residency were identified and deleted because of the impact these records had on DA-level mortality rates; dissemination areas in which institutions were located had very high mortality rates and this could introduce bias in the health inequality measurement.

3.2.4 Data analysis

All data analysis was performed using Stata 16.0 software available within the RDC. Data analysis occurred for each part of the study independently and is discussed in separate sections as follows:

3.2.4.1 Part 1: Calculating mortality rates

The first part of the study describes annual mortality rates, from 2011 to 2015, at municipal, provincial, and national levels in Canada. In doing so, five different indicators were identified, and their rates were calculated. The five mortality indicators of interest were: 1) all-cause mortality, 2) premature mortality, 3) potentially avoidable mortality, 4) preventable mortality, and 5) treatable mortality. These mortality indicators were defined and calculated based on the definition proposed by the Canadian Institute of Health Information (CIHI) and the methodology suggested by the Association of Public Health Epidemiologists (APHEO) in Ontario (24,110). Figure 3.1 illustrates the CIHI classification of mortality. These mortalities are defined in the following section (*Measuring numerators (number of deaths)*).

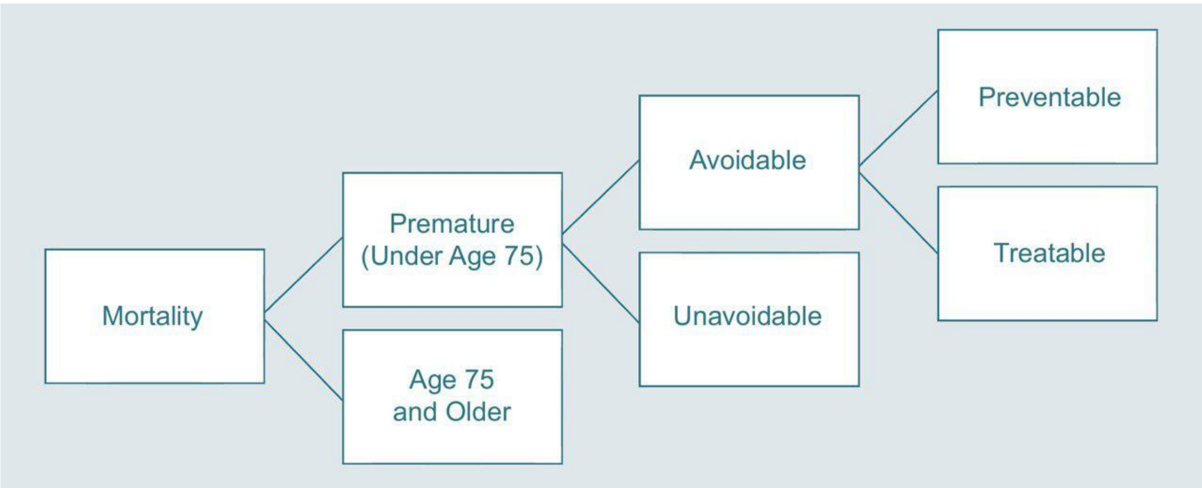


Figure 3.1: Mortality classification (24)

Data sources used in this part of the study include CVSD and Censuses 2011 and 2016. For the provincial-level analysis, the geography variable (i.e., province) was the one provided in CVSD. For the municipal-level analysis, on the other hand, postal codes were translated by PCCF+ to acquire the CMA of each death event in the CVSD. This was done following Statistics Canada's methodology and due to the numerous missing values for the CMA variable in CVSD (109).

Mortality rate calculation occurred in several steps. In the first step, numerators (number of deaths) were measured at different geographic levels. Next, population counts for the years 2011 to

2015 were estimated at different geographic levels, to be used as denominators in mortality rate formulas. Finally, age-standardized mortality rates were calculated and stratified by sex. These steps are further explained in detail.

3.2.4.1.1 Measuring numerators (number of deaths)

The CVSD datasets, for the years 2011 to 2015, were first harmonized, and the age variable was constructed as described before in the *Data sources* section. Data were then restricted to Canadian residents by eliminating deaths whose usual place of residence were unknown or outside of Canada. Next, the harmonized CVSD datasets were appended, and the number of deaths was calculated at municipal, provincial, and national levels. The mortality indicators were defined and counted at the geographic level of interest as follows:

All-cause mortality is defined as any death event. The sum of all deaths that occurred in a geographic area was calculated to be used as the numerator.

Premature mortality is defined as any death that occurred before the age of 75, meaning at the age of 74 or younger. All deaths that occurred before the age of 75 were identified as premature death, using the *age* variable. The number of premature mortalities was then counted at municipal, provincial, and national levels. Premature mortality is further split into “Potentially Avoidable Mortality” and “Unavoidable Mortality” as shown in figure 3.1.

(Potentially) avoidable mortality is defined as premature deaths that could have been potentially avoided in the presence of timely and effective health care services and public health policies, that is, through all levels of prevention (primary, secondary, and tertiary). Based on the nature of intervention that could have prevented these mortalities, avoidable causes of deaths are categorized into two sub-indicators of preventable and treatable mortality.

Preventable mortality is a subset of avoidable mortality that could have been averted through primary preventions, such as vaccination and tobacco reduction policies. This subset of avoidable mortality informs efforts for incidence reduction.

Treatable mortality is the second subset of avoidable mortalities, which includes causes of death that could have been potentially prevented through secondary (e.g., screening and early detection of diseases) and tertiary (e.g., timely and effective treatments and health interventions) preventions. Treatable mortality informs efforts for case-fatality reduction.

Avoidable, preventable, and treatable mortalities were identified in CVSD by using the CIHI’s list of avoidable causes of death (Appendix B). This list presents ICD-9 and -10 of causes of death that CIHI recognizes as avoidable, which is further categorized into preventable and/or treatable causes. This list was developed based on three decades of research on avoidable mortality, particularly, the Australian Potentially Avoidable Deaths indicator (83) and a list proposed by the Office of National Statistics in the U.K (84). Each cause of death was carefully reviewed by experts to determine if they are avoidable or not. The identified conditions for potentially avoidable mortality were further assigned to one of the two categories (preventable or treatable) “according to the two main mechanisms of mortality reduction (incidence and case-fatality reduction).” (24) In some cases, conditions could not be easily assigned to preventable or treatable categories; if there were clear arguments for a cause of death to be both preventable and treatable, CIHI’s strategy was to prioritize the preventability of that condition, and therefore the condition would be categorized as preventable.

However, where a precedent in literature existed, exceptions were made; for example, deaths due to ischemic heart disease, stroke, and diabetes were split into 50% preventable and 50% treatable (24).

After restricting data to the records with an age of 74 or younger, the variable *cause of death* was used to identify preventable and treatable deaths based on the list of avoidable causes of death developed by CIHI (24) (see Appendix B). In doing so, first, three variables of treatable, preventable, and avoidable were generated. Data were then coded based on the *cause of death*, presented by ICD-10; if the ICD-10 for an observation matched with an ICD-10 listed as preventable in the CIHI algorithm, then, for that observation, the preventable and avoidable variable took a value of one. Similarly, this procedure was carried out for the treatable causes of death. In case an ICD-10 matched with a cause of death recognized as 50% preventable and 50% treatable in the CIHI list (e.g., Diabetes mellitus with the ICD-10 code of E10–E14), both treatable and preventable variables took the value 0.5, and the avoidable variable took the value of one. Table 3.3 illustrates the process of coding and identifying avoidable causes of death in CVSD.

Table 3.3: An example showing the process of coding death events in CVSD based on the list of avoidable causes of death developed by CIHI.

Causes of death (ICD-10)	CIHI avoidable causes of death list		Coding death data by Stata		
	Preventable	**Treatable**	**Avoidable**	**Preventable**	**Treatable**
I01	x	—	1	1	—
I10	—	x	1	—	1
I60	x (50%)	x (50%)	1	0.5	0.5
I20	x (50%)	x (50%)	1	0.5	0.5
I172	—	—	—	—	—

Data were then collapsed to the geography level of interest, and the annual number of avoidable, preventable, and treatable deaths were calculated at municipal, provincial, and national levels.

It should be noted that municipal and provincial levels' number of deaths were weighted by 'age-standardization indicator' to ultimately calculate age-standardized mortality rates at these two geographic levels. The construction of this indicator is explained in the *Age standardization* section.

3.2.4.1.2 Estimating denominators (population counts)

The Canadian Census occurs every five years. As such, population counts are not known for intercensal years. Statistics Canada has developed a strategy for estimating the population for some geographies in these years (111) but not those used in this project. Also, the data sources used by Statistics Canada's strategy (e.g., number of immigrants, emigrants, and returning emigrants) were also not available. Thus, another approach had to be taken to estimate population counts. This section explains how this was done.

A linear model was fitted between the observed census counts to estimate the intercensal population. For this purpose, population counts were extracted from the raw Census 2011 and 2016 to calculate dissemination area (to be used in the second part of the thesis), municipal, provincial, and national counts for the years 2012 to 2015. First, the difference between 2011 and 2016 counts was calculated at the geographic levels of interest, and then, the differences were divided by five, which is the number of years intervals. The result was then added to the 2011 population counts in an incremental fashion as shown in the following formula:

$$C_{yg} = C_{2011g} + (y - 2011) \times \frac{C_{2016g} - C_{2011g}}{5} \quad \text{(Eq 3.1)}$$

Where *C* is population count at year *y*, the year for which the population count is estimated, and *g* is the area, DA, municipal, provincial, and national levels, for which the count is calculated. This way, population counts were calculated and used as the denominators in the mortality rates formula, as described further.

It should be noted that, in this study, to calculate different mortality rates, different denominators were needed. Whereas the all-cause mortality rate was calculated over the entire population, premature mortality rate and other indicators were calculated over people aged under 75. The two types of population counts were estimated for the years 2012 to 2015; in equation 3.1, *C* took both 'total population' and 'population aged 0 to 74 years of age' to estimate the corresponding counts at the DA, municipal, provincial, and national levels.

Additionally, as the age distribution in a geographic area is needed to be able to age-standardize rates, this method was also used to determine the age distribution across years 2012 to 2015 at municipal, provincial, and national levels. To do so, first, age groups were constructed by five-year intervals (i.e., 0 to 4, 5 to 9, 10 to 14, …. 85 to 89, 90 and older) for both 2011 and 2016 Censuses. Next, population counts for each age group were separately imputed for the intercensal period, using the 3.1 formula. For example, for the age group 0 to 4, first, the difference between 2011 and 2016 counts in this age group was calculated at the municipal and provincial levels, and then, the differences were divided by five. The result was then added to the 2011 population counts in this age group, in an incremental fashion. This procedure was done for all the age groups separately.

3.2.4.1.3 Calculating mortality rates

The mortality counts (numerators) were then used along with the estimated populations (denominators) to compute mortality rates annually. Figure 3.2 provides a summary of the steps taken in calculating mortality rates. The equations used to calculate rates are presented afterward.

All-cause mortality: The number of all-cause mortality and estimated total population were used to compute the annual all-cause mortality rate at the municipal, provincial, and national levels, by using the following equation.

$$\frac{\text{total number of deaths}}{\text{total population}} \times 100,000 \quad \text{(Eq 3.2)}$$

Premature mortality: Premature mortality rates were calculated by using the following equation.

$$\frac{\text{total number of deaths among those 0-74 years}}{\text{total population aged 0-74 years}} \times 100,000 \quad \text{(Eq 3.3)}$$

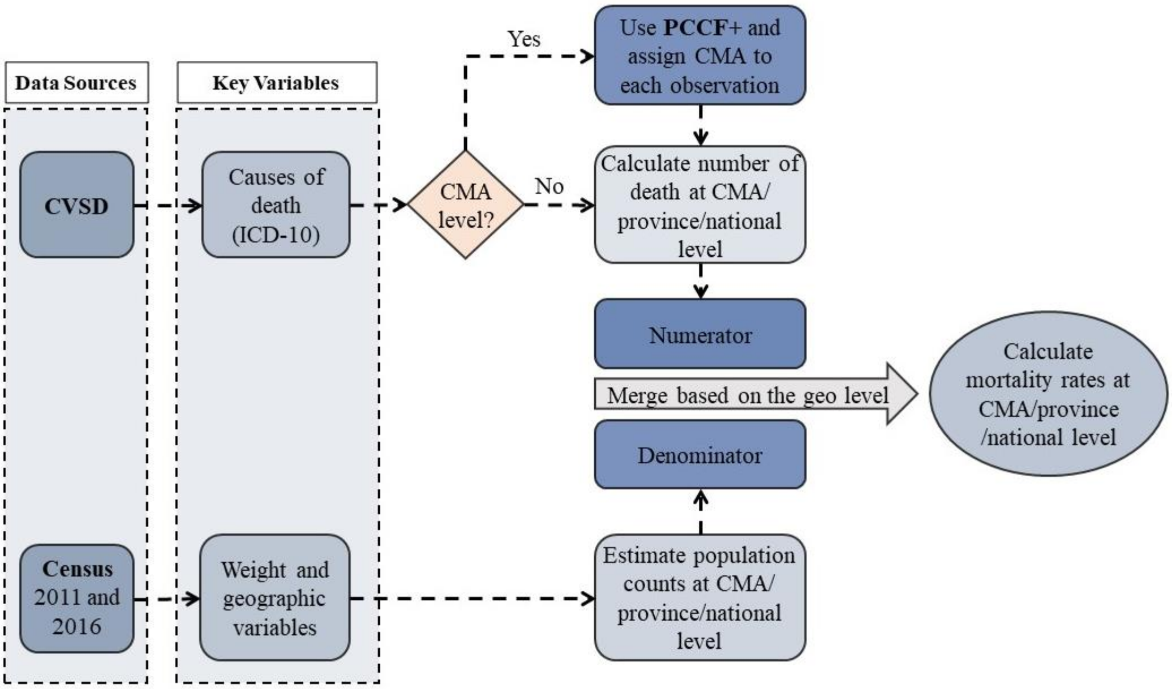


Figure 3.2: Summary of data analysis in the first part of the thesis (calculating mortality rates)

(Potentially) avoidable mortality: The number of avoidable deaths and the previously estimated population younger than 75 years of age were used as the numerator and denominator in the following formula to compute (potentially) avoidable mortality rates at the geographic levels of interest.

$$\frac{\text{total number of potentially avoidable deaths among those 0-74 years}}{\text{total population aged 0-74 years}} \times 100,000 \qquad \text{(Eq 3.4)}$$

Preventable mortality: The number of preventable deaths and the previously estimated population younger than 75 years of age were used as the numerator and denominator, respectively, in equation 3.5 to calculate annual preventable mortality rates at the municipal, provincial, and national levels.

$$\frac{\text{total number of preventable avoidable deaths among those 0-74 years}}{\text{total population aged 0-74 years}} \times 100,000 \qquad \text{(Eq 3.5)}$$

Treatable mortality: The number of treatable mortalities and the previously estimated population younger than 75 years of age were used as the numerator and denominator in the following equation to calculate the annual treatable mortality rate at the municipal, provincial, and national levels.

$$\frac{\text{total number of treatable avoidable deaths among those 0-74 years}}{\text{total population aged 0-74 years}} \times 100,000 \qquad \text{(Eq 3.6)}$$

After mortality rates were calculated for males and females separately, Z-tests were performed to examine the significance of the difference between these mortality rates.

3.2.4.1.3 Age standardization

As mortality indicators strongly depend on the age structures of populations, comparison of raw (unstandardized) mortality rates may be misleading due to the differences between age compositions of spatial units of interest. Age-standardization is performed as an answer to this problem, to allow for more meaningful mortality comparisons. As such, in this study, mortality rates were directly age-standardized taking the 2011 Canadian population structure, derived from Census 2011 available at the RDC, as the standard.

To calculate the age-standardized mortality rates, first, an age-standardization indicator was constructed at the municipal, provincial, and national levels. As described in the section *estimating denominators (population counts),* Census 2011 and 2016 were used to estimate the intercensal population in each age group at municipal, provincial, and national levels. These counts are needed, for they represent the age structure of the Canadian population between the years 2011 and 2016, which is used in the age-standardization procedure. Subsequently, the age-standardization indicator was constructed by using the following formula to be used as probability weight in equations 3.2 to 3.6 above.

$$A_{gy} = \frac{\text{National population count in } 2011_j}{\text{National population count in } 2011} \times \frac{C_{gy}}{C_{gyj}} \quad \text{(Eq 3.7)}$$

Where *A* is the standardization indicator, *g* is the geography level (i.e., CMA, province, or Canada) for which the indicator is constructed, *y* indicates the year, *C* is the population count, and *j* is the age group. This indicator was constructed at the municipal, provincial, and national levels, and the number of deaths was weighted by this indicator to obtain age-standardized mortality rates. It should be noted that *A* equals 1 when *g* is Canada and *y* takes 2011, and therefore mortality rates were not age-standardized when calculated for the year 2011 at the national level.

3.2.4.1.4 Standard error and confidence intervals

Standard errors and confidence intervals for municipal, provincial, and national age-standardized mortalities were calculated to illustrate the degree of variability associated with age-standardized mortality rates. For this purpose, the following formula, proposed by Dohoo et al. (112), was used to calculate standard errors of age-standardized mortality rates:

$$SE(MR_{dir}) = \sqrt{\Sigma((\tfrac{C_j}{C})^2 \times MR_j \times \tfrac{S_j}{N_j})} \quad \text{(Eq 3.8)}$$

Where C_j/C is the proportion of the total population allotted to the j^{th} age group in the 2011 Census, MR_j is the observed mortality rate in the j^{th} age group, S_j equals $1\text{-}MR_j$, and N_j is the total population in the j^{th} age group.

The following formula was used to calculate confidence intervals of age-standardized mortalities.

$$95\%CI = MR_{dir} \pm 1.96 \times SE(MR_{dir}) \quad \text{(Eq 3.9)}$$

3.2.4.2 Part 2: Measuring income inequality in mortality rates

After drawing attention to the existing health inequality across different social classes by *Black Report (8)*, conversations emerged around the measurement of health inequality, and various methods were proposed. In 1991, Wagstaff et al. critically reviewed the available methods employed to measure health inequality; among the reviewed summary measures, they argued that *the slope index of inequality* and *the concentration index* are the most reliable summary measures of health inequality (113). The concentration index "reflects the experience of the entire population and it is sensitive to the distribution of the population across socioeconomic groups," while this is not the case for some other measures of inequality, such as *Gini coefficient* and *range* (113). Additionally, concentration index quantifies the extent of health inequality which is systematically associated with socioeconomic status (113). Building on the evidence suggesting the concentration index as one of the most reliable tools in health inequality analysis, this index was selected to be used in this project to measure health inequality at different geographic levels in Canada.

The concentration index is best understood with reference to the concentration curve; a concentration curve graphs cumulative proportions of population ordered by their socioeconomic status on the x-axis, beginning with the most disadvantaged, against their cumulative share of health on the y-axis (figure 3.3). The concentration index is twice the area between the concentration curve and the diagonal line (the shaded area in figure 3.3) and takes minus one to plus one. In the case where there is no health inequality in a population, the concentration curve coincides with the line of equality (the 45° line), and the concentration index is zero accordingly. The concentration index takes a negative value when the concentration curve lies above the line of equality, which reflects a disproportionate concentration of the health variable amongst the worst-off. Conversely, if the concentration curve lies below the diagonal line, the concentration index takes a positive value, indicating that the population's health is concentrated amongst those who belong to higher socioeconomic status groups.

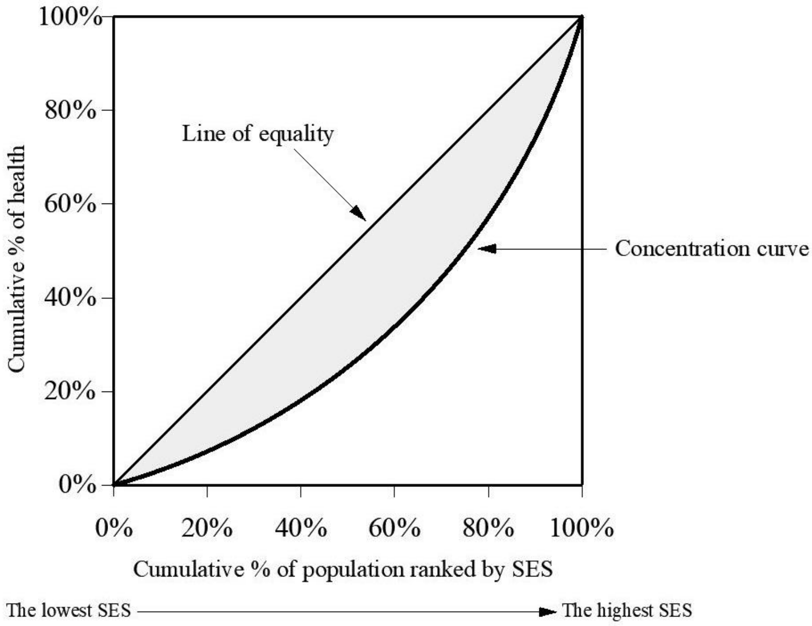


Figure 3.3: The concentration curve

Socioeconomic status is a broad term referring to an individual or groups' relative position in a social hierarchy and can be estimated by the level of education, employment, and income (114). It is ideal to systematically investigate all these three factors in health inequality measurement as they capture different dimensions of socioeconomic status. This is often done in the form of a deprivation index that intends to capture social standing by considering a combination of variables. Although there are numerous deprivation indices introduced for use in the Canadian context, none of them has been agreed upon among Canadian scholars; there is no consistency in the type of deprivation index used in Canadian literature. In addition to the national deprivation indices such as The Canadian Index of Multiple Deprivation (CIMD) (115), many researchers use indices that are constructed to measure deprivation in a specific area and are not always generalizable to other areas. For example, Ontario Marginalization Index (ON-Marg) (43) is the commonly used index in Ontario, while Pampalon's measure is used in Quebec (116).

On the other hand, income is the most commonly used proxy for SES in Canadian literature, and it is widely used in international studies on inequality in avoidable mortality (33,38,117–120). This study used income as a proxy for socioeconomic status, which is also consistent with Canadian health policy concerns reflected in Achieving Health for All: A Framework for Health Promotion; "The first challenge we face is to find ways of reducing inequities in the health of low-versus high-income groups in Canada." (121)

Over the last few decades, there has been a growing interest in measuring health inequality by taking geographical location as the unit of analysis (10). Health inequality occurs between specific groups of individuals, and these individuals usually share the same geographic location (9,10). That is, individuals living in one geographic location usually share the same adverse living circumstances. Thus, measuring health inequality among geographical units is a standard practice in this area of research. Furthermore, the individual linkage of NHS and CVSD is not possible, and therefore, they must be linked by geography. Consequently, this thesis took dissemination area (DA) as the unit of analysis in health inequality measurement. Dissemination Area is the smallest geographic unit for which all census data are disseminated in Canada. DAs are uniform in terms of population, and 400 to 700 persons reside in each DA (105).

Following these considerations, concentration indices were calculated to measure health inequalities over a five-year period from 2011 to 2015, in Canada, its provinces, and its eighth-most populous cities, while the health outcome was DA-level mortality rates for years 2011 to 2015 and DA-level income in 2011 was used as a proxy for SES indicator.

The mortality rates resulting from the previous part of the study (i.e., *Calculating mortality rates*) could not be used in this part of the thesis, as they are CMA, provincial, and national level rates which are of no use in measuring inequality at these geographic levels. For example, the mortality rate in Saskatoon could not inform health inequality measurement. Rather, mortality rates should be measured across different groups of people (or different areas) with different socioeconomic status to be able to assess inequalities. In this study, concentration index was used to measure inequality among DAs at the CMA, provincial, and national levels. As such, in this part of the study, mortality rates were calculated at the DA level. As DA-level income is derived from the NHS and income information is not available for the intercensal period, the mortality rates should be aggregated for the years 2011 to 2015 and summarized into one measure.

On this basis, to calculate mortality rates at the DA level over the five-year period from 2011 to 2015, first, the number of deaths (numerator) and the number of people at risk (denominator) were identified and calculated at the DA level, for each year. Having the numerators and denominators, annual DA-level all-cause, premature, avoidable, preventable, and treatable mortalities were computed by using equations 3.2 to 3.6. The average of mortality rates over the five years was then calculated to be used as the health outcome in concentration index calculation.

Figure 3.4 provides a summary of the steps taken in this part of the study. More details on these steps are given afterward.

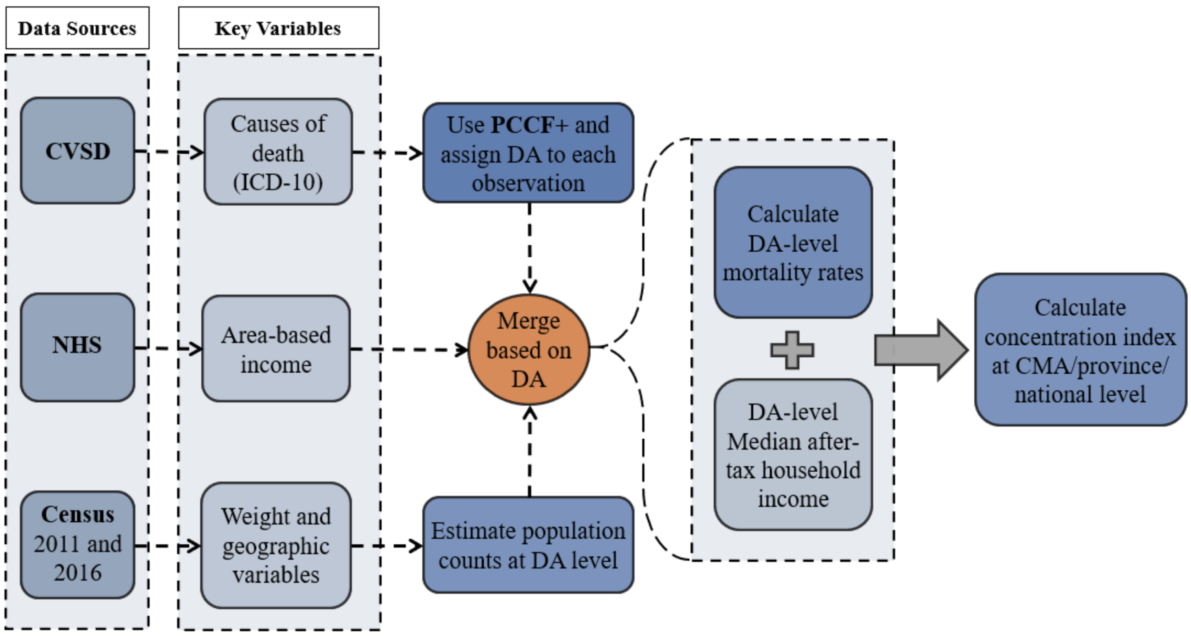


Figure 3.4: Summary of the steps taken in the second part of the study (measuring health inequality)

3.2.4.2.1 Measuring median after-tax household income at the dissemination area level

As mentioned before, this part of the study focuses on urban Canada, for there are differences in lifestyles between rural and urban areas, which in turn affects health outcomes. To restrict the study population to urban areas, the NHS dataset was first reduced to only urban areas by using SAC and POPCTR variables as described previously. Then, the institutional residents were excluded since the area-based income indicator in a dissemination area in which an institution is located might be unrelated to its residents' income level. It should be noted that to adhere to RDC confidentiality rules, Dissemination Areas with less than 250 population were dropped from the dataset.

After cleaning the data, the *after-tax household income* was adjusted for household size by dividing household income by the square root of household size, following Statistics Canada and Organization for Economic Co-operation and Development reports (122,123). This is because a five-person household with an annual income of, for example, 70,000 $ faces more hardship than a two-person household with the same income.

Finally, DA-level income was constructed. DA 'median' household income is a more robust and accurate area-based summary measure for income as compared to 'average' household income since it is not affected by outliers. To get the weighted median of the adjusted after-tax household income in each DA, data were collapsed by the DA variable, using the probability weight variable provided in NHS data.

It should be also noted that since the DA-level income variable was derived from the NHS, and therefore indicated data for only 2011, there was no need to adjust for inflation.

3.2.4.2.2 Estimating DA-level population counts for the intercensal years, using Census 2011 and 2016

To be able to calculate DA-level mortality rates, we need the total population and total population aged 0 to 74 counts in each DA for the years 2011 to 2015. However, population counts are not known for the intercensal years (i.e., 2012 to 2015). Hence, a linear estimator was built as described previously for the first part of the analysis (see section *Estimating denominators (population counts)*) to estimate DA-level population counts across years 2012 to 2015. It should be noted that to adhere to

RDC confidentiality rules, Dissemination Areas with less than 250 population were dropped from Censuses 2011 and 2016 datasets before estimating the intercensal population counts.

3.2.4.2.3 Preparing CVSD dataset to be used in PCCF+

The CVSD dataset that was harmonized and appended in the previous section (*measuring numerators (number of deaths))* was used in this step as well. The institutional residents were dropped from the appended dataset, as the institutional deaths caused some DAs to have high mortality rates. This could be explained by the fact that the decedents' usual place of residence was used to assign DAs to deaths. Therefore, data coming from individuals living in institutions such as nursing homes were concentrated in areas in which the institutions were located, which in turn resulted in high mortality rates in those areas. It should be also noted that high mortality rates were seen even for premature mortality and its components; that is, when data was restricted to people aged 0 to 74. The other reason for excluding institutional records is that the place of residence of these individuals (i.e., institutions) was not representative of the socioeconomic status of the dissemination area in which the institution is located, and therefore, these records could introduce bias in health inequality measurement. The dataset was then prepared to be used in PCCF+ for translating the postal codes to DAs.

3.2.4.2.4 Merging CVSD, NHS, and population counts

By using PCCF+, each participant's 6-digit postal code for the usual place of residence in CVSD was translated to a dissemination area. The assignment of DA to CVSD data permits the area-based merging of CVSD, NHS, and Census data by DA; the PCCF+ output, which was the CVSD prepared in the previous step plus the assigned DA variable, harmonized NHS, and estimated population counts were merged based on DA. The new dataset had causes of death (presented by ICD-10), DA-level median after-tax household income, and DA population counts. This dataset was further used to measure DA-level mortality rates, as explained in the next step.

3.2.4.2.5 Measuring health outcome (DA-level mortality rates)

Having the individual-level cause of death and DA-level population counts in one dataset, the annual mortality rates were calculated for the years 2011 to 2015 at the DA level. In doing so, first, all-cause, premature, avoidable, preventable, and treatable mortalities were identified and counted in each DA using the same method proposed in the first part of the analysis (section *Measuring numerators (number of deaths))*. The numbers of deaths were weighted by using the age-standardization indicators constructed in the first part of the thesis (see section *Age-standardization*). Next, the DA-level number of deaths and population counts (total and aged 0 to 74) in each of these datasets were used as numerator and denominator, respectively, in equations 3.2 to 3.6 to compute DA-level age-standardized mortality rates. An average of the annual mortality rates in each DA was then calculated to get one mortality indicator for the time period 2011 to 2015 to be used with the area-based income variable derived from the NHS to measure health inequality.

3.2.4.2.6 Measuring and comparing income inequality in mortality

Using the datasets produced in the last step, which included DA-level mortality rates and DA-level median after-tax household income, the concentration index was calculated for all the mortality indicators and at the municipal, provincial, and national levels. The following formula was used to compute concentration index and to quantify the degree of income inequality in different mortality indicators over the five-year period, with dissemination area as the unit of analysis:

$$C = (Z_1 L_2 - Z_2 L_1) + (Z_2 L_3 - Z_3 L_2) + \ldots + (Z_{T-1} L_T - Z_T L_{T-1}) \qquad \text{(Eq 3.11)}$$

Where Z_t is the cumulative percent of the population ranked by DA median after-tax household income in group t, L_t is the corresponding concentration curve ordinate for DA mortality rate, and T is the total number of DAs in the analysis. The acquired concentration indices were then used to compare provinces and cities in terms of income-related inequalities.

3.2.4.2.7 Standard error and confidence interval

Since the income data used to calculate the concentration index was collected from the National Household Survey, and surveys usually have an unequal probability sampling, the 95% confidence intervals were constructed by percentile bootstrapping as recommended by Berger et al. and Statistics Canada (124–126). For the same reason, the bootstrap standard error was calculated by taking the standard deviation of the bootstrap distribution. Bootstrap is a statistical procedure that uses random sampling with replacement to provide statistical inferences, that is, standard error and bias estimates, confidence intervals, and hypothesis tests (126). This method is particularly helpful in nonparametric situations and when the standard error calculation requires complicated formulas. There are various approaches to compute bootstrap confidence intervals, among which the percentile intervals are relatively simple to compute and suitable for rough approximation (126). "A 95% bootstrap percentile interval is the range of the middle 95% of a bootstrap distribution." (126), as shown by the following formula:

$$(CI^*(\alpha/2), CI^*(1-\alpha/2)) \qquad \text{(Eq 3.12)}$$

Where $CI^*(\alpha/2)$ is the $\alpha/2$ percentile of the bootstrapped concentration index. Using this formula and taking 1000 bootstrap samples, the 95% confidence intervals were calculated for concentration indices in the geographic levels of interest.

4. RESULTS

4.1 Phase 1: Scoping Review

This scoping review was conducted to answer the first research question of this study and to give an overall picture of research investigating socioeconomic inequality using avoidable mortality indicators. This review tends to shed light on the gaps in the literature with regards to this area of research, and further discusses consistency in the definition of avoidable mortality concept and related methodology.

4.1.1 Results of the search

Overall, I identified 2457 articles, including 2436 articles through database searching using the developed syntax (see Appendix B), 16 grey literature, and 5 studies by reviewing the reference lists of the included articles. The results of the database search consisted of 810 articles in Medline, 669 articles in Web of Science, and 957 articles in Scopus. After deduplication, the 1393 potential records were screened by title and abstract, except grey literature, and 1301 records were identified as irrelevant to our study and therefore were excluded. The remaining 92 articles were retrieved in full text for eligibility assessment. Reviewing the full texts of the articles, 58 more studies were excluded while the exclusion reasons were recorded. Figure 4.1 presents the Preferred Reporting Items for

Systematic Reviews and Meta-Analyses (PRISMA) flow diagram which outlines the flow of selection in this scoping review.

Reasons for exclusion of 58 articles in the third stage of the review (i.e., selecting eligible studies) included limited age group (N=31), the inequality indicator not in the inclusion criteria (i.e. income, education, and employment/occupation) such as access to health care and ethnicity (N=15), commentary article (N=2), conference abstract (N=1), examining mortality in a sub-sample of the population (1 case report, 1 case-control study in a hospital, 1 cohort of twins) (N=3), cause-specific mortality (N=2), sex restricted to only male/female (two of them also have an age restriction) (N=3), and for one study we could not get access to the full-text article even by contacting the authors.

The results for grey literature search is as follows; The World Health Organization (0 record found), Public Health Agency of Canada (0 record found), United Nations (1 record found and excluded after screening), OECD (1 record found and excluded after screening), Canadian Institute for Health Information (2 records found, 1 was included after screening), National Collaborating Centre for Determinants of Health (1 record found and excluded after screening), OPHLA-Custom Search Engine for Canadian Public Health information (6 records found, 3 were included after screening). Collectively, 5 records were retrieved from the UPHN members' websites, from which 1 report was included in the study after screening.

Finally, 34 articles were selected to review and extract data from, including 29 scientific articles (two found through searching the reference lists of the included articles) and 5 grey literature documents.

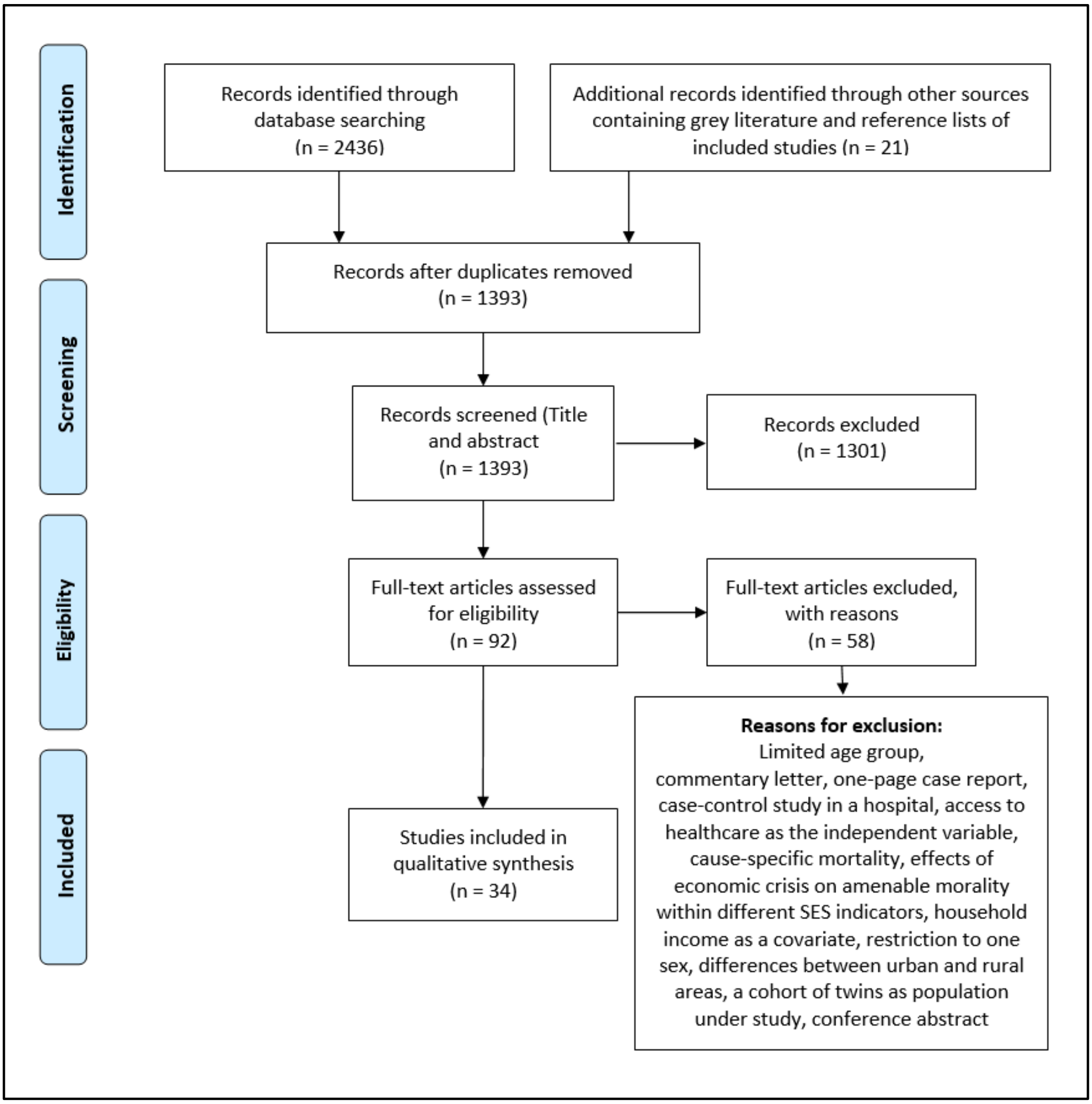


Figure 4.1: PRISMA flow diagram

4.1.2 Descriptive findings

The study designs of selected studies are quantitative observational, including population-based, ecological, longitudinal, cross-sectional, prospective cohort surveys, exploratory spatial analysis, and governmental reports. Most of the studies indicated 75 years of age as their upper age limit, and only three studies restricted their sample to deaths occurring before age 65; the time period covered for data collection in these three studies were 1971-2008, 1997-2001, and 1990s (117,127,128).

The selected articles used different units of analysis, between which they measured health inequality. Most of the studies' unit of analysis were “relatively” small areas, namely Lower Super Output Area (LSOA) in England; Dissemination Area (DA), Census Tract, and neighbourhood in Canada; Census Tract (CT) in Spain; commune and cantone in France; Local Government Area (LGA) and Statistical Local Area (SLA) in Australia; meshblock in New Zealand; and district in Brazil. A Canadian study took health regions as their unit of analysis to compare health system performance in eighteen northern regions (88). Only two studies used individual-level data for their analysis (129,130). A study conducted in Taiwan used township (city district) as their unit of analysis

(117), and three articles investigated SES inequality in avoidable mortality with a municipal-level unit of analysis (131,132). A study conducted in Mongolia examined both provincial and municipal (in capitals) data (133), and Neethling et. al. compared provinces and population groups in their analysis (134). Table 4.1 presents a summary of selected articles' characteristics.

Table 4.1: Summary of the selected articles

First author, year, reference	Data years	Study design	Region under study	Unit of analysis	SES indicator	Association between SES and Avoidable Mortality
ASIA						
Chen, 2016 (111)	1971-2008	Longitudinal study	Taiwan (354-358 townships)	township (city district)	mean annual household income	**Aggregated data:** In every period, the lowest income quartile had the highest age-standardized mortality rates, followed by areas in the second-lowest, second highest, and highest income quartiles. **Time trend:** Amenable mortality fell consistently from 1971-75 to 2006-08 across virtually all income quartiles, but fell faster in the more affluent townships than the less affluent townships.
Surenjav, 2016 (127)	2007-2014	Longitudinal study	Mongolia	provinces /capital	Percent of poor households	**Aggregated data:** Bivariate analysis did not reveal any significant association between crude overall AM and percent of poor households.
AFRICA						
Neethling, 2019 (128)	1997-2012	population-based retrospective study	South Africa	Province and population groups	Because of the existence of inequalities in education, income and welfare along racial lines due to the legacy of apartheid, apartheid classification was used as a proxy for SES	**Aggregated data:** In 2012, there were huge inequalities in amenable mortality between different population groups. The white population had a much lower proportion of amenable mortality (26.3%) compared with other population groups (>48%), while the African population had the highest proportion (64.8%). **Time trend:** A disparity in age-standardized amenable mortality rate by population group in 2000 was evident, which widened each subsequent year until 2005 and narrowed thereafter. The African population had the highest age-standardized amenable mortality rate of all population groups over the period, which was 4.6 times that of the white population in 1997, increasing to 6.5 times in 2005.
EUROPE						
Asaria, 2016 (129)	2004/05-2011/12	whole-population longitudinal study	England	Small area-LSOA	IMD[1] 2010	**Aggregated data:** There were substantial socioeconomic gradients in amenable mortality indicators in 2004/2005. **Time trend:** Although amenable

[1] IMD= Index of multiple deprivation

						mortality indicators were improved between 2004/2005 and 2011/2012, the socioeconomic gradient was persistent.
Cookson, 2017 (130)	2004/05-2011/12	whole-population longitudinal study	England and Ontario	LSOA (England), DA (Ontario)	IMD 2010 (for England), ON-Marg 2006 (for Ontario)	**Aggregated data:** A socioeconomic gradient was consistently observed for both jurisdictions in each year of the study period, with higher amenable mortality in more deprived areas.
Feller, 2017 (131)	1996-2010	longitudinal study	Switzerland and 16 high-income countries	Neighbourhood, country	Swiss-SEP[2]	**Aggregated data:** There were substantial socioeconomic inequalities in amenable mortality. All types of mortality showed increasing hazards with lower socioeconomic position.
Hoffmann, 2014 (132)	Different periods for different cities between 1995-2009	ecological study	15 large cities in different European regions	Small area	Deprivation index	**Aggregated data:** All statistically significant rate ratios indicate a positive association between area deprivation and avoidable mortality.
Manderbacka, 2013 (123)	1988-2007	register based cohort study	Finland	Individual level	Household disposable income	**Aggregated data:** Mortality amenable to health policy measures contributed 35 per cent (4 years) to socio-economic differences in life expectancy at age 35. Mortality amenable to health care contributed 17 per cent (0.7 years) to the total difference between the highest and lowest income deciles.
Nagy, 2012 (126)	2004-2008	ecological study	Hungary	municipality level	Hungarian specific deprivation index	**Aggregated data:** Strong positive association was found between the risk of mortality amenable to health care and deprivation index.
Nolasco, 2009 (133)	1996-2003	transversal ecological study	Alicante, Castellon, and Valencia (Spain)	Census Tract (CT)	Deprivation index	**Aggregated data:** In all the three cities, the rate ratio of death for men in the least vs. highest privileged socioeconomic level was over 2; for women, these differences are only statistically significant in the city of Valencia.
Nolasco, 2015 (134)	1996-2001, 2002-2007 period	ecological study	33 Spanish cities	CT	SES variable	**Aggregated data:** The estimated rate ratios show the excess risk of death at the lowest level of SES compared to the highest level.
Rey, 2009 (121)	1997-2001	cross-sectional study	France	commune[3]	Deprivation index 'FDep99'	**Aggregated data:** The avoidable mortality was much more strongly associated with the FDep99 index (+77% between the fifth and the first quintile), than the other causes for the same age group (+32%).
Windenberger, 2012 (122)	1990s	longitudinal ecological study	France	commune' and 'canton'	Deprivation indexes (FDep)	**Time trend:** In 1988-92, the 'avoidable' mortality was 40% higher for the fifth deprivation quintile communes than for the first quintile communes (78% higher in 1997-2001). The increase

[2] Swiss-SEP is an area-based index of Swiss socioeconomic position
[3] Commune is the smallest administrative unit in France

						in the association between the two periods was high for all the 'avoidable' causes of death considered separately.
Weisz, 2008 (113)	1988-90, 1998-2000	cross-sectional study	Paris, Inner London and Manhattan (France, England and Wales, US)	neighbourhood	Pre tax average household income (for Paris and Manhattan), deprivation index (for London)	**Aggregated data:** The results from OLS regression suggest a correlation between neighbourhood-level income and percentage of AM , during 1998-2000, in Manhattan at the 1% level, but no significant correlation in Paris or London at the 5% level. Despite this correlation, negative binomial regression results reveal that residence in a low income neighbourhood, as compared to the remainder of the city, is significantly correlated with increased AM rates per 1000 population in all three urban cores.
OCEANIA						
Hayen, 2002 (135)	1980-2000	longitudinal study	New South Wales, Australia	LGA[4]	IRSD[5]	**Trends in time:** Rates of PAM have decreased steeply for the three SES groups. However, the decrease has been more rapid for the highest SES group. Therefore, there was an increased relative gap between the highest SES group and the two lower SES groups. By contrast, the relative gap between the lowest and middle decreased slightly for males and remained almost constant for females.
Butler, 2010 (136)	2002-06	exploratory spatial analysis	Australia	Small area-SLA[6]	A composite score of deprivation (remoteness areas, physician to population ratios, and IRSD)	**Aggregated data:** There was a strong relationship between the combined score of deprivation and avoidable mortality.
Korda, 2007 (137)	1986,1991, 1997, 2002	longitudinal study	Australia	Small area-SLA	Index of disadvantage[7] (percentage of low-income families and percentage of early school leavers)	**Aggregated data:** The incidence rate differences and rate ratios comparing Q1 with Q5 in each year show significant absolute and relative socioeconomic inequality, respectively, in both avoidable and non-avoidable mortality. **Time trend:** The annual percentage decline in AM at the higher end of the socioeconomic continuum was larger than at the lower end, with increasing relative inequality between 1986 and 2002. The absolute inequality decreased between 1986 and 2002.

[4] LGA= Local Government Area
[5] IRSD= Index of Relative Socioeconomic Disadvantage
[6] SLA= Statistical Local Area
[7] Formerly known as the Index of Relative Socioeconomic Disadvantage

Piers, 2007 (138)	1979-2001	longitudinal study	Victoria, Australia	LGA	IRSD	**Aggregated data:** There was a clear gradient in total AM rates, highest in the most disadvantaged and lowest in the least disadvantaged IRSD quintile.
Tobias, 2001 (22)	1996, 1997	cross-sectional study	New Zealand	small area	NZDep96 index (139)	**Aggregated data:** With few exceptions, all the conditions included in the 'avoidable mortality' category show a socioeconomic gradient in cause specific mortality. The gradient is steepest for Secondary Avoidable Mortality (SAM) and flattest for Tertiary Avoidable Mortality (TAM).
Tobias, 2007 (140)	2000-02	cross-sectional study	New Zealand	Small area	NZDep2001 index (141)	**Aggregated data:** Variations in amenable mortality make a substantial contribution to inequalities in mortality for socioeconomic (deprivation) groups.
Tobias, 2009 (114)	1981-84 to 2001-04	population-based study	New Zealand	meshblock (approximately 100 people) level	income	**Aggregated data:** Absolute income inequality was found in all-cause mortality. Amenable mortality contributed 20.8% and 27.4% to income inequality in all-cause mortality in 2001-04, and 28.4% and 32.6% in 1981-04, for males and females respectively.
SOUTH AMERICA						
Grafova, 2020 (142)	2003-2013	ecological study	São Paulo, Brazil	Districts as proxies for neighbourhood	Educational attainment and two measures of neighbourhood income	**Aggregated data:** In low-income districts, the AM rate was more than 1.5 times greater than in high-income districts. Regarding Bolsa Familia and AM, no significant relationship was found. Increased literacy rates are predicted to significantly improve AM in high-income districts. **Time trend:** This difference is persistent during the 2003-2013, when AM rate declined across districts of different income levels.
NORTH AMERICA						
Ronzio, 2004 (125)	1989, 1990, 1991	cross sectional ecological study	central cities (n=138) in the US with >=100,000 population	City	Percentage in poverty	**Aggregated data:** Income inequality has a stronger correlation with mortalities attributable to preventable or immediate causes compared with all cause mortality.
Masters, 2015 (124)	1986-2006	retrospective longitudinal study	United States	Individual level	Educational attainment	**Aggregated data:** Larger education gradients in mortality risk were found for causes of death that are under greater human control than for less preventable causes of death.
James, 2007 (30)	1971, 1986, 1991, 1996	longitudinal study	Canada-metropolitan areas	neighbourhood (Census Tract)	income	**Aggregated data:** In 1996, avoidable causes of death together accounted for about half (49.6%) of all income-related excess

						mortality among men, and 42% among women.
Khan, 2017 (35)	2002-2012	population-based longitudinal study	Ontario, Canada	DA	income and education	**Aggregated data:** There was a downward gradient in age-adjusted avoidable mortality rates with increasing income quintiles and education level, among both immigrants and long-term residents.
Young, 2019 (78)	2012-2014	population-based study	Canada's 18 northern regions	health region	education, employment, income	**Aggregated data:** There was a strong influence of SES on PAM, with lower PAM in higher levels of SES. The correlation for income was less strong than attained education and employment.
Zygmunt, 2019 (82)	1993-2014	retrospective population-based study	Ontario, Canada	neighbourhood (DA)	ON-Marg	**Time trend:** Avoidable mortality rates almost haved (48.6%) from 1993 to 2014. The inequity gap in avoidable mortality rate ratio between the most and least marginalized quintiles widened for all marginalization dimensions.
Zygmunt, 2020 (83)	1993-2014	retrospective population-based study	Ontario, Canada	neighbourhood (DA)	ON-Marg	**Aggregated data:** Results from logistic regression shows decedents living in the most (Q5) materially deprived and residentially unstable neighbourhoods had significantly greater avoidable mortality than those living in the least marginalized neighbourhoods (Q1). **Time trend:** Overall avoidable mortality rates were almost halved (48.6%) from 1993 to 2014. Compared with treatable avoidable mortality, preventable avoidable mortality contributed the greater proportion of all avoidable deaths, increasing from a ratio of approximately 1.5:1 in 1993 to approximately 2:1 in 2014.
GREY LITERATURE - CANADA						
CIHI, 2012 (21)	2005-2007	annual report	Canada	neighbourhood (DA)	income	**Aggregated data:** For both preventable and treatable mortality, there were gradients in the rates by socio-economic group. Mortality rates were consistently higher among people living in the least affluent neighbourhoods, with rates gradually decreasing as socio-economic status increased. Socio-economic gradients were steeper for preventable mortality than for mortality from treatable causes.

Cui, 2019 (85)	2007-2016	provincial report	Manitoba, Canada	NA	income	**Aggregated data:** There were strong relationships between income and potentially avoidable death rates in urban and rural areas in both time periods. In urban settings, the rate of potentially avoidable deaths for residents of the lowest income areas was about 3.7 times higher than residents of the highest income areas in T1 (2007-2011) and T2 (2012-2016). In rural settings, the rate of potentially avoidable deaths for residents living in the lowest income areas was about 2.2 times higher than for residents of the highest income areas in T2.
MLHU[8], 2019 (143)	2011-2012	report	Middlesex-London, Ontario, Canada	neighbourhood	ON-Marg	**Aggregated data:** Significant differences in potentially avoidable mortality existed between populations living in neighbourhoods with differing levels of socio-economic status. **Time trend:** Inequalities between low socioeconomic status and high socioeconomic status persisted for all years between 2003 and 2012.
MLHU, 2019 (144)	2011-2015	report	Middlesex-London, Ontario, Canada	neighbourhood	Material deprivation	**Aggregated data:** Preventable mortality increased with each material deprivation quintile and varied significantly by material deprivation quintile on average from 2011 to 2015.
Rasali, 2019 (23)	2009-2013	Provincial report	British Columbia, Canada	DA	Income, education, employment, social and material deprivation indices	**Aggregated data:** Analysis of rates by income, education, employment, social deprivation, and material deprivation showed declines in preventable premature mortality as socio-economic conditions improve. Rates for treatable premature mortality showed a similar pattern, except having smaller disparity ratios for the socio-economic dimensions.

[8] MLHU= Middlesex-London Health Unit

4.1.2.1 Geographic and time distribution

Most of the selected studies were conducted in European countries, including England, Finland, Spain, France, Switzerland, and Hungary. Figure 4.2 shows the geographic distribution of the included studies, except grey literature, for the grey literature search was conducted with a focus on Canadian websites.

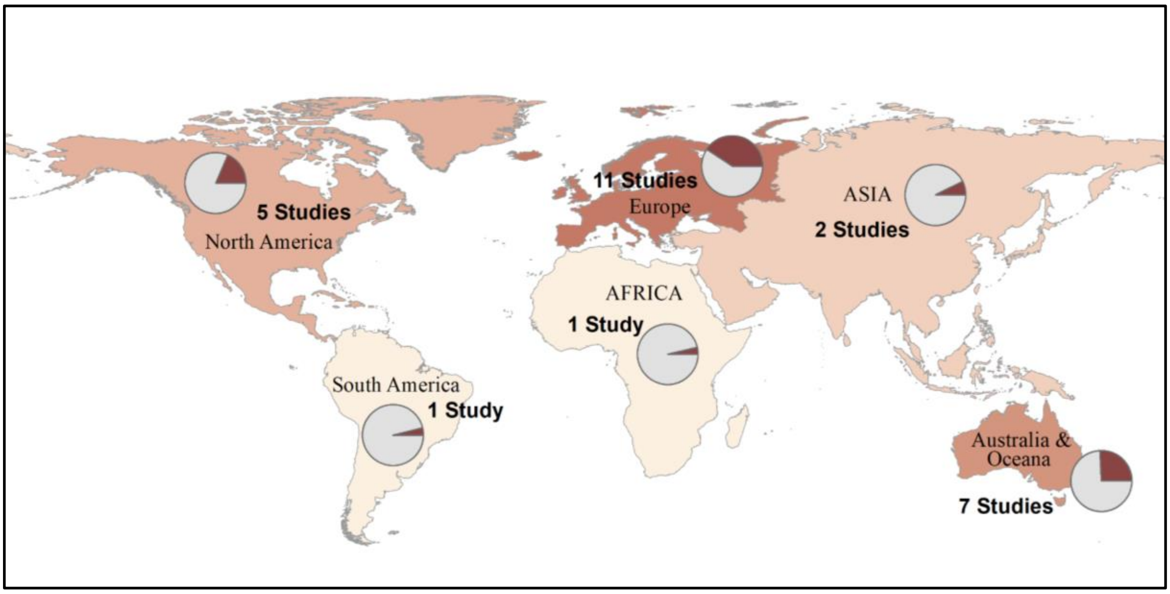


Figure 4.2: Geographic distribution of included studies (except grey literature)

In Figure 4.3, the frequency of covering a year by the analyses across selected articles are shown by a blue line, and the publication date of the articles are presented by orange bars. As seen in Figure 4.3, the frequency of data collection in a year across all the studies increased between 1971 to 2016. The year 1997 was the most covered year by the analyses, with 17 studies including this year as a period of time to gather data from. The decreasing trend from 2012 onward could be explained by the fact that data on mortality and SES were less available at the time articles were published rather than the years before. With regards to publication date, most of the studies were published in 2019 with 7 literatures in that year, of which 4 were grey literature. Year 2007 was the most frequent publication year among the included journal articles, with 4 studies published in this year.

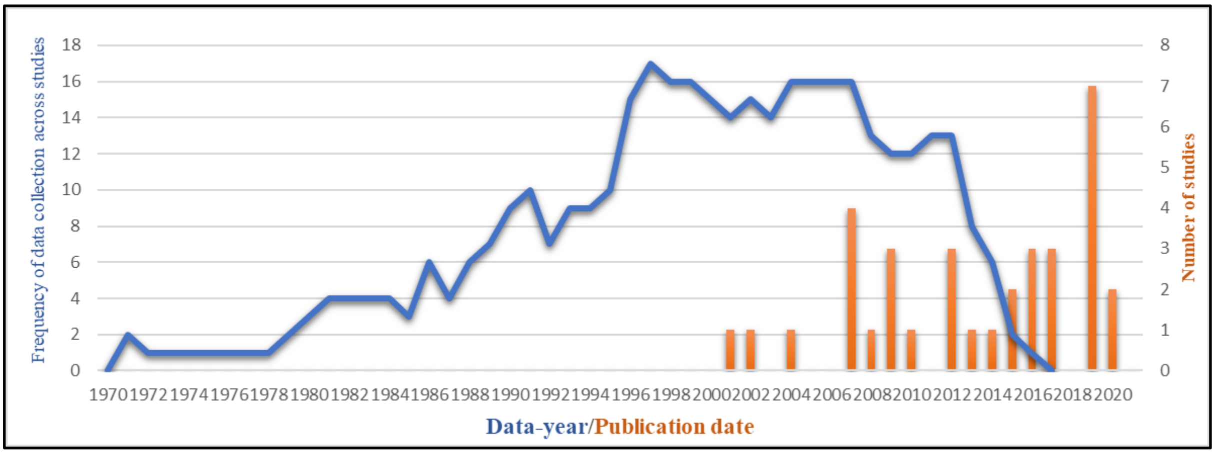


Figure 4.3: Frequency of gathering data in each year across all the included studies and publication dates of the selected articles

4.1.3 Avoidable mortality definition

The selected literature adopted different definitions for avoidable mortality on which they based their research. The definition proposed by Nolte and McKee was the most commonly used among the selected studies, with 11 studies mentioning their work as the reference for identification of avoidable deaths. A description of the frequently used definitions in the selected articles is provided in table 4.2.

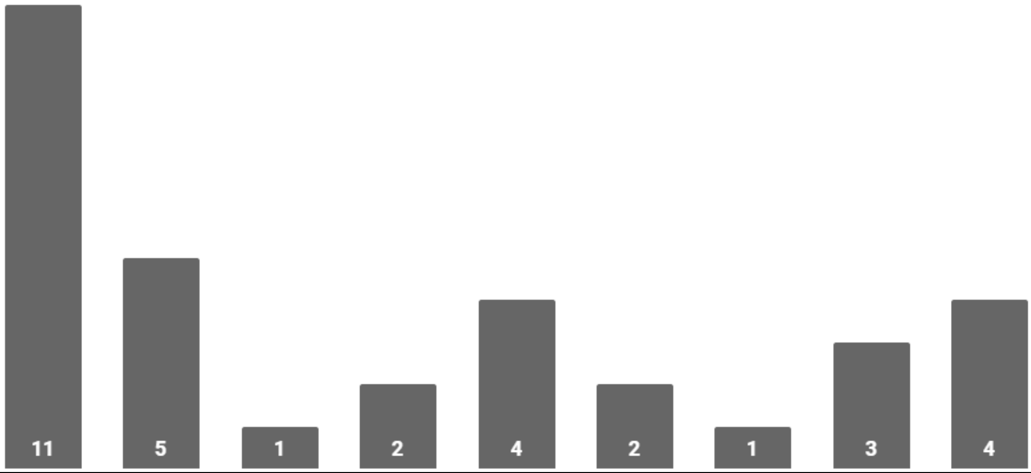
Table 4.2: Description of avoidable mortality definitions frequently used in the selected articles

Avoidable mortality Definition	Description	Subcategories of avoidable mortality
Nolte and McKee (28)	Death amenable to health care are used to examine the impact of health care, i.e. secondary prevention or medical treatment. The health care (services) is interpreted as primary care, hospital care, and collective health services such as screening and public health programmes, e.g. immunization. The conditions are chosen on the basis of having identifiable effective interventions and health care providers.The causes of amenable death do not cover all causes that are possibly treatable. Rather, it is assumed that while not all deaths from these causes would be "avoidable", health services could contribute substantially to minimizing mortality.	NA
Tobias and Jackson (22)	Avoidable deaths are partitioned among three subcategories.	(1) Primary avoidable mortality (PAM) constitutes conditions that are preventable, whether through individual behaivour change or population-level intervention (healthy public policy), i.e. primary prevention. (2) Secondary avoidable mortality (SAM) constitutes conditions that respond to early detection and intervention, typically in a primary health care setting, as well as clinical preventive services such as screening, i.e. secondary prevention. (3) Tertiary avoidable mortality (TAM) constitutes conditions whose case fatality rate can be significantly reduced by existing medical or surgical treatments, i.e. tertiary prevention.
Australian and New Zealand Atlas of Avoidable Mortality (145)	This is an update on Tobias and Jackson's 2001 list. Avoidable causes of death represent those conditions whose associated mortality is substantially avoidable, given existing health and social systems in Australia, either through incidence reduction (prevention) or case fatality reduction (treatment) or a combination of both.	Avoidable conditions are further classified into 'amenable' causes and 'preventable' causes. (1) Amenable causes are defined as those causes whose case fatality could be substantively reduced by available health care technologies. (2) Preventable causes are all other causes on the list, in that their associated mortality could be substantially reduced by preventing the condition from occurring in the first place, i.e. incidence reduction.

Simonato et. al. (27)	Avoidable causes are classified into three subcategories.	(1) Causes avoidable through primary prevention includes causes whose etiology is in part attributable to lifestyle factors and/or to occupational risk factors. It also includes deaths from injury and poisoning, which are influenced in part by legal and societal measures such as traffic safety and crime reduction policies. (2) Causes amenable to secondary prevention through early detection and treatment includes causes of death for which screening modalities have been established, as well as causes for which death is avoidable through early detection combined with adequate treatment. (3) Causes amenable to improved treatment and medical care includes infectious diseases, deaths from which are 'avoidable' largely through antibiotic treatment and immunization as well as causes that require medical and/or surgical intervention, deaths of which are related to complex interactions within the health care system, such as accurate diagnosis, transport to hospital, adequate medical and surgical care.
NHS outcome framework (146)	Deaths from causes considered ‘amenable’ to health care are premature deaths that should not occur in the presence of timely and effective health care.	NA
Canadian Institute for Health Information (21)	(Potentially) avoidable mortality is defined as premature mortality, i.e. death occurred before the age of 75, that could have potentially been avoided in the presence of timely and effective health care services and public health policies, that is, through all levels of prevention. Avoidable causes of death are classified into two subcategories.	(1) preventable mortality includes deaths that could have been averted through primary preventions. Preventable mortality informs efforts for incidence reduction. (2) Treatable mortality includes deaths that could have potentially been prevented through secondary and tertiary preventions. Treatable mortality informs efforts for case-fatality reduction.

Nevertheless, several studies applied a unique approach in defining avoidable mortality, such as using other studies' list of avoidable causes of death or proposing their own definition consulting related literature and expert panels. Table 4.3 presents the avoidable mortality definition used in each selected article, and gray columns show the frequency of use of each definition across studies.

Table 4.3: Avoidable mortality definition in included literature



First Author, year, reference	Nolte and McKee	Tobias and Jackson	Simonato et al.	NHS outcome framework	Australian and New Zealand Atlas of Avoidable Mortality	CIHI	CAEC[9]	Other[10]	Not mentioned
Grafova, 2020 (142)	✓								
Korda, 2007 (137)	✓								
Nagy, 2012 (126)	✓								
Weisz, 2008 (113)	✓								
Nolasco, 2009 (133)	✓								
Tobias, 2001 (22)		✓							
Piers, 2007 (138)		✓							
Rey, 2009 (121)		✓							
Windenberger, 2012 (122)		✓							
Asaria, 2016 (129)				✓					
Cookson, 2017 (130)				✓					

[9] CAEC = Concerted Action of the European Community on Avoidable Mortality
[10] Other means that authors consulted related literature and/or expert panels to identify avoidable deaths

Tobias, 2007 (140)					✓				
James, 2007 (30)								✓	
Khan, 2017 (35)	✓							✓	
Hoffmann, 2014 (132)									✓
Manderbacka, 2013 (123)	✓		✓		✓				
Ronzio, 2004 (125)									✓
Neethling, 2019 (128)	✓				✓				
Feller, 2017 (131)	✓								
Chen, 2016 (111)							✓		
Surenjav, 2016 (127)	✓								
Masters, 2015 (124)								✓	
Hayen, 2002 (135)		✓							
Nolasco, 2015 (134)	✓								
Butler, 2010 (136)									✓
Young, 2019 (78)									✓
Tobias, 2009 (114)					✓				
Zygmunt, 2019 (82)						✓			
Zygmunt, 2020 (83)						✓			
Grey Literature									
CIHI, 2012 (21)						✓			
Cui, 2019 (85)						✓			
MLHU, 2019 (143)						✓			
MLHU, 2019 (144)						✓			
Rasali, 2019 (23)						✓			

Furthermore, 5 articles were randomly selected and their lists of avoidable causes of death were compared by ICD codes. Table 4.4 presents the five articles selected for this purpose. The ICD codes used by authors to identify avoidable mortalities were compared across the articles. The result of this comparison is presented in Appendix F. An article code was assigned to each study (Table 4.4), which was used to refer to the studies when comparing their lists of avoidable mortality in the table provided in Appendix F. The authors of these five articles used the ICD codes listed in Appendix F to identify avoidable mortalities in their research.

Table 4.4: Articles chosen for comparison of their lists of avoidable causes of death

Article code	Article title	Avoidable mortality list basis	Author(s)	Publication date
1	Avoidable mortality in New Zealand, 1981-97	Based on Tobias and Jackson	Tobias, M; Jackson, G	2001
2	Trends in amenable deaths based on township income quartiles in Taiwan, 1971-2008: did universal health insurance close the gap?	Based on CAEC classification of Avoidable Deaths	Chen, Brian K; Yang, Y Tony; Yang, Chun-Yuh	2015
3	Avoidable mortality by neighbourhood income in Canada: 25 years after the establishment of universal health insurance	The list of avoidable deaths was created with reference to classification lists from other studies (Charlton, etc.)	James, Paul D; Wilkins, Russell; Detsky, Allan S; Tugwell, Peter; Manuel, Douglas G	2007
4	Trends and socioeconomic inequalities in amenable mortality in Switzerland with international comparisons	Based on Nolte and McKee	Feller, Anita; Schmidlin, Kurt; Clough-Gorr, Kerri M	2017
5	How much does health care contribute to health inequality in New Zealand?	Based on Australian and New Zealand Atlas of Avoidable Mortality	Tobias, M; Yeh, L C; Tobias, Martin; Yeh, Li-Chia	2007

4.1.4 Ischemic Heart Disease

There is a lack of consensus in the selected articles with respect to the categorization of death due to Ischemic Heart Disease (IHD) as an avoidable cause of death, and researchers have taken different approaches in this regard. Several studies classified IHD in two or three avoidable mortality subcategories. Arguing that prevention and treatment are equally effective in avoiding death due to IHD, some studies –mainly those following the Canadian Institute for Health Information's (CIHI) methodology– classified half of the mortalities due to IHD as treatable mortality and another half as preventable mortality (24,26,41,42,92,135,136). For the same reason, several studies included only half of the IHD mortality in their calculation of amenable mortality rates, as proposed by Nolte and McKee (31,119,120,137,138). In a study conducted by Tobias and Jackson, researchers identified three categories for avoidable mortality, namely Primary Avoidable Mortality (PAM), Secondary Avoidable Mortality (SAM), and Tertiary Avoidable Mortality (TAM). Tobias and Jackson allocated death to IHD as 50% PAM, 25% SAM, and 25% TAM (25). Adopting this definition of the concept of avoidable mortality, an Australian study classified IHD deaths the same way (139). Several studies addressed death due to IHD similar to other avoidable causes of death and accounted for any death due to IHD as avoidable mortality (117,133,134,139,140). Three studies reported death due to IHD in a group separate from other avoidable causes (33,129,130). There were some studies that did not consider IHD as an avoidable cause of death, and therefore it was not included in their avoidable mortality rate calculations (128,141,142). Figure 4.4 shows the number of articles using each type of strategy in dealing with IHD as a cause of death.

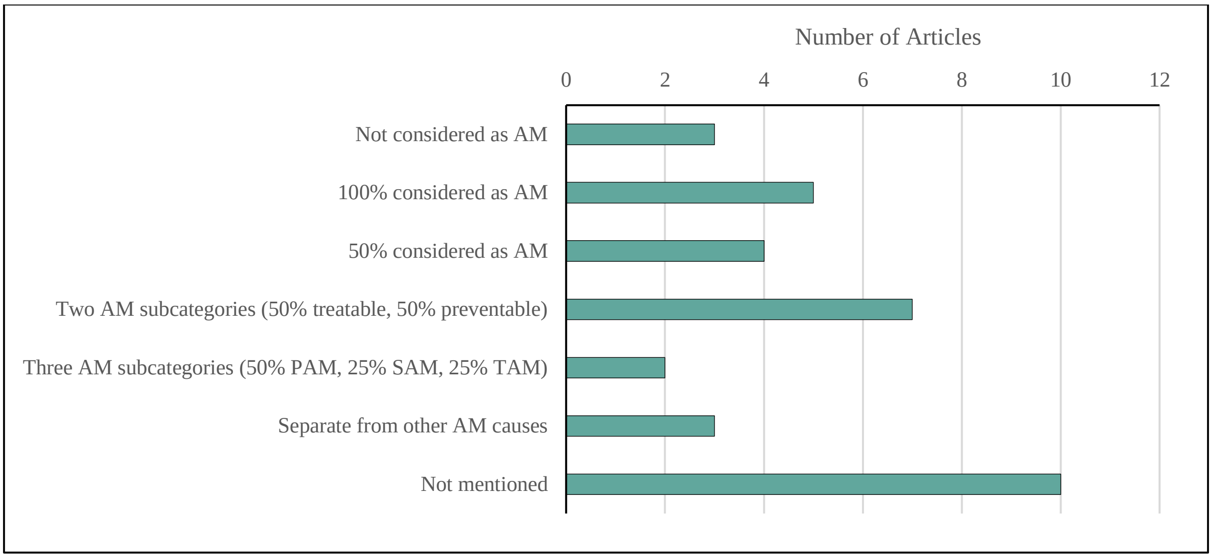


Figure 4.4: Different strategies in classification of IHD as an avoidable cause of death

4.1.5 SES indicator

Articles were classified based on the type of indicator they used for socioeconomic status into four categories, namely index, income, education, and employment. The index category contains any article using a pre-defined index for socioeconomic status, such as Ontario Marginalization Material Deprivation Index (ON-Marg) (41,42,136,143), Index of Relative Socioeconomic Disadvantage (IRSD) (139,140,144), and Index of Multiple Deprivation (IMD) (143,145). Some authors constructed a variable representing socioeconomic status in a population using indicators, such as income and education (141,146). These studies were placed in the index group as well. To make a decision whether to include or exclude an article, the indices used to construct each SES index were assessed to make sure that at least one of the indicators mentioned in the scoping review's inclusion criteria (i.e., education, income, and employment/occupation) is considered as a factor building the index. One study in South Africa that used apartheid classifications (Africans, Whites, Asians, and Coloureds) as a proxy for socioeconomic status was also included in the study, for authors argue that income and education disparities continued to persist in the population even after apartheid was ended (134).

Most of the articles (N=20) used an index to investigate SES inequality in avoidable mortality. This number was 13 for income indicators, 4 for education, and 2 for employment. If a study used more than one category in their analysis, each category was counted separately. For example, if an article examined avoidable mortality rates across different income and education groups independently, the article was counted once for the income category and once for the education category.

4.1.6 Association between SES and Avoidable Mortality

There is a consistency in the findings of selected articles with regards to the association between SES and avoidable mortality rates, suggesting a decrease in avoidable mortality rate as socioeconomic conditions improve. Khan et al. found a similar trend among immigrants and long-term residents, with a downward gradient in age-adjusted avoidable mortality rates as income quintiles increases (38). Among all the included studies, only one study did not find a significant association between crude, overall, and amenable mortality and the percent of poor households using bivariate analysis; in their research, Surenjav et al. used provinces and capitals as their unit of analysis. Nevertheless, this study reveals higher amenable mortality rates in remote western provinces in Mongolia, where there exist harsh weather conditions, high poverty rates, lack of human resources for health, and poor infrastructure (133). Table 4.1 provides more details on selected articles' findings.

While some studies adopted a descriptive approach and compared the avoidable mortality rates between different SES groups, there were many articles examining the SES inequality in avoidable mortality by using various types of analysis, including poisson regression models, calculating Slope Index of Inequality (SII) and Relative Index of Inequality (RII), disparity rate ratio, incidence rate difference, random coefficient growth curve modeling approach, ecological regression, multivariate logistic regression, among other analytical methods.

Most of the included articles used directly age-standardized mortality rates to assess avoidable mortality. In some cases, mortality rates were also standardized by sex. Some studies, however, applied unique methodologies. For example, one study estimated the smoothed standardized mortality rates, using the Bayesian model proposed by Besag, York, and Mollie (147), to address the problem of age-standardization in small areas (142). A Hungarian study also calculated mortality amenable to health care ratios by full hierarchical Bayesian methods. In doing so, the authors calculated smoothed indirectly standardized mortality ratios using sex- and age-specific rates for the Hungarian population (132). A Canadian study calculated the age-standardized expected years of life lost (SEYLL) rate, using the life expectancies of the richest income quintile as the standard, instead of mortality rate (33). Another methodology examined the contribution of different groups of mortality, including death amenable to health care and death amenable to health policy, to life expectancy at age 35 and partial life expectancy between 35 and 75 (129). Doing so, Manderbacka et al. were able to assess the impact of health policy and care on income disparities in life expectancy in Finland (129). In a study conducted by Masters et al., the authors tested central claims of Fundamental Cause Theory (FCT) and then performed a retrospective cohort study to examine the association between preventable mortality and educational attainment (130). Furthermore, an ecological study conducted in France calculated the standardized mortality ratio by dividing the observed mortality in a spatial unit by the corresponding expected mortality (127).

All the studies that preformed a time trend analysis show a decline in avoidable mortality rates through time, while the socioeconomic gradient persists (136,145,148). A study conducted in South Africa indicates that the socioeconomic disparity widened from 2000 to 2005 and narrowed thereafter until 2012 (134). This is similar to the disparity found in France, with 40% higher avoidable mortality rate for the fifth deprivation quintile communes than for the first quintile in 1988-92, and 78% higher in 1997-2001 (128). A study conducted in Taiwan indicates that the decline in avoidable mortality from 1971 to 2008 was faster for the affluent townships compared to the less affluent townships (117). Similarly, an Australian study reports a larger decline in avoidable mortality rate in higher socioeconomic groups, with increasing relative inequality and decreasing absolute inequality between years 1986 and 2002 (149).

4.2 Phase 2: Measuring income inequality in avoidable mortality in urban Canada

In the first part of the second phase of this thesis (*calculate mortality rates*), the annual age-standardized mortality rates for the five indicators of interest, including all-cause, premature, (potentially) avoidable, preventable, and treatable mortality rates were calculated for the years 2011 to 2015 at CMA, provincial, and national levels. In the second part (*measuring income inequality in mortality rates*), the DA-level age-standardized mortality rates for the years 2011 to 2015 were calculated and used to quantify inequality at different geographic levels. The findings of these two sets of analysis are presented below.

4.2.1 Prevalence of mortality indicators in 2011-2015

4.2.1.1 Mortality rates in Canada in 2011-2015

There were 1,265,595 deaths in Canada between 2011 and 2015, of which 481,465 (38.0%) occurred before the age of 75. Table 4.5 illustrates the characteristics of decedents in Canada by type of mortality, between 2011 and 2015. In this period of time, avoidable mortality accounted for 345,915 (71.8%) of all premature deaths in Canada. Of the avoidable deaths, 231,660 (67.0%) were preventable deaths, and 114,255 (33.0%) were attributable to treatable causes.

Although the focus of this thesis was not on gender differences, I decided to report mortality rates by sex as the final results showed a great difference between male and female mortality rates in all mortality indicators. The results of the Z-test showed that the difference in the proportion of male and female death across the five mortality indicators is statistically significant. Men were twice as likely to die due to preventable causes, compared to women (150,335 (64.9%) men vs. 81,325 (35.1%) women). This difference was seen in premature and avoidable mortality as well, but was significantly attenuated for treatable conditions (60,820 (53.2%) men vs. 53,435 (46.8%) women). The mean age at the time of death in all-cause mortality was 75.3 years in 2011, which increased to 76 in 2015, and was 57.7 years in avoidable mortality in 2011, which increased to 58.5 in 2015.

Table 4.5: Characteristics of decedents in Canada by type of mortality, 2011 to 2015

All-cause Mortality						
	Number of decedents in each year (percent of total decedents)					
	2011	**2012**	**2013**	**2014**	**2015**	**2011-2015**
Sex						
Female	121260 (49.8%)	122360 (49.6%)	125365 (49.7%)	128060 (49.5%)	130890 (49.5%)	627935 (49.6%)
Male	122250 (50.2%)	124235 (50.4%)	126975 (50.3%)	130760 (50.5%)	133440 (50.5%)	637660 (50.4%)
Mean age ± SD	75.3 ± 17	75.5 ± 17	75.7 ±17	75.8 ± 16.8	76 ± 16.8	
Premature Mortality						
	Number of decedents in each year (percent of total decedents)					
	2011	**2012**	**2013**	**2014**	**2015**	**2011-2015**
Sex						
Female	36905 (39.8%)	37630 (40.0%)	38180 (39.8%)	39180 (39.8%)	40300 (40.2%)	192195 (39.9%)
Male	55835 (60.2%)	56455 (60.0%)	57805 (60.2%)	59215 (60.2%)	59960 (59.8%)	289270 (60.1%)
Mean age ± SD	58.4 ± 15.4	58.6 ± 15.2	58.8 ± 15.2	59 ± 15	59.2 ± 14.9	
Avoidable Mortality						
	Number of decedents in each year (percent of total decedents)					
	2011	**2012**	**2013**	**2014**	**2015**	**2011-2015**
Sex						
Female	25865 (38.6%)	26470 (39.0%)	26740 (38.7%)	27540 (38.9%)	28145 (39.4%)	134760 (39.0%)
Male	41125 (61.4%)	41360 (61.0%)	42280 (61.3%)	43185 (61.1%)	43205 (60.6%)	211155 (61.0%)
Mean age ± SD	57.7 ± 15.8	57.8 ± 15.8	58.1 ± 15.7	58.3 ± 15.5	58.5 ± 15.4	
Preventable Mortality						
	Number of decedents in each year (percent of total decedents)					
	2011	**2012**	**2013**	**2014**	**2015**	**2011-2015**
Sex						

	2011	2012	2013	2014	2015	2011-2015
Female	15565 (34.7%)	15935 (35.1%)	16210 (35.0%)	16605 (35.1%)	17010 (35.6%)	81325 (35.1%)
Male	29275 (65.3%)	29460 (64.9%)	30075 (65.0%)	30725 (64.9%)	30800 (64.4%)	150335 (64.9%)
Mean age ± SD	57.6 ± 15.8	57.7 ± 15.7	58 ± 15.6	58.2 ± 15.5	58.4 ± 15.4	

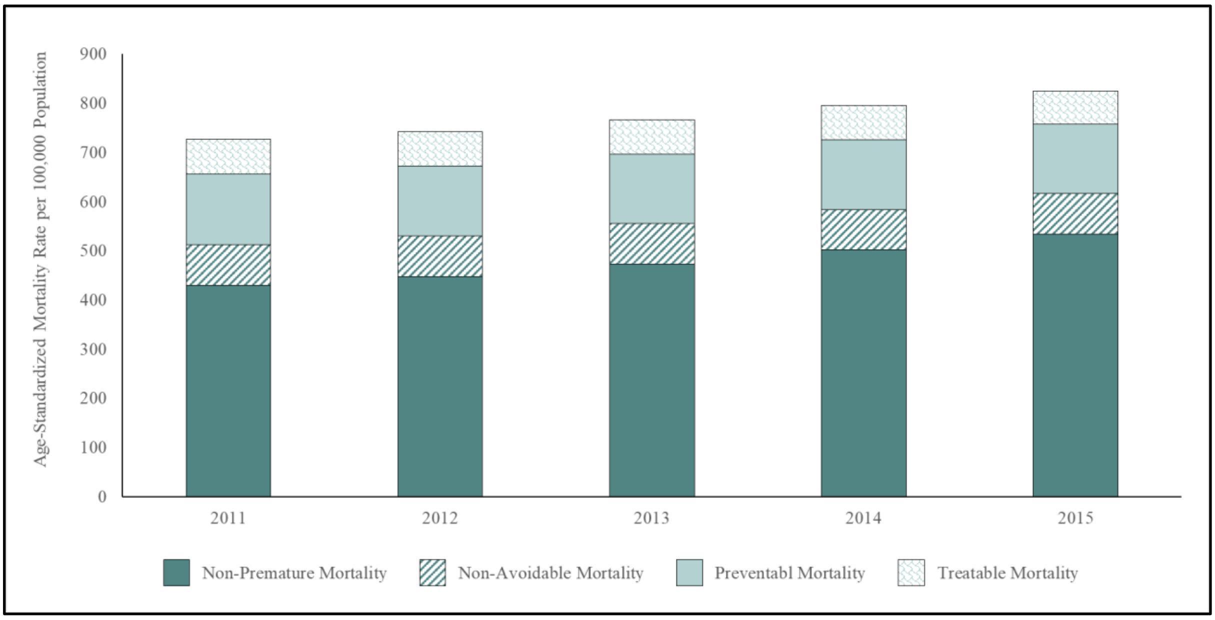
Treatable Mortality						
	Number of decedents in each year (percent of total decedents)					
	2011	**2012**	**2013**	**2014**	**2015**	**2011-2015**
Sex						
Female	10300 (46.5%)	10535 (47.0%)	10530 (46.3%)	10935 (46.7%)	11135 (47.3%)	53435 (46.8%)
Male	11850 (53.5%)	11900 (53.0%)	12205 (53.7%)	12460 (53.3%)	12405 (52.7%)	60820 (53.2%)
Mean age ± SD	60.8 ± 12.9	60.7 ± 12.9	61 ± 12.8	61.1 ± 12.7	61.4 ± 12.4	

Notes: Data was derived from Canadian Vital Statistics Death Dataset. Due to confidentiality reasons, all frequencies were randomly rounded either up or down to a multiple of "5", and the number of institutional mortalities were aggregated for the five-year period before vetting from RDC.

Table 4.6 provides the age-standardized mortality rates (per 100,000) by type of mortality, in Canada, from 2011 to 2015. The age-standardized avoidable mortality rate due to preventable causes was twice the rate attributable to treatable causes in Canada in all the investigated years. For example, in 2014, the age-standardized mortality rate from avoidable causes was 212 deaths per 100,000 people, of which 142 deaths per 100,000 were due to preventable causes, and 70 deaths per 100,000 were attributable to treatable conditions.

The proportion of treatable and preventable mortality could be also observed in Figure 4.5. The age-standardized all-cause mortality rate increased from 727 deaths per 100,000 people in 2011 to 826 deaths per 100,000 people in 2015. This was mostly attributable to the increase in non-premature mortality rates between these years, as illustrated in Figure 4.5.

Figure 4.5. Age-standardized mortality rate per 100,000 in Canada, 2011 to 2015



Notes: Data is derived from CVSD. Non-Canadian residents were excluded.

Table 4.6: Age-standardized mortality rates (per 100,000) in Canada by type of mortality, 2011 to 2015

	2011			2012			2013			2014			2015		
	ASMR[11]	95% CI	SE[12]	ASMR	95% CI	SE	ASMR	95% CI	SE	ASMR	95% CI	SE	ASMR	95% CI	SE
All-Cause mortality	727	690 - 765	19	742	705 - 780	19	766	730 - 805	19	796	760 - 835	19	826	790 - 865	19
Premature mortality	297	265 - 330	18	294	260 - 330	18	293	260 - 330	18	294	260 - 330	18	292	255 - 330	18
Avoidable mortality	215	185 - 245	15	212	180 - 240	15	211	180 - 240	15	212	180 - 240	15	209	180 - 240	15
Preventable mortality	144	120 - 170	13	142	120 - 165	13	142	115 - 165	13	142	115 - 165	13	140	115 - 165	13
Treatable mortality	71	55 - 90	9	70	55 - 85	9	69	50 - 85	9	70	50 - 85	9	68	50 - 85	9

Notes: Data was derived from Canadian Vital Statistics Death Dataset. Due to confidentiality reasons, the numerators, denominators, and confidence intervals were randomly rounded either up or down to a multiple of "5".

[11] Age-standardized Mortality Rate
[12] Standard Error

4.2.1.1 Mortality rates across provinces and territories in 2011-2015

Table 4.7 illustrates the characteristics of all decedents between 2011 and 2015 by provinces and territories. In all provinces and territories, the number of all-cause deaths was roughly equal among men and women, except in Nunavut (525 (60.7%) men vs. 340 (39.3%) women) and Yukon (415 (39.9%) men vs. 625 (60.1%) women). The mean age at the time of death in all-cause mortality was the lowest in Nunavut (47.5, 46.5, 46.9, 46.4, 50.4 in 2011 to 2015 respectively), Northwest Territories (60.4, 64.7, 64.1, 62.5, 63.4 in 2011 to 2015 respectively), and Yukon (68.2, 66, 66.5, 66.6, 67.5 in 2011 to 2015 respectively) in all the years between 2011 and 2015 compared to other provinces.

Table 4.7: Characteristics of decedents in all-cause mortality by province/territory, 2011 to 2015

	All-cause Mortality					
	Number of decedents in each year (percent of total decedents)					
	2011	**2012**	**2013**	**2014**	**2015**	**2011-2015**
Alberta						
Sex						
Female	10185 (48.0%)	10495 (47.7%)	10945 (47.9%)	11165 (47.8%)	11160 (46.8%)	53950 (47.6%)
Male	11055 (52.0%)	11510 (52.3%)	11900 (52.1%)	12195 (52.2%)	12685 (53.2%)	59345 (52.4%)
Mean age ± SD	72.9 ± 19.2	73 ± 19.1	73 ± 19.3	72.8 ± 19.5	72.6 ± 19.5	
British Columbia						
Sex						
Female	15535 (48.6%)	15850 (48.7%)	16075 (48.4%)	16270 (48.2%)	17025 (48.3%)	80755 (48.4%)
Male	16430 (51.4%)	16675 (51.3%)	17125 (51.6%)	17520 (51.8%)	18225 (51.7%)	85975 (51.6%)
Mean age ± SD	76 ± 16.7	76.3 ± 16.6	76.2 ± 16.6	76.3 ± 16.7	76.6 ± 16.5	
Manitoba						
Sex						
Female	5210 (50.8%)	5090 (50.6%)	5020 (49.7%)	5315 (49.6%)	5390 (50.5%)	26025 (50.2%)
Male	5040 (49.2%)	4970 (49.4%)	5075 (50.3%)	5395 (50.4%)	5290 (49.5%)	25770 (49.8%)
Mean age ± SD	75.3 ± 18.6	74.9 ± 18.7	75.1 ± 18.5	75.4 ± 18.3	75.4 ± 18.4	
New Brunswick						
Sex						
Female	3175 (49.5%)	3170 (49.2%)	3370 (50.9%)	3440 (50.4%)	3595 (49.7%)	16750 (50.0%)
Male	3235 (50.5%)	3275 (50.8%)	3255 (49.1%)	3380 (49.6%)	3635 (50.3%)	16780 (50.0%)
Mean age ± SD	76 ± 16.2	75.5 ± 16.7	76.4 ± 15.9	76.3 ± 15.7	76.4 ± 15.8	
Newfoundland and Labrador						
Sex						
Female	2195 (48.5%)	2185 (47.1%)	2375 (49.1%)	2395 (48.0%)	2570 (49.0%)	11720 (48.4%)
Male	2330 (51.5%)	2450 (52.9%)	2460 (50.9%)	2590 (52.0%)	2670 (51.0%)	12500 (51.6%)
Mean age ± SD	74.6 ± 15.8	74.4 ± 16	74.5 ± 16	74.7 ± 15.6	75 ± 15.4	

Northwest Territories						
Sex						
Female	80 (42.1%)	90 (45.0%)	80 (41.0%)	95 (44.2%)	85 (40.5%)	430 (42.6%)
Male	110 (57.9%)	110 (55.0%)	115 (59.0%)	120 (55.8%)	125 (59.5%)	580 (57.4%)
Mean age ± SD	60.4 ± 22.5	64.7 ± 19.3	64.1 ± 22.2	62.5 ± 22.3	63.4 ± 22	
Nova Scotia						
Sex						
Female	4340 (50.8%)	4250 (50.5%)	4430 (49.9%)	4380 (50.1%)	4735 (50.5%)	22135 (50.4%)
Male	4195 (49.2%)	4165 (49.5%)	4450 (50.1%)	4365 (49.9%)	4635 (49.5%)	21810 (49.6%)
Mean age ± SD	75.9 ± 16.1	75.8 ± 15.9	76.4 ± 15.6	76.2 ± 15.9	76.6 ± 15.4	
Nunavut						
Sex						
Female	70 (41.2%)	60 (36.4%)	80 (41.0%)	65 (37.1%)	65 (40.6%)	340 (39.3%)
Male	100 (58.8%)	105 (63.6%)	115 (59.0%)	110 (62.9%)	95 (59.4%)	525 (60.7%)
Mean age ± SD	47.5 ± 28.8	46.4 ± 27.6	46.9 ± 27.5	46.4 ± 25.1	50.4 ± 26	
Ontario						
Sex						
Female	44955 (50.0%)	45165 (49.8%)	46380 (49.7%)	47510 (49.5%)	48655 (50.0%)	232665 (49.8%)
Male	45020 (50.0%)	45575 (50.2%)	46965 (50.3%)	48430 (50.5%)	48670 (50.0%)	234660 (50.2%)
Mean age ± SD	75.6 ± 16.7	75.7 ± 16.8	76 ± 16.6	76.2 ± 16.6	76.3 ± 16.6	
Prince Edward Island						
Sex						
Female	640 (51.2%)	630 (51.0%)	610 (47.5%)	660 (51.4%)	645 (51.2%)	3185 (50.4%)
Male	610 (48.8%)	605 (49.0%)	675 (52.5%)	625 (48.6%)	615 (48.8%)	3130 (49.6%)
Mean age ± SD	76.5 ± 16	75.7 ± 15.4	76.6 ± 15.5	77.4 ± 15.2	78.1 ± 14.1	
Quebec						
Sex						
Female	30180 (50.7%)	30780 (50.6%)	31275 (51.0%)	32060 (50.7%)	32295 (50.3%)	156590 (50.7%)
Male	29360 (49.3%)	29995 (49.4%)	30015 (49.0%)	31135 (49.3%)	31865 (49.7%)	152370 (49.3%)
Mean age ± SD	75.5 ± 16.3	75.8 ± 16.1	76 ± 16.2	76.4 ± 15.8	76.5 ± 15.8	
Saskatchewan						
Sex						
Female	4615 (49.8%)	4525 (49.2%)	4630 (49.6%)	4630 (49.3%)	4580 (48.7%)	22980 (49.3%)
Male	4645 (50.2%)	4680 (50.8%)	4700 (50.4%)	4765 (50.7%)	4815 (51.3%)	23605 (50.7%)
Mean age ± SD	75.4 ± 19.3	76 ± 18.5	75.7 ± 18.8	75.6 ± 18.7	75.2 ± 18.8	
Yukon						
Sex						
Female	70 (36.8%)	80 (38.1%)	95 (44.2%)	75 (36.6%)	95 (43.2%)	415 (39.9%)

Male	120 (63.2%)	130 (61.9%)	120 (55.8%)	130 (63.4%)	125 (56.8%)	625 (60.1%)
Mean age ± SD	68.2 ± 16.9	66 ± 18.7	66.5 ± 17.1	66.6 ± 19.5	67.5 ± 19.4	

Notes: Data was derived from Canadian Vital Statistics Death Dataset. To calculate the frequencies, Canadian residents were excluded from the dataset. Due to confidentiality reasons, all frequencies were randomly rounded either up or down to a multiple of "5", and the number of institutional mortalities were aggregated for the five-year period before vetting from RDC. * To adhere to confidentiality rules, the number of institutional deaths for territories Yukon, Nunavut, Northwest Territories could not be reported separately. The number of institutional all-cause deaths in these territories collectively, is 210 (7.2%).

Table 4.8 presents the characteristics of all decedents who were younger than 75 at the time of death by provinces and territories, from 2011 to 2015. In all provinces and territories, men were almost twice as likely to die prematurely compared to women.

Table 4.8: Characteristics of decedents in premature mortality by province/territory, 2011 to 2015

	Premature Mortality					
	Number of decedents in each year (percent of total decedents)					
	2011	**2012**	**2013**	**2014**	**2015**	**2011-2015**
Alberta						
Sex						
Female	3550 (38.8%)	3705 (39.2%)	3895 (39.3%)	4010 (39.3%)	4000 (38.1%)	19160 (38.9%)
Male	5590 (61.2%)	5740 (60.8%)	6005 (60.7%)	6205 (60.7%)	6510 (61.9%)	30050 (61.1%)
Mean age ± SD	55.9 ± 17	56 ± 16.8	55.9 ± 17.3	55.7 ± 17.1	55.6 ± 17.1	
British Columbia						
Sex						
Female	4580 (39.2%)	4630 (39.2%)	16075 (39.0%)	4815 (38.2%)	5040 (39.1%)	23835 (38.9%)
Male	7100 (60.8%)	7170 (60.8%)	17125 (61.0%)	7775 (61.8%)	7860 (60.9%)	37365 (61.1%)
Mean age ± SD	58.6 ± 14.8	58.9 ± 14.5	59 ± 14.5	59.2 ± 14.6	59.4 ± 14.3	
Manitoba						
Sex						
Female	1500 (39.5%)	1555 (40.3%)	5020 (39.3%)	1630 (39.9%)	1665 (40.8%)	7905 (40.0%)
Male	2295 (60.5%)	2305 (59.7%)	5075 (60.7%)	2455 (60.1%)	2415 (59.2%)	11870 (60.0%)
Mean age ± SD	56.5 ± 17.3	59 ± 16.9	57.2 ± 16.8	57.3 ± 16.7	57.3 ± 16.9	
New Brunswick						
Sex						
Female	870 (36.3%)	975 (38.8%)	3370 (39.5%)	1065 (40.5%)	1100 (39.7%)	4995 (39.0%)
Male	1525 (63.7%)	1540 (61.2%)	3255 (60.5%)	1565 (59.5%)	1670 (60.3%)	7810 (61.0%)
Mean age ± SD	59.5 ± 13.9	61 ± 14.7	60.3 ± 13.8	60.7 ± 13.2	60.5 ± 13.2	
Newfoundland and Labrador						
Sex						
Female	730 (39.0%)	770 (38.3%)	2375 (40.5%)	825 (39.1%)	850 (39.8%)	4005 (39.4%)
Male	1140 (61.0%)	1240 (61.7%)	2460 (59.5%)	1285 (60.9%)	1285 (60.2%)	6170 (60.6%)
Mean age ± SD	60.1 ± 13.9	61.5 ± 13.6	60.1 ± 14	60.7 ± 13.4	60.5 ± 13.3	
Northwest Territories						
Sex						
Female	50 (38.5%)	55 (42.3%)	80 (34.6%)	45 (33.3%)	45 (34.6%)	240 (36.6%)
Male	80 (61.5%)	75 (57.7%)	115 (65.4%)	90 (66.7%)	85 (65.4%)	415 (63.4%)
Mean age ± SD	50 ± 19.2	60.2 ± 16.4	52.3 ± 19.1	50.4 ± 18.6	51 ± 18.6	

Nova Scotia						
Sex						
Female	1355 (41.4%)	1360 (41.2%)	4430 (39.6%)	1325 (39.1%)	1425 (39.9%)	6805 (40.2%)
Male	1920 (58.6%)	1940 (58.8%)	4450 (60.4%)	2065 (60.9%)	2150 (60.1%)	10120 (59.8%)
Institutional mortality						640 (3.8%)
Nunavut						
Sex						
Female	50 (35.7%)	45 (33.3%)	80 (41.9%)	50 (33.3%)	50 (38.5%)	260 (36.6%)
Male	90 (64.3%)	90 (66.7%)	115 (58.1%)	100 (66.7%)	80 (61.5%)	450 (63.4%)
Mean age ± SD	39.4 ± 25.8	45.2 ± 24.9	38.1 ± 23.9	40.6 ± 22.2	43.2 ± 23.7	
Ontario						
Sex						
Female	13410 (40.0%)	13660 (40.2%)	46380 (39.9%)	14255 (40.2%)	14690 (41.0%)	69780 (40.3%)
Male	20125 (60.0%)	20280 (59.8%)	46965 (60.1%)	21215 (59.8%)	21170 (59.0%)	103550 (59.7%)
Mean age ± SD	58.7 ± 15.1	60.5 ± 15.1	59.1 ± 14.9	59.2 ± 14.7	59.3 ± 14.7	
Prince Edward Island						
Sex						
Female	185 (40.2%)	215 (43.4%)	610 (34.0%)	185 (41.1%)	175 (39.8%)	925 (39.7%)
Male	275 (59.8%)	280 (56.6%)	675 (66.0%)	265 (58.9%)	265 (60.2%)	1405 (60.3%)
Mean age ± SD	60 ± 14	61.4 ± 13.2	60.9 ± 12.8	61.1 ± 12.8	62.7 ± 11.1	
Quebec						
Sex						
Female	9295 (40.5%)	9330 (40.4%)	31275 (40.5%)	9580 (40.7%)	9805 (40.8%)	47400 (40.6%)
Male	13630 (59.5%)	13750 (59.6%)	30015 (59.5%)	13980 (59.3%)	14215 (59.2%)	69360 (59.4%)
Mean age ± SD	59.5 ± 14.6	61.4 ± 14.4	59.8 ± 14.4	60.4 ± 14	60.6 ± 14.1	
Saskatchewan						
Sex						
Female	1300 (39.6%)	1270 (39.3%)	4630 (39.2%)	1350 (38.7%)	1400 (39.3%)	6640 (39.2%)
Male	1985 (60.4%)	1960 (60.7%)	4700 (60.8%)	2135 (61.3%)	2165 (60.7%)	10290 (60.8%)
Mean age ± SD	55.1 ± 18.2	59.7 ± 17.2	56.3 ± 17.6	56.5 ± 17.1	56.4 ± 17	
Yukon						
Sex						
Female	40 (33.3%)	50 (37.0%)	95 (40.7%)	45 (34.6%)	55 (40.7%)	245 (37.4%)
Male	80 (66.7%)	85 (63.0%)	120 (59.3%)	85 (65.4%)	80 (59.3%)	410 (62.6%)
Mean age ± SD	58.1 ± 13.6	60.4 ± 15.3	57.2 ± 14	55.7 ± 16.9	57.3 ± 17.3	

Notes: Data was derived from Canadian Vital Statistics Death Dataset. Due to confidentiality reasons, all frequencies were randomly rounded eighter up or down to a multiple of "5", and the number of institutional mortalities were aggregated for the five-year period before vetting from RDC. * To adhere to confidentiality rules, the number of institutional deaths for territories Yukon, Nunavut, Northwest Territories could not be reported separately. The number of institutional premature deaths in these territories collectively, is 55 (2.7%).

Table 4.9 illustrates the characteristics of all decedents who died before the age of 75 due to avoidable causes of death, between 2011 and 2015, by provinces and territories. Similar to premature mortality, in all provinces and territories, men were twice as likely to die due to avoidable causes of death compared to women. The lowest mean age at the time of death was seen in Nunavut (39.5, 38.7, 39.1, 40.8, 44 from 2011 to 2015 respectively), while the mean age for other provinces and territories in all the examined years was higher than 50 years of age.

Table 4.9: Characteristics of decedents in avoidable mortality by province/territory, 2011 to 2015

	Avoidable Mortality					
	Number of decedents in each year (percent of total decedents)					
	2011	**2012**	**2013**	**2014**	**2015**	**2011-2015**
Alberta						
Sex						
Female	2595 (37.7%)	2685 (38.0%)	2805 (37.7%)	2930 (38.1%)	2910 (36.8%)	13925 (37.6%)
Male	4290 (62.3%)	4375 (62.0%)	4635 (62.3%)	4770 (61.9%)	4995 (63.2%)	23065 (62.4%)
Mean age ± SD	54.9 ± 17.4	54.9 ± 17.2	55 ± 17.6	54.6 ± 17.4	54.4 ± 17.5	
British Columbia						
Sex						
Female	3220 (38.4%)	3220 (38.3%)	3280 (38.0%)	3335 (37.5%)	3410 (38.3%)	16465 (38.1%)
Male	5170 (61.6%)	5195 (61.7%)	5350 (62.0%)	5555 (62.5%)	5485 (61.7%)	26755 (61.9%)
Mean age ± SD	58 ± 15.1	58.3 ± 14.9	58.5 ± 14.7	58.6 ± 14.9	59.2 ± 14.4	
Manitoba						
Sex						
Female	1045 (38.0%)	1080 (39.2%)	1080 (38.2%)	1160 (39.3%)	1155 (39.7%)	5520 (38.9%)
Male	1705 (62.0%)	1675 (60.8%)	1750 (61.8%)	1795 (60.7%)	1755 (60.3%)	8680 (61.1%)
Mean age ± SD	55.4 ± 17.9	55 ± 17.4	56.2 ± 17.4	56.3 ± 17.2	56 ± 17.7	
New Brunswick						
Sex						
Female	580 (34.8%)	620 (36.5%)	640 (38.9%)	725 (39.6%)	725 (38.5%)	3290 (37.7%)
Male	1085 (65.2%)	1080 (63.5%)	1005 (61.1%)	1105 (60.4%)	1160 (61.5%)	5435 (62.3%)
Mean age ± SD	59 ± 14.3	58.1 ± 15.6	59.5 ± 14.5	60 ± 13.9	59.9 ± 13.9	
Newfoundland and Labrador						
Sex						
Female	480 (37.5%)	535 (37.4%)	550 (38.9%)	565 (37.5%)	590 (38.4%)	2720 (38.0%)
Male	800 (62.5%)	895 (62.6%)	865 (61.1%)	940 (62.5%)	945 (61.6%)	4445 (62.0%)
Mean age ± SD	59.5 ± 14.2	60 ± 14	59.7 ± 14.5	60.1 ± 14.2	60 ± 13.5	
Northwest Territories						
Sex						
Female	25 (29.4%)	40 (42.1%)	35 (35.0%)	30 (28.6%)	30 (31.6%)	160 (33.3%)
Male	60 (70.6%)	55 (57.9%)	65 (65.0%)	75 (71.4%)	65 (68.4%)	320 (66.7%)
Mean age ± SD	51.9 ± 19.6	54.5 ± 16.3	52.6 ± 19.1	50.7 ± 18.5	50.7 ± 19)	
Nova Scotia						
Sex						

Female	910 (38.8%)	970 (40.8%)	930 (38.0%)	915 (37.3%)	965 (38.4%)	4690 (38.6%)
Male	1435 (61.2%)	1405 (59.2%)	1520 (62.0%)	1540 (62.7%)	1550 (61.6%)	7450 (61.4%)
Mean age ± SD	59.6 ± 14.1	59.5 ± 14	60.3 ± 13.4	59.9 ± 13.8	61 ± 12.9	
Nunavut						
Sex						
Female	35 (33.3%)	35 (31.8%)	50 (40.0%)	40 (33.3%)	40 (38.1%)	200 (35.4%)
Male	70 (66.7%)	75 (68.2%)	75 (60.0%)	80 (66.7%)	65 (61.9%)	365 (64.6%)
Mean age ± SD	39.5 ± 24.9	38.7 ± 24.2	39.1 ± 23.1	40.8 ± 21.7	44 ± 22.8	
Ontario						
Sex						
Female	9330 (38.7%)	9585 (39.1%)	9650 (38.8%)	9935 (39.1%)	10330 (40.2%)	48830 (39.2%)
Male	14785 (61.3%)	14915 (60.9%)	15245 (61.2%)	15500 (60.9%)	15345 (59.8%)	75790 (60.8%)
Mean age ± SD	58.1 ± 15.5	57.8 ± 15.7	58.4 ± 15.4	58.5 ± 15.2	58.7 ± 15.1	
Prince Edward Island						
Sex						
Female	135 (40.3%)	160 (43.8%)	110 (32.4%)	120 (40.0%)	120 (40.0%)	645 (39.3%)
Male	200 (59.7%)	205 (56.2%)	230 (67.6%)	180 (60.0%)	180 (60.0%)	995 (60.7%)
Mean age ± SD	59.8 ± 13.9	60.3 ± 14.2	60.4 ± 13	60.5 ± 13.6	62.3 ± 11.2	
Quebec						
Sex						
Female	6555 (39.6%)	6630 (39.9%)	6625 (39.9%)	6780 (40.4%)	6915 (40.5%)	33505 (40.1%)
Male	9980 (60.4%)	9990 (60.1%)	9980 (60.1%)	10000 (59.6%)	10155 (59.5%)	50105 (59.9%)
Mean age ± SD	58.7 ± 15.2	59.1 ± 15.1	59.1 ± 15	59.7 ± 14.7	59.8 ± 14.8	
Saskatchewan						
Sex						
Female	920 (38.1%)	880 (38.2%)	950 (38.9%)	975 (38.2%)	935 (39.0%)	4660 (38.4%)
Male	1495 (61.9%)	1425 (61.8%)	1495 (61.1%)	1580 (61.8%)	1465 (61.0%)	7460 (61.6%)
Mean age ± SD	54.3 ± 18.7	55.2 ± 17.7	55.3 ± 18.1	55.8 ± 17.4	56.5 ± 17	
Yukon						
Sex						
Female	25 (33.3%)	40 (36.4%)	35 (36.8%)	30 (31.6%)	30 (42.9%)	160 (36.0%)
Male	50 (66.7%)	70 (63.6%)	60 (63.2%)	65 (68.4%)	40 (57.1%)	285 (64.0%)
Mean age ± SD	57.1 ± 14.4	56.5 ± 16	55.6 ± 15.1	54.5 ± 17.6	59.8 ± 15	

Notes: Data was derived from Canadian Vital Statistics Death Dataset. Due to confidentiality reasons, all frequencies were randomly rounded either up or down to a multiple of "5", and the number of institutional mortalities were aggregated for the five-year period before vetting from RDC. * To adhere to confidentiality rules, the number of institutional deaths for territories Yukon, Nunavut, Northwest Territories could not be reported separately. The number of institutional avoidable deaths in these territories collectively, is 30 (2.0%).

Table 4.10 shows the characteristics of all decedents who died before the age of 75 and due to preventable causes of death, between 2011 and 2015 by provinces and territories. Similar to premature and avoidable mortality, in all provinces and territories, men were twice as likely to die due to preventable conditions compared to women. The lowest mean age at the time of death was seen in

Nunavut (39.9, 39.4, 38.3, 41.8, 42.8 from 2011 to 2015 respectively), while the mean age for other provinces and territories in all the examined years were higher than 50 years of age.

Table 4.10: Characteristics of decedents in preventable mortality by province/territory, 2011 to 2015

	Preventable Mortality					
	Number of decedents in each year (percent of total decedents)					
	2011	**2012**	**2013**	**2014**	**2015**	**2011-2015**
Alberta						
Sex						
Female	1650 (34.8%)	1695 (35.0%)	1735 (34.2%)	1830 (34.2%)	1800 (32.8%)	8710 (34.2%)
Male	3095 (65.2%)	3145 (65.0%)	3335 (65.8%)	3515 (65.8%)	3695 (67.2%)	16785 (65.8%)
Mean age ± SD	54.7 ± 17.3	54.5 ± 17.2	54.5 ± 17.7	54.1 ± 17.5	53.9 ± 17.6	
British Columbia						
Sex						
Female	1980 (34.3%)	1940 (33.9%)	2005 (34.2%)	2075 (33.8%)	2025 (33.3%)	10025 (33.9%)
Male	3795 (65.7%)	3780 (66.1%)	3860 (65.8%)	4055 (66.2%)	4050 (66.7%)	19540 (66.1%)
Mean age ± SD	57.8 ± 15	58 ± 15.2	58.3 ± 14.6	58.5 ± 14.8	59.1 ± 14.3	
Manitoba						
Sex						
Female	620 (34.3%)	660 (36.7%)	625 (34.3%)	685 (36.1%)	675 (35.8%)	3265 (35.4%)
Male	1190 (65.7%)	1140 (63.3%)	1195 (65.7%)	1215 (63.9%)	1210 (64.2%)	5950 (64.6%)
Mean age ± SD	55.2 ± 17.8	54.9 ± 17	55.9 ± 17.3	55.9 ± 17.3	55.9 ± 17.6	
New Brunswick						
Sex						
Female	350 (31.3%)	385 (33.0%)	405 (36.2%)	445 (35.7%)	440 (34.8%)	2025 (34.2%)
Male	770 (68.8%)	780 (67.0%)	715 (63.8%)	800 (64.3%)	825 (65.2%)	3890 (65.8%)
Mean age ± SD	59 ± 14.1	58 ± 15.7	59.7 ± 14.4	59.9 ± 13.9	59.7 ± 14	
Newfoundland and Labrador						
Sex						
Female	270 (34.2%)	280 (32.0%)	305 (34.7%)	295 (31.2%)	340 (35.1%)	1490 (33.4%)
Male	520 (65.8%)	595 (68.0%)	575 (65.3%)	650 (68.8%)	630 (64.9%)	2970 (66.6%)
Mean age ± SD	59.2 ± 14.8	60.2 ± 13.7	59.3 ± 15.2	59.9 ± 14.6	59.8 ± 13.6	
Northwest Territories						
Sex						
Female	20 (33.3%)	30 (42.9%)	25 (35.7%)	20 (26.7%)	20 (28.6%)	115 (33.3%)
Male	40 (66.7%)	40 (57.1%)	45 (64.3%)	55 (73.3%)	50 (71.4%)	230 (66.7%)
Mean age ± SD	52.2 ± 19.2	53.9 ± 17.1	51.6 ± 18.9	50 ± 18.9	50.3 ± 19.2	
Nova Scotia						
Sex						

Female	520 (34.0%)	575 (36.9%)	535 (33.3%)	550 (33.4%)	575 (34.8%)	2755 (34.5%)
Male	1010 (66.0%)	985 (63.1%)	1070 (66.7%)	1095 (66.6%)	1075 (65.2%)	5235 (65.5%)
Mean age ± SD	59.6 ± 14.1	59.4 ± 14	60.4 ± 13.4	59.9 ± 13.8	60.8 ± 13.1	
Nunavut						
Sex						
Female	30 (35.3%)	25 (26.3%)	40 (40.0%)	30 (30.0%)	25 (31.3%)	150 (32.3%)
Male	60 (66.7%)	70 (73.7%)	60 (60.0%)	70 (70.0%)	55 (68.8%)	315 (67.7%)
Mean age ± SD	39.9 ± 24.2	39.4 ± 23.8	38.3 ± 22.5	41.8 ± 20.8	42.8 ± 23.3	
Ontario						
Sex						
Female	5410 (34.4%)	5580 (34.7%)	5720 (34.7%)	5835 (35.2%)	6075 (36.1%)	28620 (35.0%)
Male	10335 (65.6%)	10505 (65.3%)	10780 (65.3%)	10755 (64.8%)	10750 (63.9%)	53125 (65.0%)
Mean age ± SD	58.2 ± 15.4	57.9 ± 15.6	58.4 ± 15.3	58.6 ± 15.1	58.7 ± 15	
Prince Edward Island						
Sex						
Female	80 (36.4%)	85 (37.8%)	55 (25.0%)	80 (39.0%)	75 (36.6%)	375 (34.9%)
Male	140 (63.6%)	140 (62.2%)	165 (75.0%)	125 (61.0%)	130 (63.4%)	700 (65.1%)
Mean age ± SD	59.9 ± 13.2	60.9 ± 13.3	60 ± 13.2	61.2 ± 12.3	62.2 ± 11.8	
Quebec						
Sex						
Female	4070 (36.0%)	4145 (36.5%)	4145 (36.5%)	4160 (36.5%)	4385 (37.5%)	20905 (36.6%)
Male	7225 (64.0%)	7200 (63.5%)	7215 (63.5%)	7225 (63.5%)	7300 (62.5%)	36165 (63.4%)
Mean age ± SD	58.6 ± 15.3	59 ± 15.1	59.1 ± 14.9	59.6 ± 14.7	59.7 ± 14.9	
Saskatchewan						
Sex						
Female	555 (34.4%)	515 (33.6%)	600 (37.0%)	590 (34.5%)	550 (35.3%)	2810 (35.0%)
Male	1060 (65.6%)	1020 (66.4%)	1020 (63.0%)	1120 (65.5%)	1010 (64.7%)	5230 (65.0%)
Mean age ± SD	53.8 ± 18.8	54.8 ± 17.4	55 ± 17.8	55.7 ± 17.1	56.5 ± 17	
Yukon						
Sex						
Female	15 (27.3%)	20 (26.7%)	25 (35.7%)	25 (33.3%)	20 (36.4%)	105 (31.8%)
Male	40 (72.7%)	55 (73.3%)	45 (64.3%)	50 (66.7%)	35 (63.6%)	225 (68.2%)
Mean age ± SD	56.6 ± 15	56.1 ± 16.9	55.6 ± 14.5	53.1 ± 18	59.6 ± 15.3	

Notes: Data was derived from Canadian Vital Statistics Death Dataset. Due to confidentiality reasons, all frequencies were randomly rounded either up or down to a multiple of "5", and the number of institutional mortalities were aggregated for the five-year period before vetting from RDC. * To adhere to confidentiality rules, the number of institutional deaths for territories Yukon, Nunavut, Northwest Territories could not be reported separately. The number of institutional preventable deaths in these territories collectively, is 20 (1.8%).

Table 4.11 shows the characteristics of all decedents who died before the age of 75 and due to treatable causes of death, between 2011 and 2015 by provinces and territories. The difference between the percentage of deaths happening among women and men, which was seen in premature, avoidable, and preventable mortalities, was attenuated for treatable conditions, in that the proportion of treatable deaths among men were only slightly higher than women's. For example, in Alberta, between 2011 to 2015, 5,210 (45.3%) treatable deaths occurred among women, while men experienced 6,285 (45.7%) deaths due to treatable conditions. The lowest mean age at the time of death was seen in Nunavut (41.9, 45.2, 50.5, 43.1, 56.2 from 2011 to 2015 respectively), while the mean age for other provinces and territories in all the examined years were higher than 50 years of age.

Table 4.11: Characteristics of decedents in treatable mortality by province/territory, 2011 to 2015

	Treatable Mortality					
	Number of decedents in each year (percent of total decedents)					
	2011	**2012**	**2013**	**2014**	**2015**	**2011-2015**
Alberta						
Sex						
Female	945 (44.2%)	990 (44.6%)	1070 (45.1%)	1100 (46.7%)	1105 (45.9%)	5210 (45.3%)
Male	1195 (55.8%)	1230 (55.4%)	1305 (54.9%)	1255 (53.3%)	1300 (54.1%)	6285 (54.7%)
Mean age ± SD	59.3 ± 14	59.6 ± 13.9	59.9 ± 13.8	59.7 ± 13.6	59.7 ± 13.7	
British Columbia						
Sex						
Female	1245 (47.5%)	1280 (47.4%)	1275 (46.0%)	1260 (45.7%)	1385 (49.2%)	6445 (47.2%)
Male	1375 (52.5%)	1420 (52.6%)	1495 (54.0%)	1500 (54.3%)	1430 (50.8%)	7220 (52.8%)
Mean age ± SD	61.2 ± 12.4	61.5 ± 11.4	61.6 ± 12.1	61.5 ± 12.5	62 ± 12	
Manitoba						
Sex						
Female	425 (45.0%)	420 (44.2%)	455 (45.0%)	475 (44.8%)	480 (46.8%)	2255 (45.2%)
Male	520 (55.0%)	530 (55.8%)	555 (55.0%)	585 (55.2%)	545 (53.2%)	2735 (54.8%)
Mean age ± SD	59.7 ± 14.5	59 ± 14.5	60.3 ± 13.9	60 ± 13.8	59.9 ± 14.5	
New Brunswick						
Sex						
Female	235 (42.7%)	235 (44.3%)	240 (45.3%)	280 (47.9%)	280 (45.5%)	1270 (45.2%)
Male	315 (57.3%)	295 (55.7%)	290 (54.7%)	305 (52.1%)	335 (54.5%)	1540 (54.8%)
Mean age ± SD	61.1 ± 12.2	61 ± 12.4	61.4 ± 12.1	62.5 ± 10.9	62.1 ± 10.9	
Newfoundland and Labrador						
Sex						
Female	210 (42.9%)	255 (45.9%)	240 (45.3%)	270 (48.2%)	250 (44.2%)	1225 (45.4%)
Male	280 (57.1%)	300 (54.1%)	290 (54.7%)	290 (51.8%)	315 (55.8%)	1475 (54.6%)
Mean age ± SD	62.1 ± 10.1	61.5 ± 11.9	62.4 ± 10.6	62.7 ± 10.3	62.1 ± 10.9	
Northwest Territories						
Sex						
Female	10 (33.3%)	10 (40.0%)	10 (40.0%)	15 (42.9%)	10 (40.0%)	55 (39.3%)
Male	20 (66.7%)	15 (60.0%)	15 (60.0%)	20 (57.1%)	15 (60.0%)	85 (60.7%)
Mean age ± SD	57.9 ± 16.7	60.2 ± 9.6	59.8 ± 14.1	57.3 ± 13.8	56.8 ± 15.2	
Nova Scotia						
Sex						

Female	390 (47.6%)	395 (48.8%)	395 (46.7%)	365 (45.1%)	390 (44.8%)	1935 (46.6%)
Male	430 (52.4%)	415 (51.2%)	450 (53.3%)	445 (54.9%)	480 (55.2%)	2220 (53.4%)
Mean age ± SD	61.4 ± 11.8	61.5 ± 11.6	61.9 ± 11.3	61.7 ± 11.5	62.8 ± 10	
Nunavut						
Sex						
Female	10 (40.0%)	10 (50.0%)	15 (50.0%)	10 (40.0%)	10 (40.0%)	55 (44.0%)
Male	15 (60.0%)	10 (50.0%)	15 (50.0%)	15 (60.0%)	15 (60.0%)	70 (56.0%)
Mean age ± SD	41.9 ± 25.7	45.2 ± 23.5	50.5 ± 21.4	43.1 ± 24.3	56.2 ± 15.5	
Ontario						
Sex						
Female	3920 (46.9%)	4005 (47.6%)	3930 (46.8%)	4105 (46.4%)	4255 (48.1%)	20215 (47.1%)
Male	4445 (53.1%)	4415 (52.4%)	4460 (53.2%)	4740 (53.6%)	4600 (51.9%)	22660 (52.9%)
Mean age ± SD	60.8 ± 12.7	60.5 ± 12.9	61 ± 12.7	61.1 ± 12.6	61.2 ± 12.5	
Prince Edward Island						
Sex						
Female	55 (47.8%)	70 (53.8%)	55 (44.0%)	45 (42.9%)	40 (44.4%)	265 (46.9%)
Male	60 (52.2%)	60 (46.2%)	70 (56.0%)	60 (57.1%)	50 (55.6%)	300 (53.1%)
Mean age ± SD	61.1 ± 12.6	61.4 ± 13.1	62.9 ± 10.3	60.8 ± 14	63.4 ± 7.7	
Quebec						
Sex						
Female	2490 (47.5%)	2485 (47.1%)	2485 (47.3%)	2620 (48.6%)	2525 (46.9%)	12605 (47.5%)
Male	2755 (52.5%)	2790 (52.9%)	2765 (52.7%)	2775 (51.4%)	2855 (53.1%)	13940 (52.5%)
Mean age ± SD	61.4 ± 12.6	61.4 ± 12.6	61.3 ± 12.8	61.9 ± 12.2	62.4 ± 11.8	
Saskatchewan						
Sex						
Female	370 (46.0%)	365 (47.1%)	350 (42.4%)	385 (45.6%)	385 (45.6%)	1855 (45.3%)
Male	435 (54.0%)	410 (52.9%)	475 (57.6%)	460 (54.4%)	460 (54.4%)	2240 (54.7%)
Mean age ± SD	59.5 ± 14.6	59.7 ± 14.5	59.4 ± 15	59.4 ± 14.5	60.1 ± 13.7	
Yukon						
Sex						
Female	5 (33.3%)	20 (57.1%)	10 (40.0%)	5 (25.0%)	10 (66.7%)	50 (45.5%)
Male	10 (66.7%)	15 (42.9%)	15 (60.0%)	15 (75.0%)	5 (33.3%)	60 (54.5%)
Mean age ± SD	62.1 ± 8	60.4 ± 10	57.9 ± 14.2	61.7 ± 12.3	62.3 ± 11.4	

Notes: Data was derived from Canadian Vital Statistics Death Dataset. Due to confidentiality reasons, all frequencies were randomly rounded either up or down to a multiple of "5", and the number of institutional mortalities were aggregated for the five-year period before vetting from RDC. * To adhere to confidentiality rules, the number of institutional deaths for territories Yukon, Nunavut, Northwest Territories could not be reported separately. The number of institutional treatable deaths in these territories collectively, is 10 (2.8%).

The all-cause age-standardized mortality rates were increased from 2011 to 2015 in most of the provinces, as shown in Figure 4.6. Among the thirteen provinces and territories, Nunavut had the highest all-cause mortality rates in all investigated years. On the other hand, British Columbia, followed by Ontario and Quebec had the lowest all-cause mortality rates between these years. Table 4.12 provides the age-standardized mortality rates (per 100,000) by type of mortality and province.

Similar to what was found in all-cause mortality, the highest age-standardized premature mortality rate was seen in Nunavut as compared to other provinces and territories, and Ontario, Quebec, and British Columbia had the lowest premature mortality across the years 2011 to 2015. Figure 4.7 presents the age-standardized premature mortality rates per 100,000 population, from 2011 to 2015.

Table 4.12: Age-standardized mortality rates (per 100,000) by province/territory, 2011 to 2015

	2011			2012			2013			2014			2015		
	ASMR	**95% CI**	**SE**	**ASMR**	**95% CI**	**SE**	**ASMR**	**95% CI**	**SE**	**ASMR**	**95% CI**	**SE**	**ASMR**	**95% CI**	**SE**
Alberta															
All Causes mortality	737	725 - 750	6	770	760 - 780	6	810	800 - 820	6	843	830 - 855	6	879	865 - 890	6
Premature mortality	305	295 - 315	6	305	295 - 315	6	310	300 - 320	6	309	300 - 320	6	309	295 - 320	6
Avoidable mortality	228	220 - 240	5	226	215 - 235	5	231	220 - 240	5	232	220 - 240	5	231	220 - 240	5
Preventable mortality	155	145 - 165	4	153	145 - 160	4	156	145 - 165	4	159	150 - 170	4	159	150 - 165	5
Treatable mortality	73	65 - 80	3	73	70 - 80	3	76	70 - 80	3	73	65 - 80	3	72	65 - 80	3
														-	
British Columbia														-	
All Causes mortality	681	670 - 695	7	694	680 - 705	7	711	695 - 725	7	728	715 - 740	7	767	755 - 780	7
Premature mortality	275	260 - 285	6	270	260 - 285	6	273	260 - 285	6	274	260 - 285	6	274	260 - 285	6
Avoidable mortality	198	185 - 210	5	193	185 - 205	5	193	180 - 205	5	194	185 - 205	5	189	180 - 200	5
Preventable mortality	136	125 - 145	5	132	125 - 140	4	132	125 - 140	5	135	125 - 145	5	130	120 - 140	5
Treatable mortality	61	55 - 65	3	61	55 - 65	3	61	55 - 65	3	60	55 - 65	3	59	55 - 65	3
											-			-	
Manitoba											-			-	
All Causes mortality	826	820 - 835	4	824	815 - 830	4	840	835 - 850	4	911	905 - 920	4	932	925 - 940	4
Premature mortality	359	350 - 365	4	357	350 - 365	4	357	350 - 365	4	361	355 - 370	4	352	345 - 360	4
Avoidable mortality	260	255 - 265	3	254	250 - 260	3	255	250 - 260	3	262	255 - 270	3	252	245 - 260	3
Preventable mortality	170	165 - 175	3	166	160 - 170	3	164	160 - 170	3	168	165 - 175	3	163	160 - 170	3
Treatable mortality	89	85 - 95	2	88	85 - 90	2	92	90 - 95	2	94	90 - 100	2	89	85 - 90	2
											-			-	

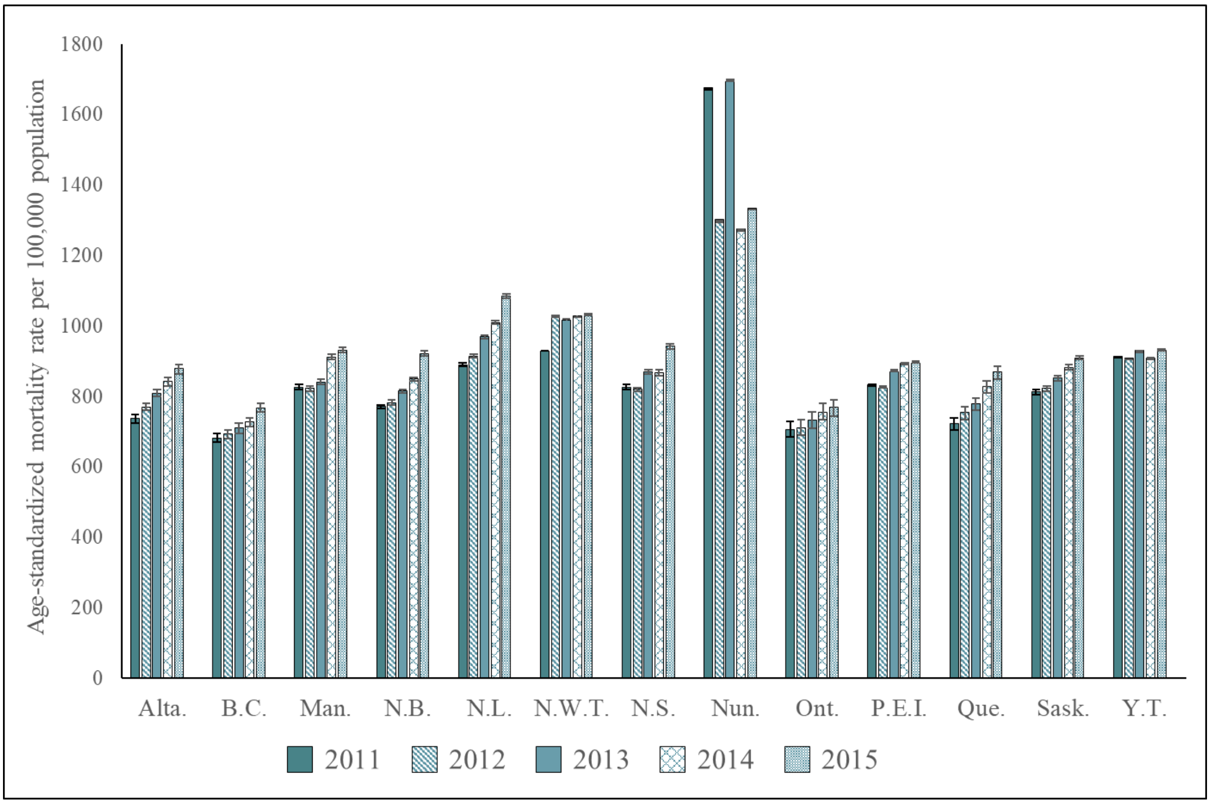
New Brunswick											-			-	
All Causes mortality	771	765 - 775	3	783	775 - 790	3	816	810 - 820	3	851	845 - 855	3	922	915 - 930	3
Premature mortality	311	305 - 315	3	323	315 - 330	3	314	310 - 320	3	325	320 - 330	3	339	335 - 345	3
Avoidable mortality	218	215 - 220	2	220	215 - 225	2	209	205 - 215	2	228	225 - 235	2	232	225 - 235	2
Preventable mortality	147	145 - 150	2	152	150 - 155	2	142	140 - 145	2	157	155 - 160	2	157	155 - 160	2
Treatable mortality	71	70 - 75	1	68	65 - 70	1	67	65 - 70	1	72	70 - 75	1	75	70 - 75	1
											-			-	
Newfoundland and Labrador											-			-	
All Causes mortality	889	885 - 895	3	915	910 - 920	3	969	965 - 975	3	1009	1005 - 1015	3	1085	1080 - 1090	3
Premature mortality	341	335 - 345	2	356	350 - 360	3	358	355 - 365	3	358	355 - 365	3	355	350 - 360	3
Avoidable mortality	234	230 - 240	2	254	250 - 260	2	248	245 - 250	2	257	255 - 260	2	256	250 - 260	2
Preventable mortality	145	140 - 150	2	157	155 - 160	2	156	155 - 160	2	163	160 - 165	2	165	160 - 170	2
Treatable mortality	88	85 - 90	1	97	95 - 100	1	92	90 - 95	1	94	90 - 95	1	92	90 - 95	1
											-			-	
Northwest Territories											-			-	
All Causes mortality	929	930 - 930	1	1027	1025 - 1030	1	1016	1020 - 1020	1	1030	1025 - 1025	1	1032	1030 - 1035	1
Premature mortality	431	430 - 430	1	456	455 - 460	1	420	415 - 415	1	408	405 - 410	1	384	385 - 390	1
Avoidable mortality	295	295 - 295	1	333	330 - 330	1	321	315 - 320	1	322	325 - 330	1	285	285 - 285	1
Preventable mortality	197	200 - 200	0	234	235 - 235	1	222	220 - 220	1	210	210 - 215	1	211	210 - 210	1
Treatable mortality	98	95 - 100	0	99	95 - 95	0	99	100 - 100	0	111	115 - 115	0	74	75 - 75	0
											-			-	
Nova Scotia											-			-	
All Causes mortality	827	820 - 835	3	820	815 - 825	4	870	865 - 875	4	868	860 - 875	4	944	935 - 950	4
Premature mortality	346	340 - 350	3	342	335 - 350	3	342	335 - 350	3	337	330 - 345	3	347	340 - 355	3
Avoidable mortality	249	245 - 255	3	247	240 - 250	3	248	245 - 255	3	245	240 - 250	3	245	240 - 250	3

Preventable mortality	163	160 - 165	2	163	160 - 170	2	163	160 - 170	2	165	160 - 170	2	162	155 - 165	2
Treatable mortality	86	85 - 90	2	83	80 - 85	2	85	80 - 90	2	80	75 - 85	2	83	80 - 85	2
											-			-	
Nunavut											-			-	
All Causes mortality	1677	1670 - 1675	1	1302	1295 - 1300	1	1693	1695 - 1700	1	1275	1270 - 1275	1	1334	1330 - 1330	1
Premature mortality	728	725 - 730	1	634	635 - 635	1	696	695 - 695	1	651	655 - 660	1	623	620 - 620	1
Avoidable mortality	554	550 - 555	1	526	520 - 525	1	590	590 - 595	1	518	520 - 525	1	507	510 - 510	1
Preventable mortality	443	445 - 445	1	433	435 - 435	1	423	430 - 430	1	429	425 - 425	1	362	365 - 365	1
Treatable mortality	111	105 - 105	0	93	90 - 90	0	166	160 - 165	0	104	95 - 95	0	145	145 - 145	0
											-			-	
Ontario											-			-	
All Causes mortality	707	685 - 730	11	712	690 - 735	11	733	710 - 755	11	755	735 - 780	12	769	745 - 790	12
Premature mortality	285	265 - 305	11	281	260 - 300	11	279	260 - 300	11	280	260 - 300	11	277	255 - 300	11
Avoidable mortality	205	185 - 225	9	203	185 - 220	9	202	185 - 220	9	201	185 - 220	9	199	180 - 215	9
Preventable mortality	134	120 - 150	7	133	120 - 150	7	134	120 - 150	8	131	115 - 145	8	130	115 - 145	8
Treatable mortality	71	60 - 80	5	70	60 - 80	5	68	55 - 80	5	70	60 - 80	5	68	60 - 80	5
											-			-	
Prince Edward Island											-			-	
All Causes mortality	834	830 - 835	1	824	825 - 830	1	871	870 - 875	1	894	890 - 895	1	894	895 - 900	1
Premature mortality	327	325 - 330	1	342	340 - 345	1	327	325 - 330	1	296	295 - 300	1	277	275 - 280	1
Avoidable mortality	238	235 - 240	1	250	250 - 255	1	231	230 - 235	1	200	200 - 200	1	189	185 - 190	1
Preventable mortality	158	155 - 160	1	158	155 - 160	1	150	150 - 150	1	131	130 - 135	1	131	130 - 130	1
Treatable mortality	81	80 - 80	1	92	90 - 95	1	81	80 - 85	1	69	65 - 70	1	58	55 - 60	1
											-			-	
Quebec											-			-	

All Causes mortality	724	705 - 740	9	754	735 - 770	9	779	760 - 795	9	828	810 - 845	9	869	850 - 885	9
Premature mortality	296	280 - 315	9	291	275 - 310	9	286	270 - 305	9	284	265 - 300	9	283	265 - 300	9
Avoidable mortality	214	200 - 230	7	210	195 - 225	7	206	190 - 220	7	203	190 - 215	7	202	190 - 215	7
Preventable mortality	146	135 - 160	6	144	130 - 155	6	141	130 - 155	6	138	125 - 150	6	139	125 - 150	6
Treatable mortality	67	60 - 75	4	66	60 - 75	4	65	55 - 75	4	65	55 - 75	4	63	55 - 70	4
											-			-	
Saskatchewan											-			-	
All Causes mortality	814	805 - 820	4	823	815 - 830	4	854	845 - 860	4	881	875 - 890	4	910	905 - 915	4
Premature mortality	365	360 - 370	3	356	350 - 360	3	366	360 - 375	3	374	365 - 380	3	379	375 - 385	3
Avoidable mortality	269	265 - 275	3	254	250 - 260	3	266	260 - 270	3	274	270 - 280	3	255	250 - 260	3
Preventable mortality	179	175 - 185	2	168	165 - 175	2	175	170 - 180	2	183	180 - 190	2	166	160 - 170	2
Treatable mortality	90	85 - 95	2	86	80 - 90	2	90	85 - 95	2	91	90 - 95	2	90	85 - 95	2
											-			-	
Yukon											-			-	
All Causes mortality	915	910 - 910	1	908	905 - 905	1	931	925 - 930	1	910	905 - 910	1	932	930 - 935	1
Premature mortality	396	395 - 395	1	438	435 - 440	1	420	420 - 425	1	388	385 - 390	1	400	400 - 405	1
Avoidable mortality	243	245 - 245	1	333	335 - 335	1	285	290 - 290	1	283	280 - 280	1	208	205 - 205	0
Preventable mortality	198	190 - 195	0	242	240 - 240	0	210	210 - 210	1	224	220 - 220	0	148	150 - 155	0
Treatable mortality	61	55 - 55	0	91	95 - 95	0	75	80 - 80	0	60	60 - 60	0	59	55 - 55	0

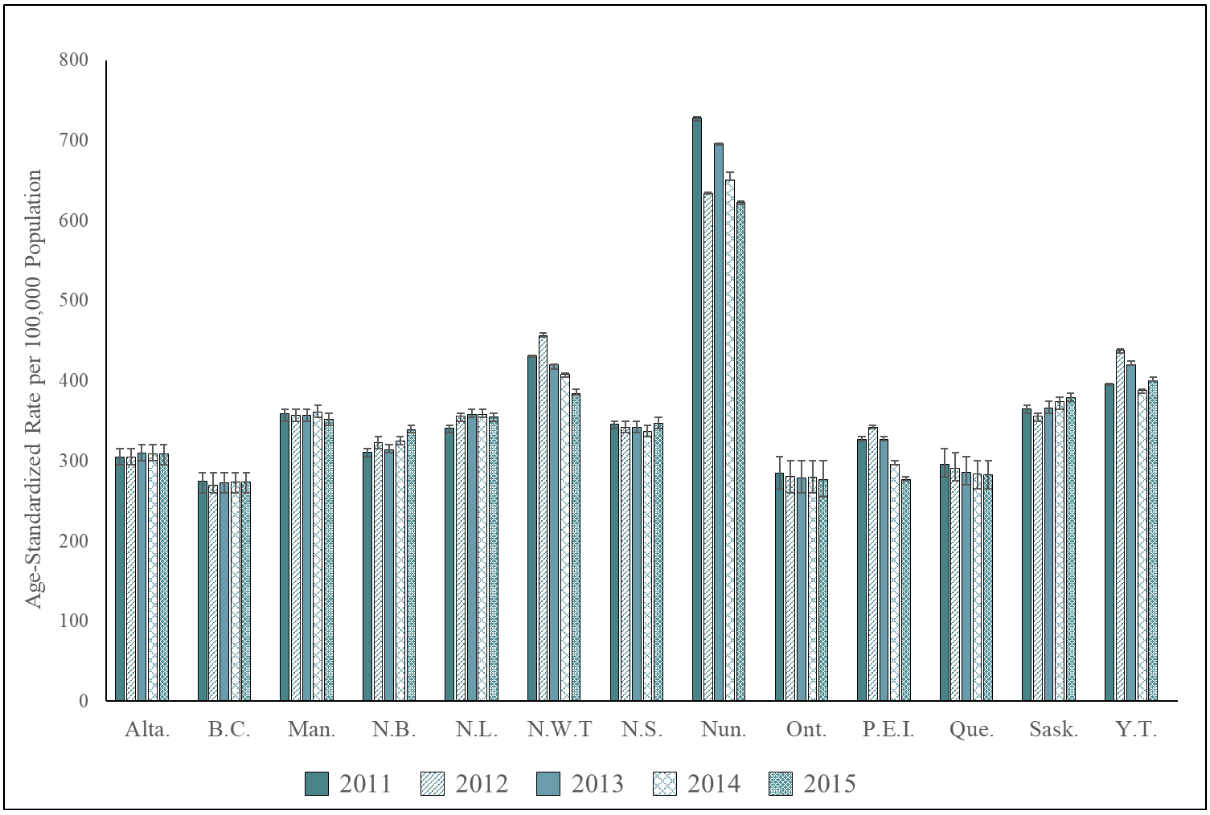
Notes: Data was derived from Canadian Vital Statistics Death Dataset. Due to confidentiality reasons, the numerators, denominators, and confidence intervals were randomly rounded either up or down to a multiple of "5".

Figure 4.6: Age-standardized all-cause mortality rates by province/territory, 2011 to 2015



Notes: 工 represents 95% confidence interval. Data is derived from CVSD. Non-Canadian residents are excluded.

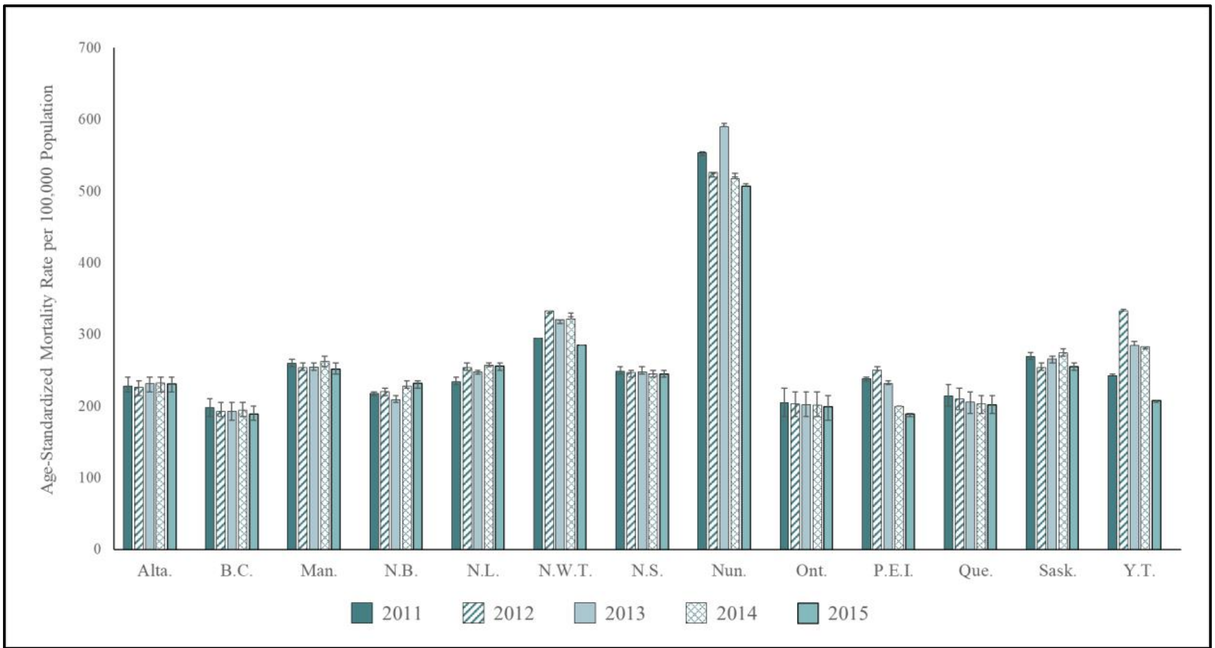
Figure 4.7: Age-standardized premature mortality rates (per 100,000) by province/territory, 2011 to 2015



Notes: 工 represents 95% confidence interval. Data is derived from CVSD. Non-Canadian residents are excluded.

Figure 4.8 shows the age-standardized avoidable mortality rate by province and territory, from 2011 to 2015. Again, the highest rate was seen in Nunavut, and the lowest mortality rates, on the other hand, were seen in Ontario, British Columbia, and Quebec.

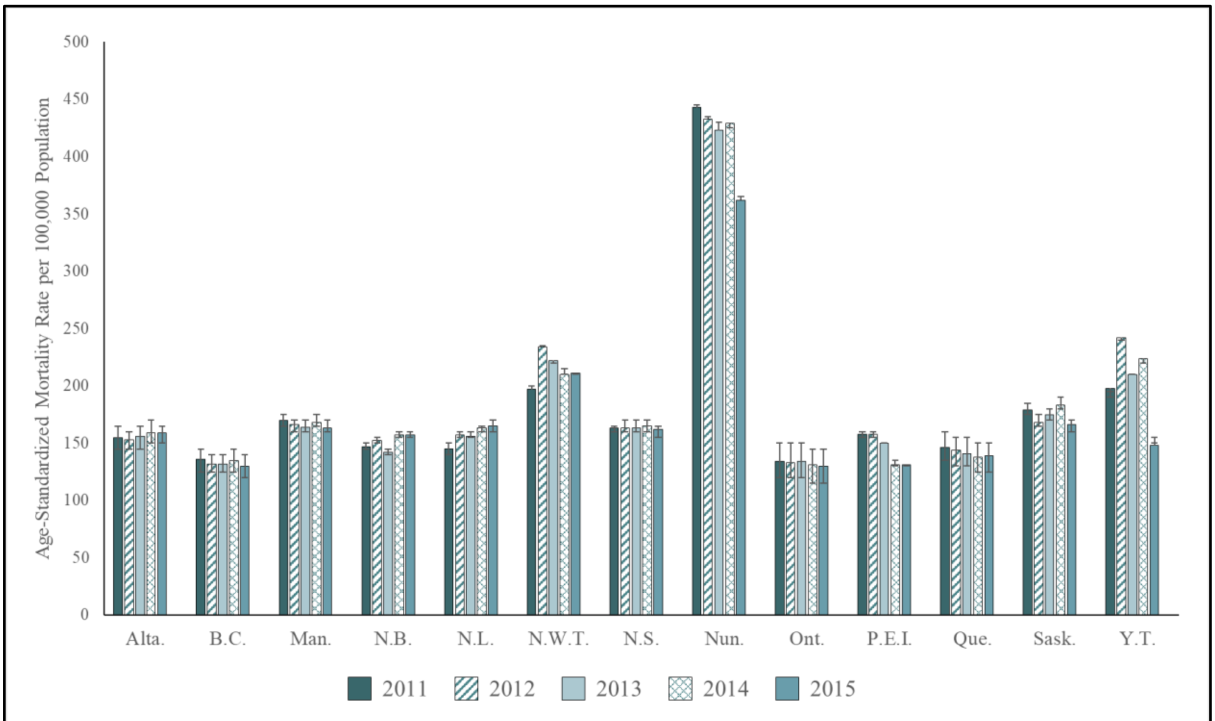
Figure 4.8: Age-standardized avoidable mortality rate by province/territory, 2011 to 2015



Notes: Data is derived from CVSD. Non-Canadian residents are excluded.

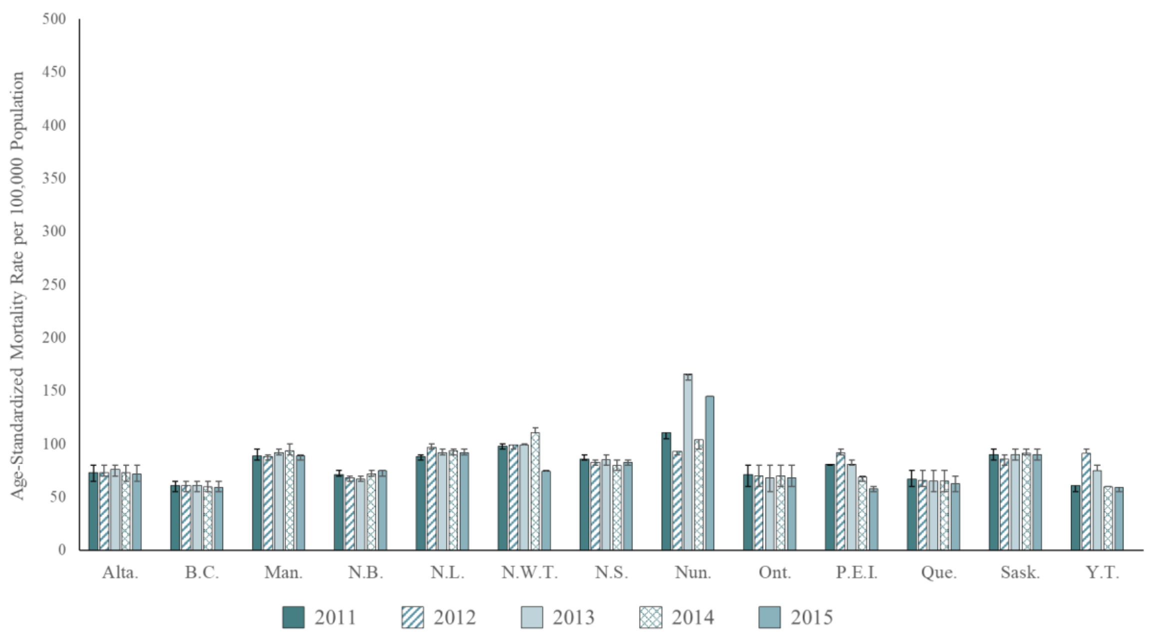
Figures 4.9 and 4.10 show the age-standardized mortality rates from preventable and treatable causes. As seen in these figures, over the years 2011 to 2015, mortality rates due to preventable causes were twice the mortality rates attributable to treatable causes across all provinces and territories. This difference between preventable and treatable mortality rates was seen even to a greater extent in Nunavut (almost four times higher) and in Yukon (almost three times higher).

Figure 4.9: Age-standardized preventable mortality rate by province/territory, 2011 to 2015



Notes: Data is derived from CVSD. Non-Canadian residents are excluded.

Figure 4.10: Age-standardized treatable mortality rate by province/territory, 2011 to 2015



Notes: Data is derived from CVSD. Non-Canadian residents are excluded.

4.2.1.1 Mortality rates across the eight most populous cities in 2011-2015

Table 4.13 illustrates the characteristics of all decedents, from 2011 to 2015, across the eight most populous cities in Canada. In all the examined CMAs, the number of all-cause deaths was virtually equal among men and women. The mean age at the time of death was slightly lower in Calgary (73.3, 73, 73, 73.4, 73.2 from 2011 to 2015 respectively) and Edmonton (72.9, 73.7, 73.3, 73.2, 72.7 from 2011 to 2015 respectively) compared to other cities and the national age at the time of death (75.3, 75.5, 75.7, 75.8, 76 from 2011 to 2015 respectively).

Table 4.13: Characteristics of decedents in all-cause mortality by CMA, 2011 to 2015

	All-cause Mortality					
	Number of decedents in each year (percent of total decedents)					
	2011	**2012**	**2013**	**2014**	**2015**	**2011-2015**
Calgary						
Sex						
Female	2660 (49.4%)	2850 (48.6%)	3025 (49.0%)	3020 (49.7%)	3110 (48.7%)	14665 (49.1%)
Male	2730 (50.6%)	3010 (51.4%)	3150 (51.0%)	3055 (50.3%)	3275 (51.3%)	15220 (50.9%)
Mean age ± SD	73.3 ± 18.8	73 ± 19.2	73 ± 19.6	73.4 ± 19.3	73.2 ± 19.4	
Edmonton						
Sex						
Female	3150 (48.3%)	3400 (48.6%)	3485 (48.0%)	3610 (47.9%)	3580 (47.2%)	17225 (48.0%)
Male	3370 (51.7%)	3595 (51.4%)	3770 (52.0%)	3925 (52.1%)	4000 (52.8%)	18660 (52.0%)
Mean age ± SD	72.9 ± 19	73.7 ± 18.3	73.3 ± 19	73.2 ± 19.1	72.7 ± 19.3	
Montreal						
Sex						
Female	13630 (51.7%)	13835 (51.5%)	14095 (52.4%)	14300 (51.8%)	14410 (51.2%)	70270 (51.7%)

Male	12740 (48.3%)	13055 (48.5%)	12810 (47.6%)	13285 (48.2%)	13730 (48.8%)	65620 (48.3%)
Mean age ± SD	75.9 ± 16.2	76.1 ± 16.2	76.4 ± 16	76.7 ± 16	76.8 ± 15.8	
Ottawa-gatineau						
Sex						
Female	3780 (51.5%)	3930 (51.5%)	3985 (51.1%)	4140 (51.2%)	4175 (50.9%)	20010 (51.2%)
Male	3565 (48.5%)	3700 (48.5%)	3820 (48.9%)	3940 (48.8%)	4030 (49.1%)	19055 (48.8%)
Mean age ± SD	74.9 ± 17.3	75.3 ± 17.1	75.6 ± 17.1	76 ± 16.4	76.1 ± 16.7	
Quebec						
Sex						
Female	2970 (52.6%)	2955 (52.4%)	3080 (53.0%)	3185 (53.7%)	3095 (52.8%)	15285 (52.9%)
Male	2680 (47.4%)	2685 (47.6%)	2735 (47.0%)	2750 (46.3%)	2770 (47.2%)	13620 (47.1%)
Mean age ± SD	76.3 ± 15.9	76.7 ± 15.6	76.6 ± 16.2	77.3 ± 15.5	77.2 ± 15.6	
Toronto						
Sex						
Female	13820 (49.1%)	14685 (49.9%)	15235 (49.5%)	15615 (49.3%)	15695 (49.3%)	75050 (49.4%)
Male	14335 (50.9%)	14755 (50.1%)	15550 (50.5%)	16075 (50.7%)	16125 (50.7%)	76840 (50.6%)
Mean age ± SD	75.3 ± 17.6	75.3 ± 17.7	76 ± 17.4	76 ± 17.4	76.2 ± 17.4	
Vancouver						
Sex						
Female	6800 (49.7%)	6780 (49.1%)	6980 (49.3%)	7135 (49.1%)	7415 (49.1%)	35110 (49.3%)
Male	6890 (50.3%)	7030 (50.9%)	7175 (50.7%)	7395 (50.9%)	7685 (50.9%)	36175 (50.7%)
Mean age ± SD	76.2 ± 17	76.4 ± 17.1	76.3 ± 17	76.6 ± 17	76.6 ± 17	
Winnipeg						
Sex						
Female	3115 (52.5%)	3105 (52.5%)	2985 (51.1%)	3225 (51.6%)	3265 (52.1%)	15695 (52.0%)
Male	2820 (47.5%)	2805 (47.5%)	2860 (48.9%)	3030 (48.4%)	3000 (47.9%)	14515 (48.0%)
Mean age ± SD	76 ± 17.5	75.7 ± 17.5	75.8 ± 17.6	76 ± 17.6	76.4 ± 17.3	

Notes: Data was derived from Canadian Vital Statistics Death Dataset. Due to confidentiality reasons, all frequencies were randomly rounded either up or down to a multiple of "5", and the number of institutional mortalities were aggregated for the five-year period prior to vetting from RDC.

Table 4.14 shows the characteristics of decedents who died before the age of 75, in the eight most populous cities in Canada. The sex gap in premature mortality exists in all the cities but to different extents; Montreal had the lowest difference between the number of premature deaths among men (36,040 (54.2%)) and women (30,460 (45.8%)), whereas the highest difference was found in Vancouver (15,675 (61.1%) men vs. 9,965 (38.9%) women). Edmonton, Montreal, and Vancouver experienced a noticeable variation in the mean age at the time of death across the years 2011 to 2015. In Edmonton, the mean age at the time of death was 72.9 and 73.7 in 2011 and 2012, which decreased to 56.6, 56.2, 55.9 in 2013, 2014, and 2015 respectively. A similar fluctuation in the mean age was seen in Vancouver and Montreal.

Table 4.14: Characteristics of decedents in premature mortality by CMA, 2011 to 2015

Premature Mortality						
	Number of decedents in each year (percent of total decedents)					
	2011	**2012**	**2013**	**2014**	**2015**	**2011-2015**
Calgary						
Sex						
Female	865 (38.4%)	1000 (39.9%)	1035 (39.4%)	1015 (39.6%)	1075 (39.7%)	4990 (39.4%)
Male	1385 (61.6%)	1505 (60.1%)	1590 (60.6%)	1550 (60.4%)	1635 (60.3%)	7665 (60.6%)
Mean age ± SD	55.8 ± 16.3	55.7 ± 17	55.4 ± 17.5	55.8 ± 17.2	55.6 ± 17.1	
Edmonton						
Sex						
Female	3150 (39.5%)	1155 (39.8%)	1240 (39.6%)	1260 (38.7%)	1300 (38.9%)	8105 (42.3%)
Male	3370 (60.5%)	1750 (60.2%)	1895 (60.4%)	2000 (61.3%)	2045 (61.1%)	11060 (57.7%)
Mean age ± SD	72.9 ± 16.8	73.7 ± 16.2	56.6 ± 17.1	56.2 ± 16.6	55.9 ± 16.8	
Montreal						
Sex						
Female	4075 (41.6%)	13835 (41.8%)	4070 (41.9%)	4160 (42.0%)	4320 (42.3%)	30460 (45.8%)
Male	5710 (58.4%)	13055 (58.2%)	5635 (58.1%)	5755 (58.0%)	5885 (57.7%)	36040 (54.2%)
Mean age ± SD	59.6 ± 14.7	76.1 ± 14.8	59.8 ± 14.6	60 ± 14.4	60.5 ± 14.2	
Ottawa-Gatineau						
Sex						
Female	1180 (41.4%)	1270 (42.5%)	1240 (41.0%)	1305 (42.0%)	1335 (42.4%)	6330 (41.9%)
Male	1670 (58.6%)	1715 (57.5%)	1785 (59.0%)	1800 (58.0%)	1810 (57.6%)	8780 (58.1%)
Mean age ± SD	58 ± 15.4	58.6 ± 15	58.7 ± 15.1	59.6 ± 14	59.4 ± 14.6	
Quebec						
Sex						
Female	820 (39.7%)	805 (40.3%)	875 (42.1%)	870 (42.5%)	865 (42.0%)	4235 (41.3%)
Male	1245 (60.3%)	1195 (59.8%)	1205 (57.9%)	1175 (57.5%)	1195 (58.0%)	6015 (58.7%)
Mean age ± SD	59.9 ± 14.2	60.3 ± 13.9	59.7 ± 14.8	60.8 ± 14.2	60.8 ± 14.2	
Toronto						
Sex						
Female	4110 (39.6%)	4435 (40.4%)	4480 (40.3%)	4570 (39.8%)	4565 (40.1%)	22160 (40.1%)
Male	6270 (60.4%)	6540 (59.6%)	6630 (59.7%)	6910 (60.2%)	6820 (59.9%)	33170 (59.9%)
Mean age ± SD	57.4 ± 16.4	57.4 ± 16.3	58 ± 16.1	57.8 ± 15.9	58 ± 15.9	
Vancouver						

Sex						
Female	1950 (39.6%)	1895 (38.8%)	1975 (38.4%)	2035 (38.9%)	2110 (38.6%)	9965 (38.9%)
Male	2975 (60.4%)	2985 (61.2%)	3165 (61.6%)	3200 (61.1%)	3350 (61.4%)	15675 (61.1%)
Mean age ± SD	76.2 ± 15	58.1 ± 15.2	58.5 ± 14.8	58.5 ± 14.9	58.7 ± 14.8	
Winnipeg						
Sex						
Female	855 (39.9%)	915 (42.0%)	910 (40.6%)	960 (41.0%)	965 (42.1%)	4605 (41.1%)
Male	1290 (60.1%)	1265 (58.0%)	1330 (59.4%)	1380 (59.0%)	1325 (57.9%)	6590 (58.9%)
Mean age ± SD	57.7 ± 15.8	57.5 ± 15.3	58.2 ± 15.5	58.1 ± 15.4	58.4 ± 15.2	

Notes: Data was derived from Canadian Vital Statistics Death Dataset. Due to confidentiality reasons, all frequencies were randomly rounded either up or down to a multiple of "5", and the number of institutional mortalities were aggregated for the five-year period before vetting from RDC.

Table 4.15 illustrates the characteristics of all decedents who died before the age of 75 and due to avoidable causes of death in the eight most populous cities in Canada. Similar to premature mortality, in all CMAs, men were more likely to die due to avoidable causes of death compared to women. Calgary and Edmonton had relatively lower mean age in avoidable mortality compared to other cities.

Table 4.15: Characteristics of decedents in avoidable mortality by CMA, 2011 to 2015

Avoidable Mortality						
Number of decedents in each year (percent of total decedents)						
	2011	**2012**	**2013**	**2014**	**2015**	**2011-2015**
Calgary						
Sex						
Female	615 (36.5%)	715 (38.2%)	740 (37.7%)	735 (38.1%)	775 (38.5%)	3580 (37.8%)
Male	1070 (63.5%)	1155 (61.8%)	1225 (62.3%)	1195 (61.9%)	1240 (61.5%)	5885 (62.2%)
Mean age ± SD	55 ± 16.6	54.9 ± 17.3	54.5 ± 17.8	55 ± 17.3	54.4 ± 17.5	
Edmonton						
Sex						
Female	820 (38.9%)	835 (38.3%)	890 (37.6%)	900 (37.6%)	950 (38.1%)	4395 (38.1%)
Male	1290 (61.1%)	1345 (61.7%)	1475 (62.4%)	1495 (62.4%)	1545 (61.9%)	7150 (61.9%)
Mean age ± SD	55.6 ± 17	56 ± 16.4	55.9 ± 17.3	55.2 ± 16.9	54.6 ± 17.3	
Montreal						
Sex						
Female	2855 (41.6%)	2925 (41.4%)	2880 (41.4%)	2970 (42.2%)	3045 (42.3%)	14675 (41.5%)
Male	4195 (58.4%)	4140 (58.6%)	4080 (58.6%)	4070 (57.8%)	4160 (57.7%)	20645 (58.5%)
Mean age ± SD	58.9 ± 15.4	58.9 ± 15.4	59.2 ± 15.1	59.3 ± 15.2	59.7 ± 15	
Ottawa-Gatineau						
Sex						
Female	845 (41.4%)	880 (41.2%)	870 (40.4%)	880 (40.9%)	975 (42.5%)	4450 (41.1%)
Male	1245 (58.6%)	1255 (58.8%)	1285 (59.6%)	1270 (59.1%)	1320 (57.5%)	6375 (58.9%)
Mean age ± SD	57.3 ± 15.9	57.9 ± 15.5	57.8 ± 15.8	59.3 ± 14.4	59 ± 14.9	

Quebec						
Sex						
Female	600 (39.7%)	545 (39.8%)	635 (42.9%)	600 (42.3%)	625 (42.5%)	3005 (41.6%)
Male	875 (60.3%)	825 (60.2%)	845 (57.1%)	820 (57.7%)	845 (57.5%)	4210 (58.4%)
Mean age ± SD	59 ± 14.9	59.5 ± 14.9	58.8 ± 15.3	59.9 ± 15.1	59.9 ± 14.8	
Toronto						
Sex						
Female	2820 (39.6%)	3085 (39.3%)	3090 (38.9%)	3110 (37.7%)	3125 (38.6%)	15230 (38.5%)
Male	4580 (60.4%)	4760 (60.7%)	4845 (61.1%)	5135 (62.3%)	4975 (61.4%)	24295 (61.5%)
Mean age ± SD	56.8 ± 16.9	56.5 ± 17	57.1 ± 16.7	56.8 ± 16.6	57.2 ± 16.6	
Vancouver						
Sex						
Female	1380 (39.6%)	1335 (37.7%)	1355 (37.4%)	1385 (37.7%)	1415 (37.8%)	6870 (37.9%)
Male	2175 (60.4%)	2210 (62.3%)	2265 (62.6%)	2290 (62.3%)	2325 (62.2%)	11265 (62.1%)
Mean age ± SD	57.7 ± 15.3	57.5 ± 15.5	58 ± 15.1	57.7 ± 15.2	58.5 ± 14.7	
Winnipeg						
Sex						
Female	580 (39.9%)	635 (40.7%)	625 (39.1%)	675 (40.3%)	660 (40.7%)	3175 (39.7%)
Male	955 (60.1%)	925 (59.3%)	975 (60.9%)	1000 (59.7%)	960 (59.3%)	4815 (60.3%)
Mean age ± SD	57 ± 16.1	56.6 ± 15.8	57.3 ± 16	57.2 ± 16	57.4 ± 15.7	

Notes: Data was derived from Canadian Vital Statistics Death Dataset. Due to confidentiality reasons, all frequencies were randomly rounded either up or down to a multiple of "5", and the number of institutional mortalities were aggregated for the five-year period before vetting from RDC.

Table 4.16 shows the characteristics of decedents who died before the age of 75 and due to preventable conditions in the eight most populous cities in Canada. A more pronounced sex gap was seen in the number of preventable deaths as compared to premature and avoidable mortality; men were twice as likely to die due to preventable conditions compared to women in all the eight CMAs.

Table 4.16: Characteristics of decedents in preventable mortality by CMA, 2011 to 2015

	Preventable Mortality					
	Number of decedents in each year (percent of total decedents)					
	2011	**2012**	**2013**	**2014**	**2015**	**2011-2015**
Calgary						
Sex						
Female	370 (32.2%)	410 (33.5%)	440 (33.3%)	455 (34.0%)	470 (33.7%)	2145 (33.4%)
Male	780 (67.8%)	815 (66.5%)	880 (66.7%)	885 (66.0%)	925 (66.3%)	4285 (66.6%)
Mean age ± SD	55 ± 16.3	54 ± 17.5	53.9 ± 18.1	54.6 ± 17.3	54.2 ± 17.5	
Edmonton						
Sex						

Female	520 (36.2%)	545 (36.1%)	545 (34.0%)	560 (34.4%)	590 (34.2%)	2760 (34.9%)
Male	915 (63.8%)	965 (63.9%)	1060 (66.0%)	1070 (65.6%)	1135 (65.8%)	5145 (65.1%)
Mean age ± SD	55.4 ± 16.9	55.7 ± 16.4	55.6 ± 17.2	54.8 ± 17	54.2 ± 17.3	
Montreal						
Sex						
Female	1730 (36.9%)	1785 (38.0%)	1735 (37.4%)	1770 (38.1%)	1875 (38.6%)	8895 (37.8%)
Male	2955 (63.1%)	2915 (62.0%)	2905 (62.6%)	2880 (61.9%)	2985 (61.4%)	14640 (62.2%)
Mean age ± SD	58.8 ± 15.4	59 ± 15.2	59.1 ± 15.2	59.3 ± 15.1	59.7 ± 15	
Ottawa-Gatineau						
Sex						
Female	520 (37.4%)	510 (36.3%)	510 (35.9%)	500 (36.0%)	600 (39.2%)	2640 (37.0%)
Male	870 (62.6%)	895 (63.7%)	910 (64.1%)	890 (64.0%)	930 (60.8%)	4495 (63.0%)
Mean age ± SD	57.3 ± 15.7	58 ± 15.3	57.5 ± 16.1	59.4 ± 14.5	58.8 ± 15.2	
Quebec						
Sex						
Female	380 (36.7%)	350 (37.2%)	415 (40.5%)	365 (38.0%)	390 (39.0%)	1900 (38.3%)
Male	655 (63.3%)	590 (62.8%)	610 (59.5%)	595 (62.0%)	610 (61.0%)	3060 (61.7%)
Mean age ± SD	58.8 ± 15	59.5 ± 15	59.1 ± 14.9	59.7 ± 14.9	59.4 ± 15.2	
Toronto						
Sex						
Female	1550 (32.7%)	1665 (33.5%)	1715 (33.7%)	1700 (32.4%)	1700 (32.8%)	8330 (33.0%)
Male	3195 (67.3%)	3305 (66.5%)	3380 (66.3%)	3550 (67.6%)	3485 (67.2%)	16915 (67.0%)
Mean age ± SD	56.7 ± 17	56.4 ± 17.1	57.1 ± 16.6	56.6 ± 16.7	57.1 ± 16.6	
Vancouver						
Sex						
Female	845 (35.1%)	775 (32.2%)	790 (32.8%)	800 (32.7%)	800 (32.0%)	4010 (33.0%)
Male	1560 (64.9%)	1630 (67.8%)	1615 (67.2%)	1645 (67.3%)	1700 (68.0%)	8150 (67.0%)
Mean age ± SD	57.6 ± 15.2	57.3 ± 15.8	57.9 ± 14.9	57.9 ± 14.8	58.3 ± 14.7	
Winnipeg						
Sex						
Female	330 (33.3%)	395 (38.9%)	360 (35.1%)	395 (37.1%)	370 (35.9%)	1850 (36.1%)
Male	660 (66.7%)	620 (61.1%)	665 (64.9%)	670 (62.9%)	660 (64.1%)	3275 (63.9%)
Mean age ± SD	56.6 ± 16.1	56.3 ± 15.8	57.2 ± 15.9	56.8 ± 16.2	57.3 ± 15.6	

Notes: Data was derived from Canadian Vital Statistics Death Dataset. Due to confidentiality reasons, all frequencies were randomly rounded either up or down to a multiple of "5", and the number of institutional mortalities were aggregated for the five-year period before vetting from RDC.

Table 4.17 presents the characteristics of decedents in the eight most populous cities in Canada who died before the age of 75 and due to treatable causes of death. Similar to what was seen in the national- and provincial-level results, the sex gap in the number of deaths attenuated in deaths attributable to treatable conditions compared to premature, avoidable, and preventable mortalities. The mean age at the time of death is approximately equal across the eight CMAs.

Table 4.17: Characteristics of decedents in treatable mortality by CMA, 2011 to 2015

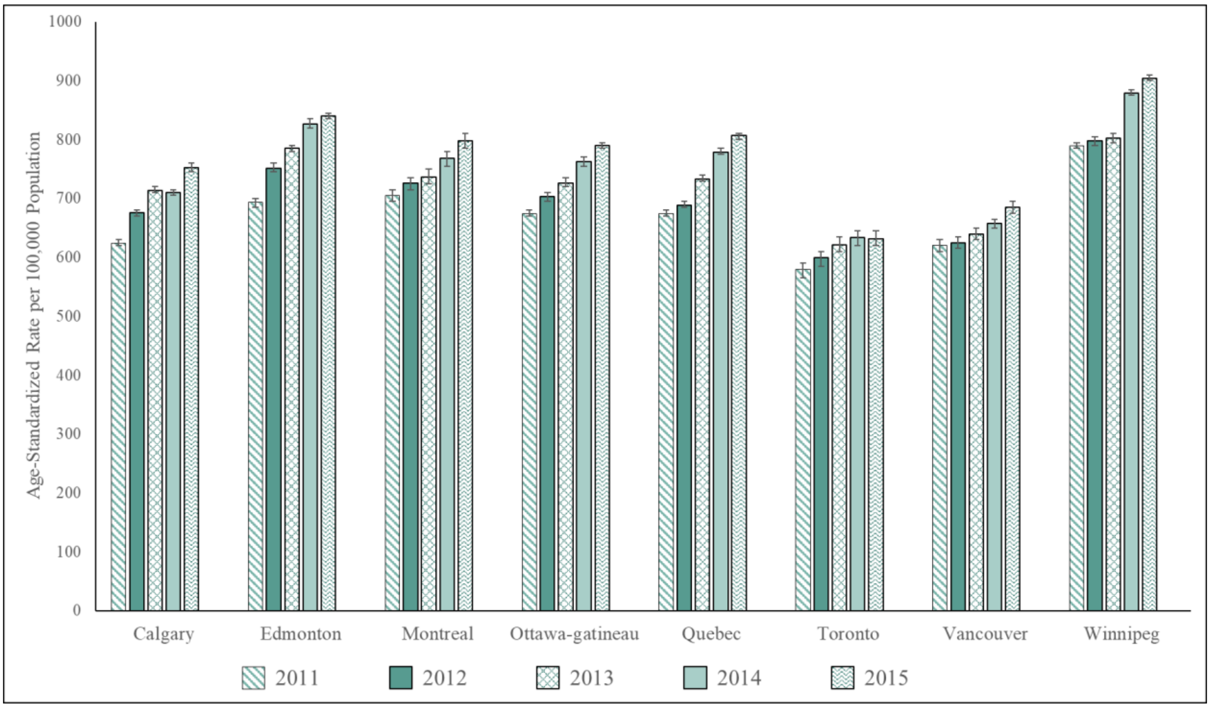
	Treatable Mortality					
	Number of decedents in each year (percent of total decedents)					
	2011	**2012**	**2013**	**2014**	**2015**	**2011-2015**
Calgary						
Sex						
Female	245 (46.2%)	305 (47.3%)	300 (50.0%)	275 (47.0%)	305 (48.8%)	1430 (47.9%)
Male	285 (53.8%)	340 (52.7%)	300 (50.0%)	310 (53.0%)	320 (51.2%)	1555 (52.1%)
Mean age ± SD	58.5 ± 14.5	59.9 ± 13.5	59.3 ± 13.8	60.2 ± 14	58.8 ± 14.5	
Edmonton						
Sex						
Female	305 (44.9%)	285 (42.9%)	345 (45.4%)	345 (44.8%)	360 (46.8%)	1640 (45.0%)
Male	375 (55.1%)	380 (57.1%)	415 (54.6%)	425 (55.2%)	410 (53.2%)	2005 (55.0%)
Mean age ± SD	59.5 ± 13.6	59.8 ± 13.2	60.1 ± 14.1	59.2 ± 13.3	59.5 ± 13.7	
Montreal						
Sex						
Female	1120 (47.5%)	1140 (48.2%)	1145 (49.4%)	1200 (50.2%)	1175 (50.0%)	5780 (49.0%)
Male	1240 (52.5%)	1225 (51.8%)	1175 (50.6%)	1190 (49.8%)	1175 (50.0%)	6005 (51.0%)
Mean age ± SD	61.2 ± 13	60.8 ± 13.2	61.3 ± 12.6	61.4 ± 13	62.1 ± 12.2	
Ottawa-Gatineau						
Sex						
Female	325 (46.4%)	370 (50.7%)	360 (49.0%)	380 (50.0%)	375 (48.7%)	1810 (49.0%)
Male	375 (53.6%)	360 (49.3%)	375 (51.0%)	380 (50.0%)	395 (51.3%)	1885 (51.0%)
Mean age ± SD	60.1 ± 13.2	60.2 ± 13	60.9 ± 12.3	61.3 ± 11.8	61.7 ± 11.5	
Quebec						
Sex						
Female	220 (50.0%)	195 (45.3%)	225 (48.4%)	235 (51.1%)	235 (50.0%)	1110 (49.0%)
Male	220 (50.0%)	235 (54.7%)	240 (51.6%)	225 (48.9%)	235 (50.0%)	1155 (51.0%)
Mean age ± SD	61.5 ± 12.1	61.5 ± 12.3	60.7 ± 13.7	62.3 ± 13	62.5 ± 11.8	
Toronto						
Sex						
Female	1265 (47.7%)	1420 (49.4%)	1380 (48.4%)	1410 (47.1%)	1425 (48.9%)	6900 (48.3%)
Male	1385 (52.3%)	1455 (50.6%)	1470 (51.6%)	1585 (52.9%)	1490 (51.1%)	7385 (51.7%)
Mean age ± SD	59.9 ± 13.7	59.9 ± 13.5	60.1 ± 13.6	60.3 ± 13.3	60.3 ± 13.6	

Vancouver						
Sex						
Female	535 (46.7%)	560 (48.9%)	565 (46.5%)	585 (47.8%)	615 (49.6%)	2860 (47.9%)
Male	610 (53.3%)	585 (51.1%)	650 (53.5%)	640 (52.2%)	625 (50.4%)	3110 (52.1%)
Mean age ± SD	60.7 ± 12.8	60.7 ± 12.1	61.3 ± 12.9	60.3 ± 13.7	61.3 ± 12.7	
Winnipeg						
Sex						
Female	250 (45.5%)	245 (44.5%)	265 (46.1%)	280 (45.9%)	295 (49.6%)	1335 (46.4%)
Male	300 (54.5%)	305 (55.5%)	310 (53.9%)	330 (54.1%)	300 (50.4%)	1545 (53.6%)
Mean age ± SD	60.6 ± 12.8	60.1 ± 12.7	60.6 ± 13	60.3 ± 12.8	59.9 ± 13.4	

Notes: Data was derived from Canadian Vital Statistics Death Dataset. Due to confidentiality reasons, all frequencies were randomly rounded either up or down to a multiple of "5", and the number of institutional mortalities were aggregated for the five-year period before vetting from RDC.

Figure 4.11 shows that the age-standardized all-cause mortality rates increased from 2011 to 2015 across the eight most populous cities in Canada. This trend was seen to a lesser extent in Toronto and Vancouver. These two cities also had the lowest all-cause mortality rates compared to other CMAs, with Toronto having the lowest rates among the eight cities. The CMA-level age-standardized mortality rates are provided in Table 4.18.

Figure 4.11: Age-standardized all-cause mortality rate (per 100,000) by CMA, 2011 to 2015



Notes: 工 represents 95% confidence interval. Data is derived from CVSD. Non-Canadian residents are excluded.

Table 4.18: Age-standardized mortality rates (per 100,000) by CMA, 2011 to 2015

	2011			2012			2013			2014			2015		
	ASMR	**95% CI**	**SE**	**ASMR**	**95% CI**	**SE**	**ASMR**	**95% CI**	**SE**	**ASMR**	**95% CI**	**SE**	**ASMR**	**95% CI**	**SE**
Calgary															
All Causes mortality	624	620 - 630	3	675	670 - 680	3	714	710 - 720	3	710	705 - 715	3	752	745 - 760	3
Premature mortality	236	230 - 240	3	252	245 - 260	3	252	245 - 260	3	237	230 - 245	3	240	235 - 245	3
Avoidable mortality	174	170 - 180	3	186	180 - 190	3	187	180 - 190	3	177	170 - 180	3	177	170 - 180	3
Preventable mortality	117	115 - 120	2	119	115 - 125	2	123	120 - 125	2	121	115 - 125	2	121	115 - 125	2
Treatable mortality	57	55 - 60	1	67	65 - 70	1	64	60 - 65	2	56	55 - 60	1	56	55 - 60	1
Edmonton															
All Causes mortality	693	685 - 700	3	751	745 - 760	3	785	780 - 790	3	826	820 - 835	4	840	835 - 845	4
Premature mortality	294	290 - 300	3	295	290 - 300	3	308	300 - 315	3	309	300 - 315	3	307	300 - 315	3
Avoidable mortality	220	215 - 225	3	220	215 - 225	3	231	225 - 235	3	226	220 - 230	3	227	220 - 235	3
Preventable mortality	147	145 - 150	2	151	145 - 155	2	155	150 - 160	2	151	145 - 155	2	155	150 - 160	3
Treatable mortality	73	70 - 75	2	69	65 - 70	2	76	75 - 80	2	74	70 - 75	2	72	70 - 75	2
Montreal															
All Causes mortality	704	695 - 715	6	726	715 - 735	6	736	725 - 750	6	769	755 - 780	6	798	785 - 810	6
Premature mortality	282	270 - 295	6	276	265 - 285	6	265	255 - 275	6	264	255 - 275	6	265	255 - 275	6
Avoidable mortality	203	195 - 215	5	198	190 - 210	5	190	180 - 200	5	187	180 - 195	5	187	180 - 195	5
Preventable mortality	135	125 - 145	4	132	125 - 140	4	127	120 - 135	4	124	115 - 130	4	126	120 - 135	4
Treatable mortality	68	65 - 75	3	66	60 - 70	3	63	60 - 70	3	64	60 - 70	3	61	55 - 65	3

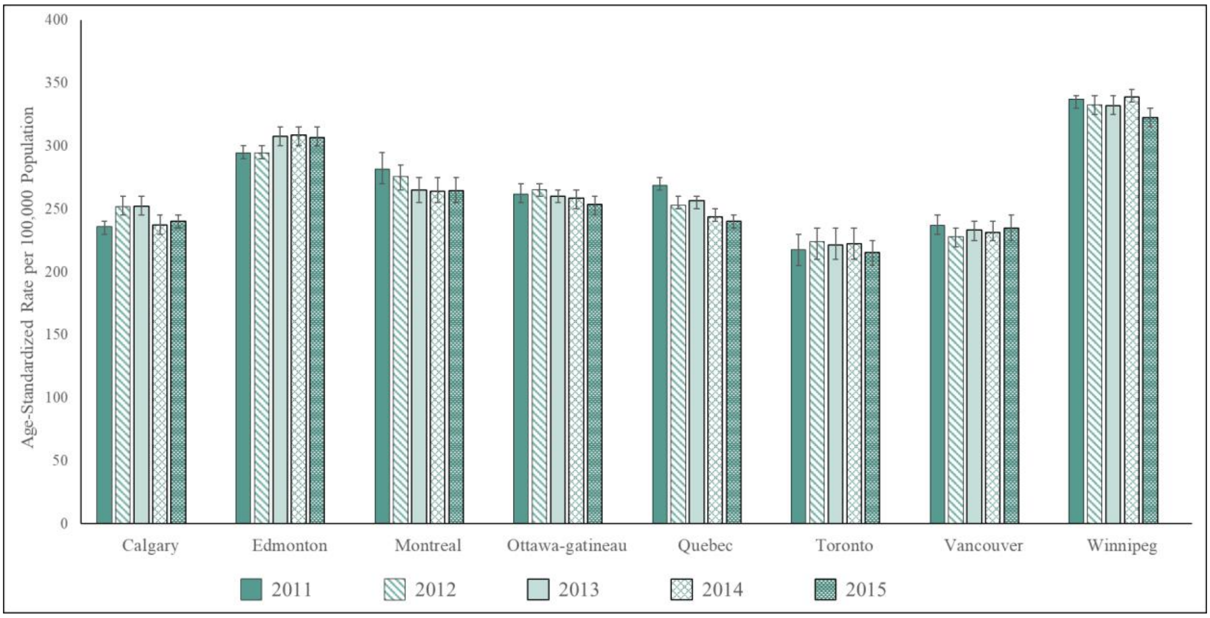
Ottawa-gatineau															
All Causes mortality	675	670 - 680	3	704	695 - 710	3	726	720 - 735	3	763	755 - 770	3	790	785 - 795	3
Premature mortality	262	255 - 270	3	265	260 - 270	3	260	255 - 265	3	258	250 - 265	3	254	245 - 260	3
Avoidable mortality	191	185 - 195	3	189	185 - 195	3	185	180 - 190	3	179	175 - 185	3	185	180 - 190	3
Preventable mortality	126	120 - 130	2	124	120 - 130	2	121	115 - 125	2	115	110 - 120	2	123	120 - 130	2
Treatable mortality	65	60 - 70	2	65	60 - 70	2	63	60 - 65	2	63	60 - 65	2	62	60 - 65	2
Quebec															
All Causes mortality	674	670 - 680	3	688	685 - 695	3	733	730 - 740	3	778	775 - 785	3	807	800 - 810	3
Premature mortality	269	265 - 275	3	253	250 - 260	3	256	250 - 260	3	244	240 - 250	2	240	235 - 245	3
Avoidable mortality	192	190 - 195	2	174	170 - 180	2	184	180 - 190	2	171	165 - 175	2	172	170 - 175	2
Preventable mortality	135	130 - 140	2	119	115 - 125	2	127	125 - 130	2	116	115 - 120	2	119	115 - 125	2
Treatable mortality	57	55 - 60	1	54	50 - 55	1	57	55 - 60	1	55	50 - 55	1	54	50 - 55	1
Toronto															
All Causes mortality	579	565 - 590	6	599	585 - 610	7	621	610 - 635	7	633	620 - 645	7	631	620 - 645	7
Premature mortality	218	205 - 230	6	224	210 - 235	6	221	210 - 235	6	223	210 - 235	6	215	205 - 225	6
Avoidable mortality	155	145 - 165	5	160	150 - 170	5	158	145 - 170	5	160	150 - 170	5	153	145 - 165	5
Preventable mortality	99	90 - 105	4	101	90 - 110	4	101	95 - 110	4	101	95 - 110	4	98	90 - 105	4
Treatable mortality	56	50 - 60	3	59	55 - 65	3	57	50 - 65	3	58	50 - 65	3	55	50 - 60	3
Vancouver															
All Causes mortality	621	610 - 630	4	625	615 - 635	4	639	630 - 650	4	657	650 - 665	4	685	675 - 695	5
Premature mortality	237	230 - 245	4	228	220 - 235	4	233	225 - 240	4	231	225 - 240	4	235	225 - 245	4

Avoidable mortality	171	165 - 175	4	166	160 - 170	4	164	155 - 170	4	162	155 - 170	4	161	155 - 170	4
Preventable mortality	115	110 - 120	3	112	105 - 120	3	109	105 - 115	3	108	100 - 115	3	107	100 - 115	3
Treatable mortality	56	50 - 60	2	54	50 - 55	2	55	50 - 60	2	54	50 - 60	2	53	50 - 55	2
Winnipeg															
All Causes mortality	790	785 - 795	3	798	790 - 805	3	803	795 - 810	3	879	875 - 885	3	904	900 - 910	3
Premature mortality	337	330 - 340	3	333	325 - 340	3	332	325 - 340	3	339	335 - 345	3	323	315 - 330	3
Avoidable mortality	240	235 - 245	2	237	230 - 240	2	237	230 - 240	2	243	240 - 245	2	228	225 - 235	2
Preventable mortality	154	150 - 155	2	154	150 - 155	2	151	150 - 155	2	154	150 - 160	2	144	140 - 150	2
Treatable mortality	87	85 - 90	1	84	80 - 85	1	86	85 - 90	1	88	85 - 90	1	84	80 - 85	1

Notes: Data was derived from Canadian Vital Statistics Death Dataset. Due to confidentiality reasons, the numerators, denominators, and confidence intervals were randomly rounded either up or down to a multiple of "5".

Figure 4.12 presents the annual age-standardized premature mortality rate (per 100,000) across the eight most populous cities in Canada. The lowest premature mortality rates were seen in Toronto and Vancouver, while Winnipeg had the highest premature mortality rates.

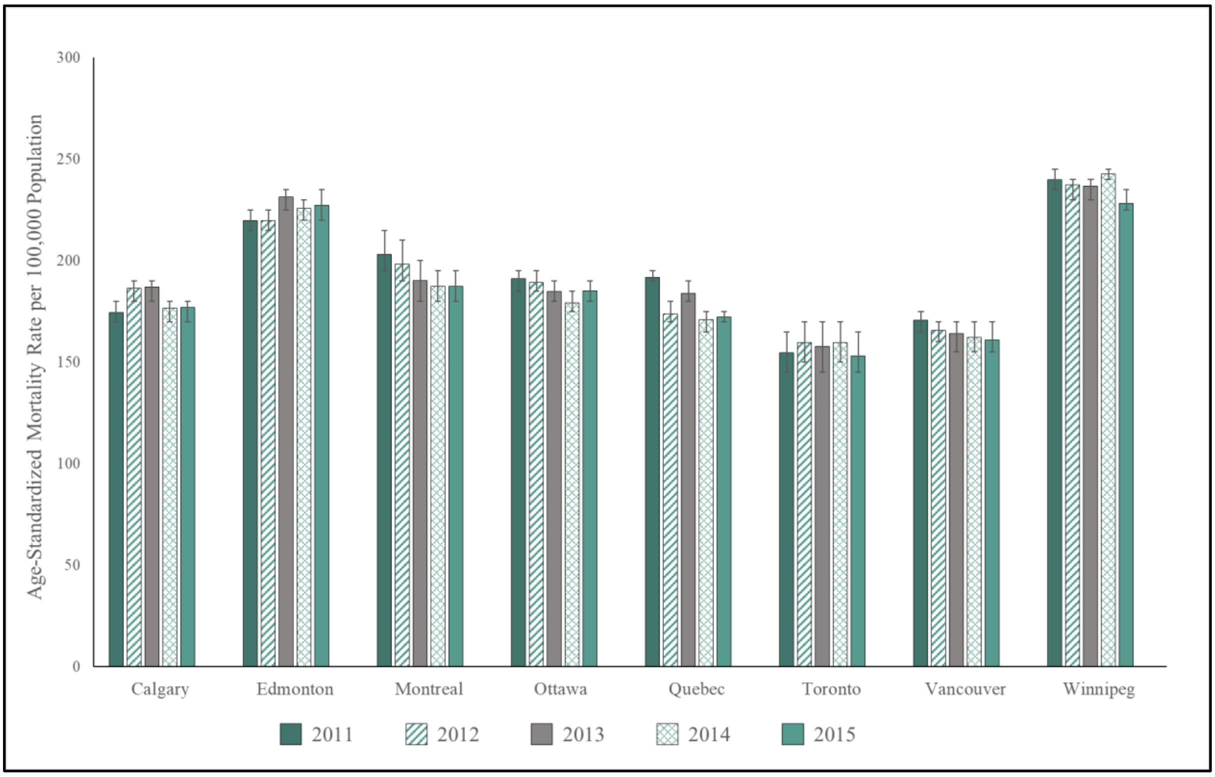
Figure 4.12: Age-standardized premature mortality rate (per 100,000) by CMA, 2011 to 2015



Notes: ⌶ represents 95% confidence interval. Data is derived from CVSD. Non-Canadian residents are excluded.

Figure 4.13 shows the age-standardized avoidable mortality rate by CMA. The highest avoidable mortality rate was seen in Winnipeg, followed by Edmonton. On the other hand, Toronto and Vancouver had the lowest avoidable mortality rates.

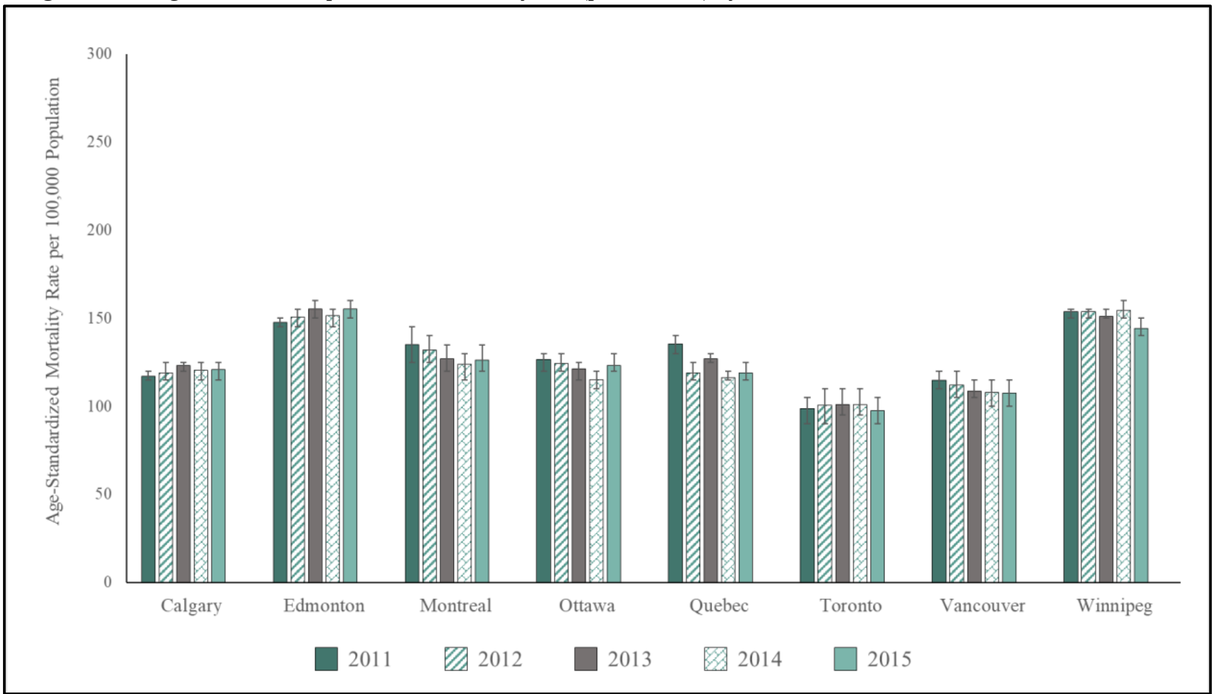
Figure 4.13: Age-standardized avoidable mortality rate (per 100,000) by CMA, 2011 to 2015



Notes: ⌶ represents 95% confidence interval. Data is derived from CVSD. Non-Canadian residents are excluded.

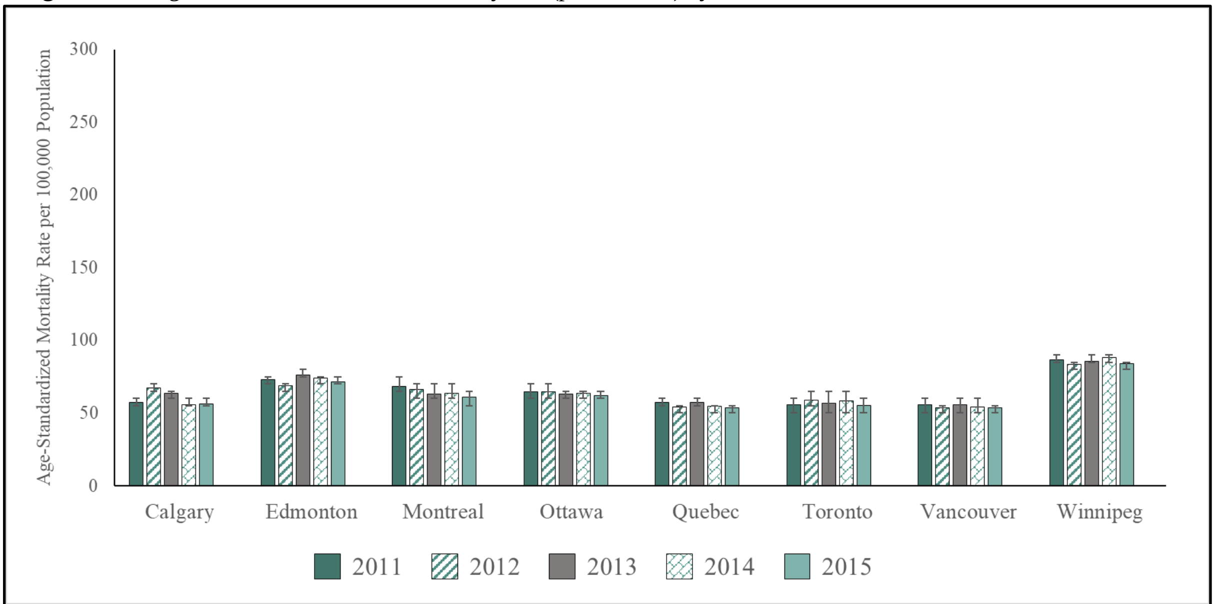
Figure 4.14 and 4.15 presents the age-standardized preventable and treatable causes of death by CMA. In all cities, the preventable mortality rate is consistently two times higher than treatable mortality rates over the years from 2011 to 2015. Overall, the highest age-standardized death rates due to preventable causes were seen in Winnipeg and Edmonton. Winnipeg had also the highest mortality rate due to treatable causes compared to other cities, across all years. Toronto, followed by Vancouver and Calgary had the lowest age-standardized preventable mortality rates compared to other cities.

Figure 4.14: Age-standardized preventable mortality rate (per 100,000) by CMA, 2011 to 2015



Notes: ⌶ represents 95% confidence interval. Data is derived from CVSD. Non-Canadian residents are excluded.

Figure 4.15: Age-standardized treatable mortality rate (per 100,000) by CMA, 2011 to 2015



Notes: ⌶ represents 95% confidence interval. Data is derived from CVSD. Non-Canadian residents are excluded.

4.2.2 Income inequality in mortality in 2011-2015

Inequalities were measured by the concentration index (CI). The negative CI indicates inequality with higher mortality rates among poorer neighbourhoods. Table 4.16 provides CI at the national, provincial, and city levels. As seen in the table, inequality was present in all mortality indicators and across all jurisdictions. Among different mortality indicators, the lowest inequality was seen in all-cause mortality at the national level (CI = -0.1191 , 95% CI = -0.1194 to -0.1185) and in most provinces, except Quebec, and across most cities, except Quebec and Montreal. The highest inequality, on the other hand, was seen in preventable mortality compared to other mortality indicators, at the national level (CI = -0.1779 , 95% CI = -0.1787 to -0.1777) and across most provinces, except Newfoundland and Labrador and Prince Edward Island, and in most cities, except Quebec.

Table 4.19: Income inequality in mortality in urban Canada, 2011-2015

	CI	SE	95% CI
Canada			
All Causes mortality	-0.1191	0.0003	-0.1194 , -0.1185
Premature mortality	-0.1469	0.0002	-0.1476 , -0.1469
Avoidable mortality	-0.1648	0.0003	-0.1656 , -0.1647
Preventable mortality	-0.1779	0.0003	-0.1787 , -0.1777
Treatable mortality	-0.1384	0.0004	-0.1395 , -0.1383
Provinces			
Alberta			
All Causes mortality	-0.1344	0.001	-0.1365 , -0.1332
Premature mortality	-0.1602	0.0008	-0.1625 , -0.1597
Avoidable mortality	-0.1785	0.0009	-0.1812 , -0.1781
Preventable mortality	-0.1867	0.001	-0.1893 , -0.1861
Treatable mortality	-0.1611	0.0013	-0.1647 , -0.1605
British Columbia			
All Causes mortality	-0.1132	0.0007	-0.1144 , -0.1123
Premature mortality	-0.123	0.0006	-0.1241 , -0.1222
Avoidable mortality	-0.1431	0.0006	-0.1445 , -0.1423
Preventable mortality	-0.1584	0.0007	-0.1599 , -0.1576
Treatable mortality	-0.1105	0.0009	-0.1121 , -0.1094
Manitoba			
All Causes mortality	-0.1479	0.0012	-0.1495 , -0.1459
Premature mortality	-0.1674	0.0011	-0.1695 , -0.166
Avoidable mortality	-0.1945	0.0012	-0.1966 , -0.1926
Preventable mortality	-0.2099	0.0014	-0.212 , -0.2077
Treatable mortality	-0.1668	0.0018	-0.1703 , -0.1644

New Brunswick			
All Causes mortality	-0.1545	0.0015	-0.1557 , -0.1509
Premature mortality	-0.1816	0.0015	-0.1837 , -0.1788
Avoidable mortality	-0.2097	0.0019	-0.2119 , -0.2056
Preventable mortality	-0.2268	0.0022	-0.2296 , -0.2222
Treatable mortality	-0.1735	0.0024	-0.1766 , -0.1687
Newfoundland and Labrador			
All Causes mortality	-0.1296	0.0022	-0.132 , -0.125
Premature mortality	-0.1282	0.0018	-0.1305 , -0.1243
Avoidable mortality	-0.1406	0.0018	-0.1429 , -0.1367
Preventable mortality	-0.1365	0.002	-0.1389 , -0.1322
Treatable mortality	-0.1482	0.0024	-0.1518 , -0.1437
Nova Scotia			
All Causes mortality	-0.1156	0.0013	-0.1172 , -0.1134
Premature mortality	-0.1631	0.0012	-0.165 , -0.1611
Avoidable mortality	-0.1823	0.0013	-0.184 , -0.1798
Preventable mortality	-0.1988	0.0015	-0.2009 , -0.1961
Treatable mortality	-0.1491	0.0017	-0.1516 , -0.1457
Ontario			
All Causes mortality	-0.0935	0.0004	-0.0939 , -0.0927
Premature mortality	-0.1434	0.0004	-0.1442 , -0.1429
Avoidable mortality	-0.1662	0.0004	-0.167 , -0.1657
Preventable mortality	-0.1812	0.0004	-0.1819 , -0.1805
Treatable mortality	-0.1376	0.0005	-0.1388 , -0.1371
Prince Edward Island			
All Causes mortality	-0.1113	0.0031	-0.1157 , -0.1072
Premature mortality	-0.1449	0.0032	-0.1497 , -0.1404
Avoidable mortality	-0.1624	0.0037	-0.1678 , -0.1559
Preventable mortality	-0.1665	0.004	-0.1732 , -0.1599
Treatable mortality	-0.1545	0.0048	-0.1626 , -0.1459
Quebec			
All Causes mortality	-0.1405	0.0005	-0.1409 , -0.1391
Premature mortality	-0.1299	0.0005	-0.131 , -0.1295
Avoidable mortality	-0.1471	0.0005	-0.1483 , -0.1466

Preventable mortality	-0.161	0.0006	-0.1622 , -0.1602
Treatable mortality	-0.1173	0.0008	-0.1194 , -0.1166
Saskatchewan			
All Causes mortality	-0.1863	0.0016	-0.1892 , -0.1843
Premature mortality	-0.1944	0.0013	-0.1976 , -0.1932
Avoidable mortality	-0.2073	0.0015	-0.2109 , -0.206
Preventable mortality	-0.2183	0.0017	-0.2221 , -0.2165
Treatable mortality	-0.1853	0.0022	-0.1902 , -0.1828
CMAs			
Quebec			
All Causes mortality	-0.1875	0.0015	-0.1895 , -0.1845
Premature mortality	-0.1486	0.0014	-0.1517 , -0.147
Avoidable mortality	-0.1668	0.0017	-0.1704 , -0.165
Preventable mortality	-0.1852	0.0019	-0.1897 , -0.1833
Treatable mortality	-0.1249	0.0024	-0.1287 , -0.121
Montreal			
All Causes mortality	-0.1045	0.0007	-0.1052 , -0.1028
Premature mortality	-0.1041	0.0006	-0.1055 , -0.1034
Avoidable mortality	-0.125	0.0007	-0.1266 , -0.1242
Preventable mortality	-0.139	0.0009	-0.1405 , -0.1376
Treatable mortality	-0.0966	0.0011	-0.0995 , -0.0959
Ottawa - Gatineau			
All Causes mortality	-0.1029	0.0013	-0.1054 , -0.1014
Premature mortality	-0.1619	0.0013	-0.1652 , -0.1611
Avoidable mortality	-0.1898	0.0014	-0.1935 , -0.1888
Preventable mortality	-0.2105	0.0016	-0.2147 , -0.2095
Treatable mortality	-0.15	0.0021	-0.1541 , -0.1476
Toronto			
All Causes mortality	-0.0316	0.0005	-0.0321 , -0.0305
Premature mortality	-0.0794	0.0005	-0.0803 , -0.0786
Avoidable mortality	-0.0977	0.0006	-0.0988 , -0.0968
Preventable mortality	-0.1078	0.0007	-0.1088 , -0.1065
Treatable mortality	-0.08	0.0007	-0.0817 , -0.0792
Winnipeg			

All Causes mortality	-0.1491	0.0013	-0.1508 , -0.147
Premature mortality	-0.1771	0.0011	-0.1792 , -0.1754
Avoidable mortality	-0.2082	0.0013	-0.2103 , -0.2062
Preventable mortality	-0.2228	0.0014	-0.2249 , -0.2204
Treatable mortality	-0.1821	0.0018	-0.1854 , -0.1796
Calgary			
All Causes mortality	-0.0697	0.0017	-0.0726 , -0.0677
Premature mortality	-0.138	0.0013	-0.1407 , -0.1366
Avoidable mortality	-0.1622	0.0014	-0.1655 , -0.161
Preventable mortality	-0.1751	0.0015	-0.1782 , -0.1734
Treatable mortality	-0.1364	0.0022	-0.1418 , -0.1343
Edmonton			
All Causes mortality	-0.1239	0.0013	-0.1267 , -0.1227
Premature mortality	-0.1538	0.0012	-0.1563 , -0.1525
Avoidable mortality	-0.1746	0.0013	-0.1773 , -0.1733
Preventable mortality	-0.188	0.0014	-0.1907 , -0.1864
Treatable mortality	-0.1466	0.0017	-0.1501 , -0.1447
Vancouver			
All Causes mortality	-0.0721	0.0009	-0.0737 , -0.0709
Premature mortality	-0.0894	0.0008	-0.0909 , -0.0882
Avoidable mortality	-0.1124	0.0009	-0.1141 , -0.1112
Preventable mortality	-0.1255	0.001	-0.1276 , -0.1241
Treatable mortality	-0.0863	0.0011	-0.0883 , -0.0847

Notes: Data was derived from CVSD, Census 2011 and 2016, and NHS. Non-Canadian and institutional residents, and non-urban areas were excluded.

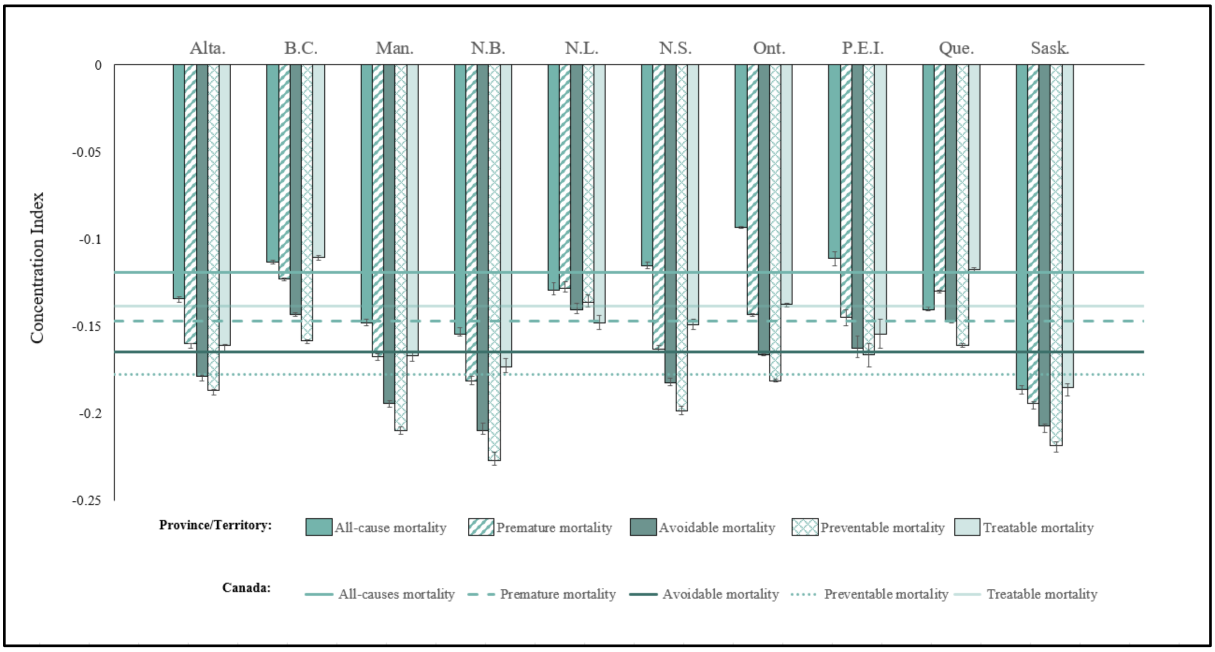
Saskatchewan followed by New Brunswick, and Manitoba had the highest inequality in mortality rather than other provinces and compared to the national results. Figure 4.16 shows the measured inequality across provinces by bar charts, and national CIs are presented by lines for different mortality indicators.

Territories were not included in the inequality measurement. This was because inequality measurement covered only urban areas, and after excluding DAs which did not meet the requirement to be considered as urban areas, Nunavut was eliminated from the dataset, the sample size for Yukon and Northwest Territories was not sufficient to execute the inequality measurement.

The lowest inequality in avoidable and preventable mortality was seen in Newfoundland and Labrador with CI = -0.1406 (95% CI = -0.1429 to -0.1367) in avoidable mortality and CI = -0.1365 (95% CI = -0.1389 to -0.1322) in preventable mortality. British Columbia had the lowest inequality in premature (CI = -0.123, 95%CI = -0.1241 to -0.1222) and treatable mortality (CI = -0.1105, 95% CI = -0.1121 to -0.1094). The lowest inequality in all-cause mortality was seen in Ontario with CI = -0.0935 (95% CI = -0.0939 to -0.0927). British Columbia was the only province in which inequality in all mortality indicators was less than the national level.

On the other hand, the highest inequality in all-cause (CI = -0.1863 , 95%CI = -0.1892 to -0.1843), premature (CI = -0.1944 , 95%CI = -0.1976 to -0.1932), and treatable (CI = -0.1853 , 95%CI = -0.1902 to -0.1828) mortality was seen in Saskatchewan, and New Brunswick had the highest inequality in avoidable (CI = -0.2097 , 95%CI = -0.2119 to -0.2056), and preventable (CI = -0.2268, 95%CI = -0.2296 to -0.2222) mortality.

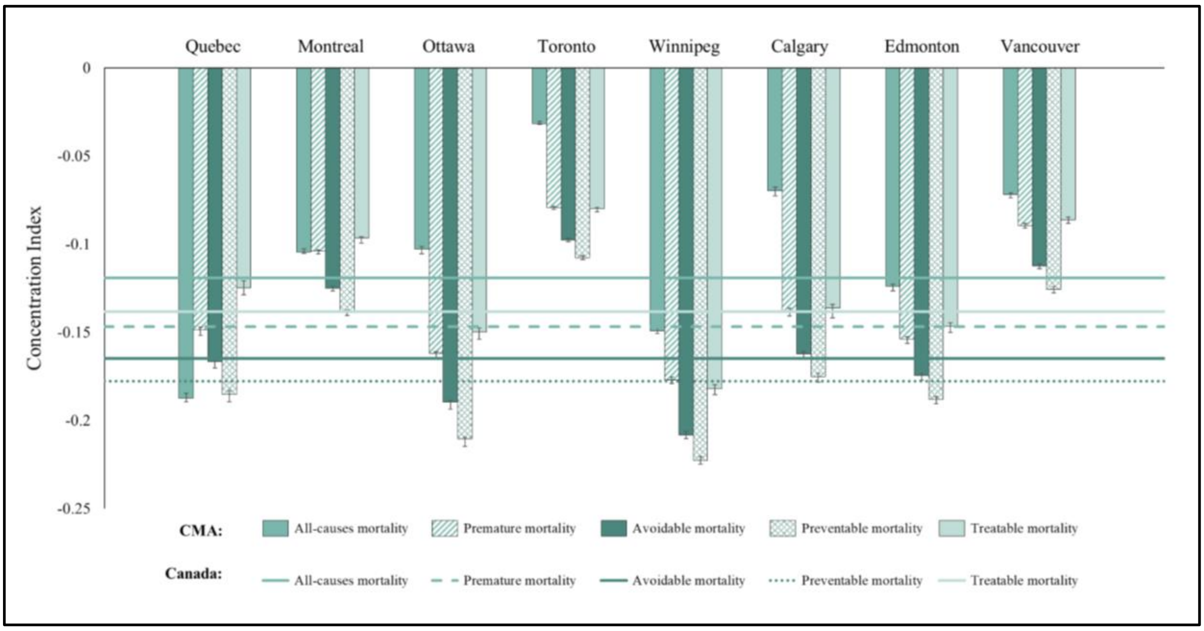
Figure 4.16: Income inequality in mortality in urban areas by province, 2011-2015



Notes: ⊥ represents 95% confidence interval. Data was derived from CVSD, Census 2011 and 2016, and NHS. Non-Canadian and institutional residents, and non-urban areas were excluded. Lines represent CI in urban Canada.

At the city level, Toronto was the most equal city in all mortality indicators with CI = -0.0316 (95% CI = -0.0321 to -0.0305) in all-cause mortality, CI = -0.0794 (95% CI = -0.0803 to -0.0786) in premature mortality, CI = -0.0977 (95% CI = -0.0988 to -0.0968) in avoidable mortality, CI = -0.1078 (95% CI = -0.1088 to -0.1065) in preventable mortality, and CI = -0.08 (95% CI = -0.0817 to -0.0792) in treatable mortality. The highest inequality in all-cause mortality was seen in the city of Quebec (CI = -0.1875, 95% CI = -0.1895 to -0.1845). Winnipeg had the highest inequality in premature (CI = -0.1771, 95% CI = -0.1792 to -0.1754), avoidable (CI = -0.2082, 95% CI = -0.2103 to -0.2062), preventable (CI = -0.2228, 95% CI = -0.2249 to -0.2204), and treatable mortality (CI = -0.1821, 95% CI = -0.1854 to -0.1796). Cities with inequalities lower than the national results in all mortality indicators included Toronto, followed by Vancouver, Montreal, and Calgary. Figure 4.17 shows the measured inequality across CMAs by bar charts, and national CIs are presented by lines for different mortality indicators.

Figure 4.17: Income inequality in mortality in urban areas by CMA, 2011-2015



Notes: 工 represents 95% confidence interval. Data was derived from CVSD, Census 2011 and 2016, and NHS. Non-Canadian and institutional residents, and non-urban areas were excluded. Lines represent CI in urban Canada.

5. DISCUSSION

This final chapter, first, summarizes the results of this thesis, presented in chapter five, and discusses the findings in the context of the overall thesis purpose, and then, reviews limitations of the study. This chapter concludes with recommendations and future work.

5.1 Phase 1: scoping review

The scoping review identified 29 scientific articles and 5 grey literature reporting on SES inequality in avoidable mortality. Most of the studies were conducted in Europe followed by Australia and New Zealand. This might be due to the availability of definitions for avoidable mortality and the list of amenable causes in Australia, New Zealand, and Europe (150,151). In the case of Canada, it is evident that after the introduction of the first Canadian list of avoidable causes of death in 2012 (24), the number of studies performed in this area has accelerated (41,42); though most of the selected Canadian literature in this review are governmental reports (24,26,92,135,136) Hence, it is reasonable to expect more publications on avoidable mortality in the future years in Canada.

Furthermore, most of the articles were conducted in high-income countries. Developing a list of avoidable mortality is determined by the context, such as the available technologies in the health care system which is different across low- middle- and high- income countries. Therefore, avoidable causes of death may be defined differently across countries with dissimilar levels of economic development. The fact that the available definitions for avoidable mortality are apt for high-income countries is one of the reasons that hinders performing research on avoidable mortality in lower-income countries. This suggests that the first step in evoking these types of research in a country might be developing a list of avoidable causes of death compatible with the context.

Other than the significant increase in inequality research in avoidable mortality in the selected grey literature, the distribution of the scientific articles' publication date does not indicate a change in conducting research in this area between 2000 and 2020. The reason for the recent increase in Canadian research on the topic of interest might be that Canada's first list of potentially avoidable causes of death was introduced in 2012 by CIHI (24). Four out of five Canadian governmental reports included in this review were published in 2019, after the introduction of the potentially avoidable causes of death list in 2012 (24). Although OECD proposed a definition for avoidable mortality and the corresponding list of avoidable causes of death in 2019 (152), it seems that introduction of a national list for avoidable causes of death promotes the performance of this kind of research in a country.

There was no standard definition or terminology in using the avoidable mortality concept across the selected articles. The findings of another scoping review also suggest a lack of consistency in conceptualizing ‘preventable mortality’ (153). The selected articles adopted a wide range of definitions for 'avoidable mortality,' and the authors used different terminology to refer to it. The ‘amenable mortality’ was mostly used to refer to the causes of death amenable to health care intervention, and it is accounted as the same as 'treatable mortality' in some literature (31,151,154). Some other studies/definitions, on the other hand, don't use 'amenable mortality' terminology, such as the definition developed by CIHI to be used in the Canadian context (24). Nolte and McKee, whose definition is the most commonly used across the included articles, use 'amenable mortality' to refer to premature deaths that should have been avoided in the presence of timely and effective health care (31). Thus, Nolte and McKee’s list of amenable causes of death does not include mortalities which could have been prevented through public policy interventions (31), which is called 'preventable mortality' and have been assessed by some researchers (41,42,53).

I tried to collate and summarize the definitions used for the avoidable mortality concept in the collected articles; however, it should be noted that the scope of this review was narrowed, and the main goal was not to explore avoidable mortality definitions used in “public health” research, but it was focused on “SES-related inequality” research. Therefore, caution should be taken when interpreting the results, and findings should not be extrapolated to definitions used for avoidable mortality in “public health” research overall. As such, there is a need to systematically investigate how ‘avoidable mortality,’ ‘amenable mortality,’ ‘treatable mortality,’ and ‘preventable mortality’ is defined by researchers globally.

Due to the complicated nature of ischemic heart disease, researchers have to decide how to categorize deaths due to heart diseases in terms of being avoidable. Nolte and McKee's avoidable mortality definition, one of the most popular definitions for avoidable causes of death, proposes to analyze this group of mortality separately (31). One reason for this segregation is that death due to IHD is responsible for a large amount of mortality, and given the unclear impact of health care on reducing IHD mortality, any changes will obscure the impact of health policy and care on other causes of death (31). The CIHI list of avoidable causes of death recommends categorizing half of the death due to IHD as treatable deaths and the other half as preventable, as both prevention and treatment measures have impacts on IHD mortality rates (24).

Given the number of articles included in this scoping review (i.e., 34), the number of articles/reports using education (2 articles) or employment/occupation (2 articles) as a SES indicator in investigating inequality in avoidable mortality was relatively low. On the other hand, using indices such as ON-Marg, IRSD, IMD is prevalent across the articles. The education and employment are nested in these indices. Therefore, one could say that these indicators are studied through the deprivation indices and not individually. Still, these indicators were neglected compared to income (13 articles), which is consistent with findings of a South-Asian scoping review on the indices used for measuring socioeconomic inequality in health research, identifying asset-based wealth index as the most frequent indicator used in urban health studies (155).

All the selected articles show a significant association between the avoidable mortality rate and SES. This is in accordance with the huge body of knowledge indicating the role of SES in the health status of a population. The reason why the study conducted in Mongolia was not able to find a significant relationship might be because of the lack of individual or neighbourhood level data (133). It is well-established that data disaggregation strengthens the monitoring and evaluating of health inequality (156), and therefore large units of analysis, such as cities and provinces, could weaken the assessment of health inequality and the accountability of the results. This could be explained by the fact that as the unit of analysis grows in size the possibility of people with different socioeconomic status living in one unit increases, and therefore the ability to capture health inequality is reduced.

5.2 Phase 2: Measuring income inequality in avoidable mortality in urban Canada

Overall, the findings of this study shows that income inequality in mortality exists at every level of geography in Canada. Although the magnitude of inequality is different across cities, provinces and different indicators, it is present in every jurisdiction investigated in this thesis. The existence of socioeconomic inequalities in mortality was previously reported in both Canada and globally (24,26,33,35,38,41,42,53,88,92,117,128,132,138,142,143,145,157). The socioeconomic gradient in avoidable mortality is also demonstrated in the findings of the scoping review done as a part of this thesis. Furthermore, this study found a higher inequality in preventable mortality as compared to the inequality in all-cause, premature, avoidable, and treatable mortality, at all geographic levels in Canada. Other finding of this study shows that, at the provincial level, Saskatchewan was the only province with an inequality higher than national level inequality in all the mortality indicators, and at the CMA level, Winnipeg was the most unequal CMA in premature, avoidable, preventable, and treatable mortality indicators compared to the other seven CMAs investigated in this study.

Findings spanning the period of 2011 to 2015 suggest that overall, inequality in premature mortality was substantially higher compared to all-cause mortality, and more pronounced in avoidable mortality and its sub-indicators (i.e., preventable and treatable mortalities) rather than premature mortality, in almost all cities, provinces, and in Canada. Given the definition of these indicators, these findings were expected and are consistent with previous studies examining socioeconomic inequalities in mortality in Canada (42,53).

At all geographic levels, the greater proportion of avoidable mortalities were attributable to preventable causes rather than to treatable causes. This has been also observed in previous evidence from studies conducted in Canada (24,41,42); the findings of a study conducted in Ontario showed that the ratio of preventable to treatable mortality increased from 1.5:1 in 1993 to 2:1 in 2014 (42). Furthermore, this thesis found that inequality in preventable mortality was higher in all jurisdictions compared to treatable mortality over the years from 2011 to 2015. This has been seen in other research as well (24,41,42); Zygmunt et al. found that decedents residing in the most materially deprived and residentially unstable neighbourhoods in Ontario had significantly greater mortality from preventable conditions rather than treatable causes compared to those living in the least deprived neighbourhoods (42). These findings highlight the need for an improvement in policies whose primary purpose is prevention to curb the preventive mortality burden.

The current study also examined the trends in mortality rates over a five-year period; from 2011 to 2015, the rates of all mortality indicators decreased in all investigated jurisdictions, which confirms findings of other research (24,33,34,41). A previous work studying mortality in Canada from 1975 to 1999, found a more pronounced decrease in avoidable mortality rate (46.9%), compared to mortality from other causes (24.9%) (34). According to the *Health Indicators 2012* report by CIHI, between 1979 and 2008, premature mortality rates decreased by 45% in all provinces and territories; rates for avoidable mortality reduced by half; and preventable and treatable mortality rates decreased by 47% and 56% respectively (24). A more recent study conducted by Shahidi et al. showed similar trends; between 1991 and 2016, premature, preventable, and treatable mortality decreased by 40%, 41%, and 47% respectively (53). Zygmunt et al. explored avoidable mortality in Ontario from 1993 to 2014 and found that avoidable mortality rates almost halved between these years, which is similar to the national level trends (41).

While the current thesis did not examine trends in inequality over time, a previous study showed that socioeconomic mortality gradients decreased in Canada between 1971 and 1996; their findings indicated that mortalities amenable to medical care decreased 60% in men and 78% in women from 1971 to 1996, having the largest contribution in narrowing mortality disparities over this period. In this study, James et al. also found that deaths amenable to public health measures increased 0.7% in men and 20% in women, suggesting that public health initiatives have the potential to help reduce inequality in mortality (33). A more recent study examining income inequality in mortality found that, between 1991 and 2011, relative income inequality in all-cause mortality increased by 12% among men and by 21% among women (157). Similarly, Shahidi et al. found that relative socioeconomic inequalities in premature and avoidable mortality widened between 1991 and 2016; over this period, premature mortality increased by 33% among men and by 47% among women (53). Given these findings, it seems that between the 1970s and 1990s, socioeconomic inequalities in mortality have decreased, and since the 1990s until recent years the mortality disparity has been widening in Canada. However, there is a need for more research on trends in socioeconomic inequality in mortality, using different methodology, to be able to better interpret the results and identify actionable interventions to close the mortality gap.

The descriptive findings of this study demonstrate a huge sex difference in mortality, in that females generally have lower death incidence than males. This gap was seen, in particular, in avoidable causes of death, with a greater magnitude in preventable conditions. The gender difference in avoidable mortality has been reported in other Canadian studies as well (24,34,41,42,53); Zygmunt et al. examined avoidable mortality in Ontarian population from 1993 to 2014, and found that men were nearly twice as likely to have avoidable mortality from preventable causes compared to women (65.9% men vs. 34.1% women) (42); findings from another study investigating socioeconomic gradients in avoidable mortality among immigrants and Canadian residents confirmed the presence of the female mortality advantage in Canada (38). The female mortality advantage was also documented in a study reviewing patterns in Canadian mortality over a century (158). In contrast, there is evidence suggesting females experiencing higher mortality rates than males in particular cases; findings of a study conducted by Khan et al. over the period of 2002 to 2012 showed an exception to female mortality advantage; both immigrant and non-immigrant women had higher mortality rates rather than their male counterparts, for causes of death amenable to medical care and public health, and specifically for causes amenable to medical care. Khan et al. argued that this finding could point to the presence of barriers in access to primary care services in Ontario for immigrant women (38). Along with these findings, Shahidi et al. found that, although premature mortality has decreased over time, from 1991 to 2011; this trend reversed, for some conditions, among the most socioeconomically disadvantaged women (53). The overall evidence on female mortality advantage could be explained by the healthier lifestyle behaviours that females are engaged with compared to men (159). A population-based study conducted in Ontario found a stronger association between unhealthy behaviors and all-cause and premature mortality among men rather than women (160).

Several intermediary factors in developing health inequality are identified which include material, psychosocial, biological, behavioural, and health system factors (161). Recently, Rosella et al. examined the association of all-cause and premature mortality with unhealthy behaviours in Ontario. They demonstrated that mortality is associated with patterns of smoking, BMI, physical inactivity, and alcohol consumption. Their findings show that the magnitude of this association was higher for premature mortality compared to all-cause mortality, while deaths amenable to health system intervention contributed to a large portion of the premature deaths. A considerable portion of amenable mortalities occurred among those with unhealthy behaviours, such as heavy smokers, followed by obesity (almost 40% amenable), heavy drinkers (about one-third amenable), and physical inactivity (about one-fifth amenable) (160). Furthermore, results reported by Mackenbach and colleagues showed that in Europe, mortality attributable to smoking-related conditions accounted for 22% of the inequalities in all-cause mortality rate among men and 6% of those among women (22). Findings of this thesis also suggest that preventable mortality holds a great share of premature mortality, suggesting that a large proportion of avoidable mortality could be averted by public health efforts focused on preventing diseases from developing in the first place. Given these findings, one approach to improve population health and address health inequality is to enhance public health interventions for improvement of healthy lifestyles behaviours.

While risk factors such as insufficient physical activity and tobacco use are acknowledged by WHO Global Action Plan for the Prevention and Control of Non-Communicable Diseases as predictors of premature mortality, global health strategies do not consider low socioeconomic status as a modifiable risk factor (162,163). As such, Stringhini and colleagues argue that SES should be targeted by local and governmental population health initiatives to reduce mortality (163). In Canada, however, jurisdictions at different levels acknowledge socioeconomic status as an important driver of health inequality. Nevertheless, evidence indicates that more efforts are needed to tackle socioeconomic-related health inequality in all jurisdictions in Canada.

The provincial results show that income inequality across mortality indicators is considerably higher in Saskatchewan, New Brunswick, and Manitoba compared to other provinces. This confirms the findings of a report by Statistics Canada on income inequality and mortality among the working-age (22 to 64) population. In this report, Saskatchewan was found the least equal province in Canada; however, there was no statistically significant relationship between income inequality and mortality across Canadian provinces (164). Given that there is evidence highlighting a gap in avoidable mortality between First Nations and non-Indigenous adults (91), one reason behind the persistent high inequality in mortality in Saskatchewan could be the relatively high proportion of |Indigenous people residing in this province; in 2016, 16.3% of Saskatchewan population were identified as Indigenous people, while this number was 4.9% for Canada as a whole (165). On the other hand, in the current study, British Columbia and Ontario were consistently among the lowest unequal provinces across all mortality indicators.

Previously, James et al. compared mortality rates between five regions in Canada, namely the Atlantic region (including the provinces Prince Edward Island, Newfoundland, Nova Scotia, and New Brunswick), the Prairies region (including the provinces Manitoba, Saskatchewan, and Alberta), Ontario, British Columbia, and Quebec, between 1975 and 1999; over these years, avoidable mortality rates in Ontario and British Columbia were consistently lower than other regions. In this period, Ontario had the lowest mortality from injuries, and British Columbia experienced the lowest mortality due to IHD. For lung cancer mortality, Ontario, British Columbia, and the Prairies shared the lowest rates compared to other regions. For other causes, provincial differences narrowed over the study period, until reaching a small difference by 1990-1994 (34). In the *Health Indicators 2012* report by CIHI, the provincial variation in mortality is investigated between 1979 and 2008; the highest preventable mortality in this period was seen in Manitoba and Saskatchewan. Examining the cause-specific mortality rates across different jurisdictions, CIHI argued that one of the drivers of provincial variation in preventable mortality was deaths due to injuries; Manitoba and Saskatchewan experienced significantly higher mortality due to injuries compared to other provinces (24). This is supported by James et al.' findings, in that, between 1975 and 1999, the largest regional differences in avoidable mortality were due to injuries (34).

These findings can serve to inform policy makers; given the provincial variation in inequality found in this study, indicating Saskatchewan and Manitoba to be among the most unequal provinces, and previous findings by CIHI, suggesting that Saskatchewan and Manitoba experienced significantly higher mortality due to injuries (24), it seems that deaths due to injuries could be targeted to reduce inequity in mortality across these provinces. Furthermore, James et al. found that Ontario and British Columbia had the lowest death rates due to injuries over the years 1975 to 1999, while findings of the current thesis show that these two provinces were among the lowest unequal provinces. Nevertheless, future studies on cause-specific mortality and the related inequalities are warranted to provide more meaningful recommendations. Furthermore, future studies examining avoidable health outcomes may consider focusing on how different policy initiatives in different jurisdictions are related to socioeconomic inequality in avoidable mortality.

At the city level, the highest income inequality was seen in Winnipeg and Quebec. A report on income inequality and mortality in 1991 suggested that among 53 metropolitan areas in Canada, Montreal was the least equal in terms of income. It should be also mentioned that this report did not find a statistically significant relationship between income inequality and mortality across these 53 cities at the time (164). These findings support the need for more examination on contributing conditions to inform policy.

In the end, it should be noted that due to the complex nature of disease development and death events, not every death considered avoidable in this study was truly avoidable. Many factors, including health risk factors, disease incidence, disease severity, physical and social environment, and other determinants of health could potentially contribute to a death event. Therefore, it is difficult to relate an ‘avoidable’ death to a specific health care intervention. Notwithstanding, avoidable mortality is a valuable indicator of population health and a useful tool, providing insights into outcomes pertinent to the organization and delivery of health care services and indicating where further research is warranted.

5.3 Limitations

There are a number of limitations in the scoping review done in the first phase of this thesis. There was only one reviewer screening the articles' titles/abstracts and full texts. This could lead to bias despite the rigorous inclusion/exclusion criteria. I tried to address this problem by bringing controversial cases to the research team's attention to come up with a comprehensive decision that was applied when screening the remaining articles. Furthermore, many articles were excluded due to the age eligibility criteria. Although it seems unlikely that these excluded articles might have changed the results of the current scoping review, the exclusion of these articles might have still introduced some bias in this study. I decided to have this exclusion criteria anyway, for the sake of consistency in the final included articles. Had I decided not to have this criterion, I should have kept literature which was not the focus of this review, such as articles examining infant mortality.

Furthermore, there are some limitations to acknowledge when interpreting the results of the second phase of this thesis. The unit of analysis in inequality measurement was dissemination area, while a validated method, this level of analysis may not always reflect individual level inequality. Furthermore, When CVSD data needed to be translated by PCCF+ (in calculating CMA-level mortality rates and inequality at all levels), about %0.6 of CVSD did not have postal codes, and therefore, these death events had to be eliminated as the postal codes were needed to assign CMAs or DAs to deaths using PCCF+. Although the proportion of the mortalities without recorded postal codes was low, the characteristics of these deaths were examined to see if there was a pattern in missing postal codes. The age and sex distribution across these records were similar to the total population, and approximately 70% and 20% of these records has happened in Ontario and Alberta respectively. Hence, it seems that dropping these observations did not significantly affect the final results of this study.

This study was cross-sectional in nature, and therefore, one cannot comment on the causality of income for mortality. Additionally, any changes in mortality rates and the related inequality over time was not captured.

Mortality rates in this study were age-standardized to ignore differences in age-distribution in different populations when comparing rates. Results, however, were not adjusted for sex, which could be a potential source of bias in this study. The best practice in research in which mortality rates are calculated across different populations, is to adjust the rates for both age and sex. Nevertheless, the age-standardized mortality is an acceptable health outcome indicator in this area of research.

The other limitation to acknowledge is that income inequalities were not statistically compared across provinces and cities. Although some cities and provinces were found to have higher income inequality in mortality than others, it is not determined whether this difference is significant or not. Hence, caution should be taken when interpreting the comparison findings of this study.

Finally, it should be noted that because this study derived the income variable from the NHS, the final results are about 10 years old, and may not be representative of the current state. In particular, over the last two years, the pandemic situation might have had an impact on the extent of inequality in different jurisdictions, especially given that each provincial or local public health authority has been employing different approaches to fight COVID-19. Therefore, the magnitude of inequality in mortality across provinces, cities, and even in Canada may have been pronounced or mitigated over the years after the period investigated in this study.

5.4 Future work and recommendation

While there have been several studies on inequality in premature and avoidable mortality in Canada (38,41,42,53,91,160), there is a lack of studies that examined geographical variation, particularly cities, across the country. This thesis assessed inequality in only eight CMAs in Canada. Future studies should investigate inequality in mortality in other cities as well. Examining inequality in mortality in cities such as Saskatoon and Regina is warranted, for, in the current study, Saskatchewan was the most unequal province in the country over the study period.

The geographic variation in inequality found in this study points to the need for future research on identifying the roots of this difference in inequality across jurisdictions. For example, future studies should focus on finding the factors leading to the higher inequality in Saskatchewan compared to British Columbia. Furthermore, as this study only assessed inequality over the period of 2011 to 2015, future research should consider including more years of data to be able to track trends in inequality across provinces and cities.

Moreover, as shown in other research investigating mortality disparity in Canada, the socioeconomic gradient in mortality varies by cause (24,33). Therefore, further research to examine inequality associated with cause-specific avoidable mortalities is warranted, particularly, the sex difference and geographical variation that exist in deaths due to different conditions.

Additionally, examining trends in treatable and preventable mortalities point to gains and loss in population health, attributed to the health system. For example, decreased treatable mortality rates could be, in part, due to improvements in medical care, and decline in preventable mortality rates provides insights on successful strategies in primary prevention, which is often applied through intersectoral collaboration (24). Further, examining geographical variation in cause-specific mortality's time trends could inform policy makers on the effectiveness of preventive measures currently applied in corresponding jurisdiction. For example, exploring deaths due to injury across provinces could lead to evaluate injury prevention and safety promotion policies in different jurisdictions and ultimately be able to identify potential successful interventions.

As using different definitions for avoidable mortality may make interpretation of results across studies difficult and erroneous, it is suggested that future studies use a standard list of avoidable causes of death to avert this problem. As such, it is strongly recommended that future Canadian studies use the CIHI's list of avoidable causes of death (24,39), for this is the first and only list of avoidable causes of death developed to be used in the Canadian context. One example of this issue is a study conducted by Khan et al. on Ontarian immigrants and long-term residents. It was difficult to compare the results of this study with the current thesis' as Khan and colleagues classified premature mortalities into 1) amenable to medical care and public health 2) only amenable to public health and 3) only amenable to medical care (38).

One of the important contributions of this study is to highlight the consistently higher inequality in preventable mortality compared to other mortality indicators. This highlights the need for the improvement of policies whose primary purpose is prevention. Nevertheless, to be able to propose more actionable and evidence-based recommendations, there is a need for more cross-sectional and longitudinal research on inequality in avoidable mortality, at different levels of geography.

Since the findings of this study showed that income inequality existed in all mortality indicators and in all the investigated jurisdictions, none of the thesis hypotheses were rejected. It should be also noted that the focus of this study was mostly on the structural determinants portion of the social determinants of health inequalities are presented in the CSDH framework; the findings of the thesis demonstrate that income is one of the social determinants of health that could be targeted in developing policy initiatives with a goal of tackling health inequalities in the Canadian urban context. In this, upstream interventions should focus on improving social and economic structures to reduce income inequality; for example, reducing the prevalence of poverty. Another strategy to tackle health inequity is to adopt a 'proportionate universalism' point of view in allocating resources and services as a way to mitigate the impacts of income inequality on health. Future studies could explore the optimal mix of interventions by various levels of government to improve health equity.

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APPENDICES

Appendix A: Ethics Exemption Letter

UNIVERSITY OF SASKATCHEWAN

To:	Dr. Cordell Neudorf
Student:	Anousheh Marouzi
Date:	16 November 2021
RE:	Letter of Exemption

Thank you for submitting your project entitled *"Avoidable Mortality"*. This project meets the requirements for exemption status as per **Article 2.2 of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans – TCPS 2 (2018)**, which states "Research does not require REB review when it relies exclusively on information that is:

a. publicly available through a mechanism set out by legislation or regulation and that is protected by law; or
b. in the public domain and the individuals to whom the information refers have no reasonable expectation of privacy."

It should be noted that though your project is exempt of ethics review, your project should be conducted in an ethical manner (i.e. in accordance with the information that you submitted). It should also be noted that any deviation from the original methodology and/or research question should be brought to the attention of the Behavioural Research Ethics Board for further review.

Digitally Approved by Diane Martz, Chair
Behavioural Research Ethics Board
University of Saskatchewan

Appendix B: The list of potentially avoidable causes of death developed by CIHI (24)

Causes of death	ICD-9 codes	ICD-10 codes	Preventable (incidence reduction)	Treatable (case-fatality reduction)
Infections				
Enteritis and other diarrheal disease	001–009	A00–A09	x	—
Tuberculosis	010–018 137	A16–A19 B90 J65	—	x
Vaccine- preventable diseases	032, 033, 036, 037, 038.2 041.5, 045, 052, 055, 056 481, 482.2, 487 320.0, 320.1	A35–A37, A39 A40.3, A41.3 A49.2, A80 B01, B05, B06 J09–J11, J13, J14 G00.0, G00.1	x	—
Selected invasive bacterial infections	034.1, 482.8 041.0	A38, A48.1 A49.1	—	x
Sepsis	038 (except 038.2)	A40 (except A40.3) A41 (except A41.3)	—	x
Malaria	84	B50–B54	—	x
Meningitis	320.2, .3, .8, .9	G00.2, .3, .8, .9	—	x
Cellulitis	035 681, 682	A46 L03	—	x
Pneumonia	480, 482.0, .1, .3, .4 483, 485, 486, 514	J12, J15, J16, J18	—	x
Sexually transmitted infections, except HIV/AIDS	131, 054.1, .7 078.1, 090–098 099.0, .1, .2, .8, .9	A50–A60, A63, A64	x	—
Viral hepatitis	70	B15–B19	x	—
HIV/AIDS	042.0–044.9	B20–B24	x	—
Neoplasms				
Lip, oral cavity and pharynx cancer	140–149	C00–C14	x	—
Esophageal cancer	150	C15	x	—
Stomach cancer	151	C16	x	—
Colorectal cancer	153, 154	C18–C21	—	x
Liver cancer	155	C22	x	—
Lung cancer	162	C33, C34	x	—
Melanoma skin cancer	172	C43	x	—

Non-melanoma skin cancer	173	C44	x	—
Malignant neoplasm of breast	174	C50	—	x (female only)
Cervical cancer	180	C53	—	x
Uterus cancer	179, 182	C54, C55	—	x
Testicular cancer	186	C62	—	x
Bladder cancer	188	C67	—	x
Thyroid cancer	193	C73	—	x
Hodgkin's disease	201	C81	—	x
Leukemia	204.0, .1; 205.1	C91.0, C91.1, C92.1	—	x (age <45)
Benign neoplasms	210–229	D10–D36	—	x
Diseases of the circulatory system				
Rheumatic heart disease	391–398	I01, I02, I05–I09	x	—
Hypertensive diseases	401 402–405	I10 I11–I13, I15	—	x
Cerebrovascular diseases	430–432 433, 434, 436–438	I60–I62 I63–I64, I67, I69	x (50%)	x (50%)
Ischemic heart disease	410–414 423.0, .9; 429.5, .6, .8	I20–I25	x (50%)	x (50%)
Other atherosclerosis	440, 443.9	I70, I73.9	x (50%)	x (50%)
Aortic aneurysm	441	I71	x	—
Venous thromboembolism	415 451 453.9	I26 I80 I82.9	x	—
Diseases of the respiratory system				
Chronic obstructive pulmonary disorders	490–492, 496	J40–J44	x	—
Asthma and bronchiectasis	493, 494	J45, J47	—	x
Acute lower respiratory infections	466	J20, J22	—	x
Upper respiratory infections	034.0, 460–465 470–478	J00–J06 J30–J39	—	x
Lung diseases due to external agents	117.3, 495 500–508 511.0, 518.3	C45, J60–J64, J66–J70, J82, J92	x	—
Adult respiratory distress syndrome	518.5	J80	—	x
Pulmonary edema	518.4	J81	—	x
Abscess of lung and mediastinum; pyothorax	510, 513	J85, J86	—	x
Other pleural disorders	511.9, 512	J90, J93, J94	—	x

Other respiratory disorders	518.0, .1, .2, .8 519.1, .3, .4, .8, .9	J98	—	x
Diseases of the digestive system				
Peptic ulcer disease	531–534	K25–K28	—	x
Diseases of appendix; hernia; disorders of gallbladder, biliary tract and pancreas	540–543 550–553 574–576 577	K35–K38 K40–K46 K80–K83 K85.0, .1, .3, .8, .9 K86.1, .2, .3, .8, .9	—	x
Chronic liver disease (excluding alcohol-related disease)	571.4, .5, .9	K73, K74.0, .1, .2, .6	x	—
Diseases of the genitourinary system				
Nephritis and nephrosis	580–583	N00–N07	—	x
Renal failure	584–586	N17–N19	—	x
Obstructive uropathy, urolithiasis and prostatic hyperplasia	590.8, 591, 592 593.3, .5, .7; 594 598, 599.6, 600	N13, N20, N21, N23 N35, N40	—	x
Inflammatory diseases of genitourinary system	099.4, 614, 615 616.0, .2, .3, .4, .5	N34.1, N70–N73 N75.0, N75.1, N76.4 N76.6	—	x
Disorders resulting from impaired renal tubular function	588	N25	—	x
Infant and maternal causes				
Complications of perinatal period	771.3	A33	x	—
	760–779 (except 779.4)	H31.1, P00–P96	x	—
Congenital malformations, deformations and chromosomal anomalies	740–759	Q00–Q99	—	x
Pregnancy, childbirth and the puerperium	630–676	O00–O99	—	x
Unintentional injuries				
Transport accidents	E800–E848	V01–V99	x	—
Falls	E880–E886, E888	W00–W19	x	—
Other external causes of accidental injury	E887, E900–E909 E911–E928	W20–W64 W75–W99 X10–X39, X50–X59	x	—
Drowning	E910	W65–W74	x	—
Fires and flames	E890–E899	X00–X09	x	—
Accidental poisonings	E850–E858 E860–E869	X40–X49	x	—
Injuries of undetermined intent				
Injuries of undetermined intent	E980–E989	Y10–Y34	x	—

Intentional injuries				
Suicide and self- inflicted injuries	E950–E959	X60–X84, Y87.0	x	—
Assault	E960–E969	X85–X99 Y00–Y09, Y87.1	x	—
Alcohol and drug use disorders				
Alcohol-related diseases, excluding external causes	291, 303, 305.0 357.5, 425.5 535.3 571.0, .1, .2, .3	F10, G31.2 G62.1, I42.6 K29.2 K70, K85.2, K86.0	x	—
Drug use disorders	292, 304, 305 (except 305.0, .1)	F11–F16, F18, F19	x	—
Nutritional, endocrine and metabolic disorders				
Nutritional deficiency anemia	280, 281	D50–D53	x	—
Thyroid disorders	240.0, .9 241.0, .1, .9 242–246	E00–E07	—	x
Diabetes mellitus	250	E10–E14	x (50%)	x (50%)
Adrenal disorders	255	E24, E25, E27	—	x
Congenital metabolic disorders	271.0, .1	E74.0, E74.2	—	x
Neurological disorders				
Epilepsy	345	G40, G41	—	x
Disorders of musculoskeletal system				
Osteomyelitis	730.0, .1, .2, .3	M86	—	x
Adverse effects of medical and surgical care				
Drugs, medicaments and biological substances causing adverse effects in therapeutic use	E930–E949	Y40–Y59	x	—
Misadventures to patients during surgical and medical care	E870–E876	Y60–Y66, Y69	x	—
Medical devices associated with adverse incidents in diagnostic and therapeutic use	No corresponding codes	Y70–Y82	x	—
Surgical and other medical procedures as the cause of abnormal reaction	E878, E879	Y83, Y84	x	—

Appendix C: Search strategy for literature review

Data base	Syntax
Medline	1. (avoidable or preventable or treatable or amenable or untimely or unnecessary).tw. 2. death/ or mortality/ or "cause of death"/ or mortality, premature/ 3. 1 and 2 4. (mortality or death* or mortalities).tw. 5. ((avoidable or preventable or treatable or amenable or untimely or unnecessary) adj (mortality or death* or mortalities)).tw. 6. 3 or 5 7. sociological factors/ or education/ or "social determinants of health"/ or exp socioeconomic factors/ or health care costs/ or health expenditures/ 8. (socioeconomic* or socio-economic* or SES or "social determinant of health" or "social determinants of health" or education* or income* or salar* or wage* or employment or unemployment or job* or occupation* or poor or poverty or low-income or middle-income or "marital status").tw. 9. 7 or 8 10. 6 and 9 11. limit 10 to (english language and yr="2000 - 2020")
Web of Science	TS=((avoidable or preventable or treatable or amenable or untimely or unnecessary) NEAR/0 (mortality or death* or mortalities)) AND TS=(socioeconomic* or socio-economic* or SES or "social determinant of health" or "social determinants of health" or education* or income* or salar* or wage* or employment or unemployment or job* or occupation* or poor or poverty or low-income or middle-income or "marital status") AND LANGUAGE: (English) Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=2000-2020
Scopus	(TITLE-ABS-KEY(avoidable or preventable or treatable or amenable or untimely or unnecessary) PRE/0 TITLE-ABS-KEY(mortality or death* or mortalities)) AND TITLE-ABS-KEY(socioeconomic* or socio-economic* or SES or {social determinant of health} or education* or income* or salar* or wage* or employment or unemployment or job* or occupation* or poor or poverty or low-income or middle-income or {marital status}) AND PUBYEAR > 1999 AND PUBYEAR < 2021 AND LANGUAGE(english)

Appendix D: UPHN members

Health Authority	**Region**
Vancouver Island Health Authority	Victoria, B. C.
Vancouver Coastal Health Region	Vancouver, B. C.
Fraser Health	Surrey, B. C.
Alberta Health Services	Calgary + Edmonton, AB
Saskatchewan Health Authority	Saskatoon + Regina, SK
Winnipeg Regional Health Authority	Winnipeg, MB
Middlesex-London Health Unit	London, ON
Hamilton Public Health	Hamilton, ON
Ottawa Public Health	Ottawa, ON
Peel Public Health	Mississauga, ON
Region of York Public Health	York Region, ON
Toronto Public Health	Toronto, ON
Montreal Public Health	Montreal, QC
Monteregie Health and Social Services Agency	Longueuil, QC
Quebec City Health and Social Services Agency	Quebec City, QC
L'Agence de la sante et des services sociaux de laval	Laval, QC
Centre integre universitaire de sante et de services sociaux de l'Estrie	Estrie/ Sherbrooke, QC
New Brunswick- Saint John Area	Saint John, NB
New Brunswick-Fredericton Area	Fredericton, NB
Capital District Health Authority	Halifax, NS
Eastern Health	St. John's, NL

Appendix E: Statistics Canada - Research Data Centres

"Research Data Centres (RDCs) promote and facilitate research that uses Statistics Canada microdata within secure facilities managed by Statistics Canada. They include University based RDCs, Government based RDCs in Federal and Provincial/Territorial government buildings and Secure Access Points in approved locations where employees from all levels of government can access microdata.

Researchers who become deemed employees of Statistics Canada access a wide variety of data, including social and business surveys, administrative data and linked data. The confidentiality of respondents is protected through the use of policies and procedures that create a culture of confidentiality within the research community." (162)

Appendix F: Comparison of five articles' lists of avoidable causes of death by ICD codes

Article code	1	2	3	4	5
Cause of Death	**ICD-9 Codes**			**ICD-10 Codes**	
Infections					
Enteritis and other diarrhoeal diseases	001-999				
Selected invasive bacterial and protozoal infections					A38-A41, A46, A48.1, B50-B54, G00, G03, J02.0, J13-J15, J18, L03
Intestinal infection			001–009	A00-A09	
Tuberculosis	010-018, 137	010-018, 137	010-018, 137	A15-A19, B90	A15-A19, B90
Other (bacterial) infections (diphtheria, tetanus, poliomyelitis)	023–031, 034–036, 084, 320, 3201–3209, 7700, 7711–2, 7714–9		019–031, 034, 320–322, 381–383, 390–392, 680–686, 711	A36, A35, A80	
Poliomyelitis			45		
Whooping cough			33	A37	
Diphtheria			32		
Tetanus			37		
Measles			55	B05	
Septicaemia			38	A40-A41	
Ear infections	381–383				
(Other acute) Respiratory infections	460–466, 480, 487		460–466		
Influenza			487	J10-J11	
Pneumonia			480-483, 485-486	J12-J18	
Immunisation-preventable	032-033, 037, 045, 055-056, 3200, 7710,7713				
HIV/AIDS	42		42		
Sextually transmitted diseases	090-099, 6140-6145, 6147-6169, 633				
Infections of the urinary system			590-595		
Syphilis			090-097		

Neoplasms					
Hepatitis and liver cancer	070, 155				
Skin cancers	140, 172, 173		173	C44	
Melanoma of skin neoplasm					C43
Non-melanotic skin neoplasm					C44
Colorectal cancer	153-154			C18-C21	C18-C21
Oral cancers	141, 143-6, 148-9, 161				
Lung cancer	162	162	162		
Breast cancer	174	174	174	C50	C50
Cervical cancer (Malignant neoplasm of cervix uteri)	180	180	180	C53	C53
Stomach cancer	151				
(Other) Uterine cancer (Malignant neoplasm of cervix uteri and body of the uterus)	182, 179	182, 179	179, 182	C54, C55	C54, C55
Cancer of bladder					C67
Cancer of testis	186		186	C62	
Eye cancer	190				
Thyroid cancer	193				C73
Hodgkin's disease	201	201	201	C81	C81
Leukaemia	204		204-208	C91-C95	
Lymphoid leukaemia-acute/chronic					C91.0, C91.1
Benign cancers	210–234				D10-D36
Diseases of the Circulatory System					
Rheumatic fever/heart disease	390-398				
Active rheumatic fever			390-392		
Chronic rheumatic heart disease			393-398	I05-I09	

Rheumatic and other valvular heart disease					I01-I09
Hypertensive (heart) disease	401–405, 4372		401–405	I10-I13, I15	I11
Hypertension and cerebrovascular disease		401–405, 430-438			
Cerebrovascular disease			430-438	I60-I69	I60-I69
Ischaemic Heart Disease	410-414	410-414, 429.2	410-414, 429.2	I20-I25	I20-I25
Stroke	431, 433, 434, 436				
Diseases of the Respiratory System					
Chronic obstructive pulmonary disease	490-492, 496		490-492, 496		
Asthma	493	493	493		J45, J46
All respiratory diseases (excl. pneumonia/influenza)				J00-J09, J20-J99	
Diseases of the Digestive System					
Peptic ulcer (Gastric and duodenal ulcer [ulcers])	531–534	531–534	531–534	K25-K27	K25-K28
Acute abdomen					K35-K38, K40-K46 K80-K83, K85, K86, K91.5
Appendicitis	540–543	540–543	540–543	K35-K38	
Cholecystitis/lithiasis (and cholangitis)			574-575.1, 576.1	K80-K81	
Pancreatitis					
Intestinal obstruction	550–553, 560				
(Abdominal) Hernia		550–553	550–553	K40-K46	
Ileus without hernia			560		
Gallbladder disease	574, 57699	575-476			
Cirrhosis of the liver			571		

Diseases of the Genitourinary System					
Acute renal failure	584				
Nephritis and nephrosis			580-589	N00-N07, N17-N19, N25-N27	I12, I13, N00-N09, N17-N19
Obstructive uropathy and prostatic hyperplasia					N13, N20, N21, N35, N40, N99.1
Benign prostatic hyperplasia (Hyperplasia of the prostate)			600	N40	
Infant and Maternal Causes					
Pregnancy complications (maternal mortality)	630–632, 634–676	630–676	630–676	O00-O99	
Perinatal conditions (excluding stillbirths)		760-779	760-779	P00-P96, A33, A34	P03, P05-P95
Low birthweight babies	764-765, 769, 7707				
Sudden Infant Death Syndrome	7980				
Neural tube defects	740-742				
Newborn screening conditions	243, 2552, 2701, 2711				
Congenital anomalies (Birth defects)	743–7466, 7468–7479, 749–757				H31.1, P00, P04, Q00-Q99
Congenital cardiovascular anomalies			745-747	Q20-Q28	
Congenital digestive anomalies			750-751		
Birth trauma and asphyxia	767–768, 7701, 7720, 7723				
Other perinatal conditions	766, 769, 7702–6, 7708–9, 7721–2, 7724–9, 773–779				
Unintentional Injuries					

(Motor vehicle accidents) Road traffic injury	810-829		E810–825		
Accidents/Poisonings/Violence [Injuries]		800-999			
Poisoning	850-869				
Swimming pool injury	8830, 9105, 9106				
Sport injury	8840, 8845, 8860, 9170, 927				
Fire	890-899				
Drowning	910-9104,9107-9109,984				
Intentional Injuries					
Suicide	950–959, 980–989				
Alcohol and Drug Use Disorders					
Alcohol related conditions	291, 303, 3050, 4255, 5353, 5710-3				
Nutritional, Endocrine and Metabolic Disorders					
Nutrition	260-9, 280, 281				
Deficiency anaemias			280-281		
Thyroid disease	240–242, 244		240–246	E00-E07	E00-E07
Diabetes	250		250	E10-E14	E10-E14
Neurological Disorders					
Epilepsy	345		345	G40, G41	G40, G41
Disorders of Musculoskeletal System					
Musculoskeletal infections	680–686, 711, 730				
Osteomyelitis and periostitis			730		
Adverse Effects of Medical and Surgical Care					
Iatrogenic conditions (Misadventure to patients during surgical and medical care)	870–879			Y60-Y69, Y83-Y84	
Other					

Deaths amenable to both medical care/public health		001-999			

Appendix H: Canadian Census of Population - Variables

Variable Identification		Answer Option
Variable Name: **Variable Code:** **Census Label:**	population centre type pop_cntr_ind (pop_cntr 2011) Population centre indicator	1- rural areas 2- small population centres 3- medium population centres 4- large urban populations
Variable Name: **Variable Code:** **Census Label:**	private dwelling doctp Document type classification	2 - occupied private N1 9 - occupied private N2
Variable Name: **Variable Code:** **Census Label:**	dissemination area PRCDDA Province, Census Division, Dissemination Area	
Variable Name: **Variable Code:** **Census Label:**	census metropolitan area cma Census metropolitan area or census agglomeration of current residence	0- Territories (outside CAs) 1- St. John's 5 Bay Roberts 10- Grand Falls-Windsor 15- Corner Brook 105- Charlottetown 110- Summerside 205- Halifax 210- Kentville 215- Truro 220- New Glasgow 225- Cape Breton 305- Moncton 310- Saint John 320- Fredericton 328- Bathurst 329- Miramichi 330- Campbellton 335- Edmundston 403- Matane 404- Rimouski 405- Rivière-du-Loup 406- Baie-Comeau 408- Saguenay 410- Alma

	411- Dolbeau-Mistassini 412- Sept-Îles 421- Québec 428- Saint-Georges 430- Thetford Mines 433- Sherbrooke 437- Cowansville 440- Victoriaville 442- Trois-Rivières 444- Shawinigan 447- Drummondville 450- Granby 452- Saint-Hyacinthe 454- Sorel-Tracy 456- Joliette 459- Saint-Jean-sur-Richelieu 462- Montréal 465- Salaberry-de-Valleyfield 468- Lachute 480 Val-d'Or 481- Amos 485- Rouyn-Noranda 501- Cornwall 502- Hawkesbury 505- Ottawa - Gatineau 512- Brockville 515- Pembroke 516- Petawawa 521- Kingston 522- Belleville 527- Cobourg 528- Port Hope 529- Peterborough 530- Kawartha Lakes 531- Centre Wellington 532- Oshawa 533- Ingersoll 535- Toronto 537- Hamilton 539- St. Catharines - Niagara 541- Kitchener - Cambridge - Waterloo 543- Brantford 544- Woodstock 546- Tillsonburg 547- Norfolk 550- Guelph 553- Stratford 555- London 556- Chatham-Kent 557- Leamington 559- Windsor 562- Sarnia 566- Owen Sound 567- Collingwood 568- Barrie 569- Orillia 571- Midland 575- North Bay

	580- Greater Sudbury / Grand Sudbury 582- Elliot Lake 584- Temiskaming Shores 586- Timmins 590- Sault Ste. Marie 595- Thunder Bay 598- Kenora 602- Winnipeg 605- Steinbach 607- Portage la Prairie 610- Brandon 640- Thompson 705- Regina 710- Yorkton 715- Moose Jaw 720- Swift Current 725- Saskatoon 735- North Battleford 745- Prince Albert 750- Estevan 805- Medicine Hat 806- Brooks 810- Lethbridge 820- Okotoks 821- High River 825- Calgary 826- Strathmore 828- Canmore 830- Red Deer 831- Sylvan Lake 832- Lacombe 833- Camrose 835- Edmonton 840- Lloydminster 845- Cold Lake 850- Grande Prairie 860- Wood Buffalo 865- Wetaskiwin 905- Cranbrook 913- Penticton 915- Kelowna 918- Vernon 920- Salmon Arm 925- Kamloops 930- Chilliwack 932- Abbotsford - Mission 933- Vancouver 934- Squamish 935- Victoria 937- Duncan 938- Nanaimo 939- Parksville 940- Port Alberni 943- Courtenay 944- Campbell River 945- Powell River 950 -Williams Lake

	952- Quesnel 955- Prince Rupert 965- Terrace 970- Prince George 975- Dawson Creek 977- Fort St. John 990- Whitehorse 995- Yellowknife 996- Strong metropolitan influenced zone 997- Moderate metropolitan influenced zone 998- Weak metropolitan influenced zone 999- No metropolitan influenced zone
Variable Name: province **Variable Code:** pr **Census Label:** Province or territory of current residence	10- Newfoundland and Labrador 11- Prince Edward Island 12- Nova Scotia 13- New Brunswick 24- Quebec 35- Ontario 46- Manitoba 47- Saskatchewan 48- Alberta 59- British Columbia 60- Yukon 61- Northwest Territories 62- Nunavut
Variable Name: primary breadwinner **Variable Code:** hmain **Census Label:** Primary Household maintainer	0- person is not primary maintainer 1- person is primary maintainer
Variable Name: household total income **Variable Code:** hhinc **Census Label:** Household total income	continuous
Variable Name: household size **Variable Code:** NUnits **Census Label:** Number of persons in household	continuous
Variable Name: Census area classification **Variable Code:** sac **Census Label:** Statistical Area Classification of residence	1- CMA 2- CA(tracted) 3- CA(untracted) 4- Stong (MIZ) 5- Moderate(MIZ) 6- Weak (MIZ) 7- Mo influence (MIZ) 8- Territories

Variable Name:	probability weight	
Variable Code:	compw2	
Census Label:	Composite Weight	

Appendix I: Canadian Vital Statistics - Death Database - Variables

Variable Identification		**Answer Option**
Variable Label: **Variable Code:**	Usual residence of deceased: geographic code RESIDENCE_PROVINCE_3DIGIT	909 - Canada (province/territory unknown) 910 - Newfoundland and Labrador 911 - Prince Edward Island 912 - Nova Scotia 913 - New Brunswick 924 - Quebec 935 - Ontario 946 - Manitoba 947 - Saskatchewan 948 - Alberta 959 - British Columbia 960 - Yukon 961 - Northwest Territories 962 - Nunavut 970 - Soviet Union (Former USSR) 971 - Czechoslovakia (Former) 972 - Africa 973 - Asia 974 - Europe 975 - South America 976 - Central America 977 - Caribbean 978 - Yugoslavia (Former) 979 - Oceania (STC Code) 899 - At sea 000 - Unknown
Variable Label: **Variable Code:**	Year of event event_year	
Variable Label: **Variable Code:**	Sex of the Deceased sex	1 - Male 2 - Female 9 - Unknown
Variable Label: **Variable Code:**	Age of Deceased: Code age_code	1 - Minutes: For ages between 1 and 59 minutes. If age is 60 minutes, it will be coded as 1 hour. 2 - Hours: For ages between 1 and 23 hours. If age is 24 hours, it will be coded as 1 day. 3 - Days: For ages between 1 and 27 days accordingly. If age unit is equal to 28 days or more, it will be coded as 1 month. 4 - Months: For ages between 1 and 11 months. If

		age is 11 months and 28 days or greater, it will be coded as 1 year. 5 - Years: For ages between 1 and 130 years. 9 - Unknown
Variable Label: **Variable Code:**	Age of Deceased: Value age_value	999 - Unknown
Variable Label: **Variable Code:**	Usual Residence of Deceased: postal code residence_postalcode	
Variable Label: **Variable Code:**	Underlying Cause of Death deaths_cause_4digits	
Variable Label: **Variable Code:**	Institutional Flag instflg	E=School or university residences H=Hospitals I=Hospital (only from building name) N=Nursing home S=Seniors residence P=Prison, jails U=Other Blank=Not applicable (Area not predom inst)

Appendix J: Stata code

```
/*==============================================================================
		MTHIC - Avoidable Mortality
================================================================================
Programmer: Anousheh Marouzi
Task: harmonize NHS data and calculate median income for each DA.
Date started: 20th May, 2021
Last edited: 20th Oct, 2021
================================================================================
Details
================================================================================
steps
		0. setup
		1. open and reduce NHS 2011 data

		X. control

inputs
		1. NHS - 2011 - RAW

outputs
		1. NHS - 2011 - harm
		2. NHS - 2011 - MASTER

==============================================================================*/

* 0. setup
*-------------------------------------------------------------------------------
//name project
		local projectname "Avoidable Mortality"
		local filename "NHS_harm"

//global settings
		set more off, permanently
		clear all

//set directory
		cd "H:\Plante_6734\Avoidable Mortality"

//set ado path
		adopath + ".\ADO"

//open log
		capture log close main
		local date= subinstr(c(current_date)," ","",.)
		log using "./Log/`filename'_`date'.log", name(main) replace

//set graph scheme
		set scheme s1color


* 1. Open and reduce NHS 2011 data
capture program drop reduce_data
```

```
program define reduce_data
*-------------------------------------------------------------------------------------------------------------------------------
//open 2011 census
            use ".\Data\NHS - 2011 - RAW.dta", clear

//keep variables we need
   keep persno frame_id doctp prcdda pcsd cma pcd pr csdtype sac_type            ///
                     pop_cntr_ind hmain age sex hhinc_at nunits compw2

//rename variables
            rename  persno          pid                   //person id
            rename  frame_id        hid                   //household id
            rename  doctp           doc_type              //questionnaire type
            rename  prcdda          da                    //dissemination area
            rename  pcsd            csd                   //census subdivision
            rename  cma             cma                   //census metro area
            rename  pcd             cd                    //census division
            rename  pr              prov                  //province
            rename  csdtype         csd_type              //csd type
*           rename  sac             sac                   //census area classification
            rename  sac_type        sac_type              //census area classification 2006
            rename  pop_cntr_ind    pop_cntr              //population centre indicator
            rename  hmain           main                  //primary breadwinner
            rename  age             age                   //age
            rename  sex             sex                   //sex
            rename  hhinc_at        hhatinc               //household after-tax income
            rename  nunits          hhsize                //household size
            rename  compw2          weight                //probability weight

//recode variables as needed
            gen private= inlist(doc_type,2,9) if !missing(doc_type)     //boolean private dwellings
            gen primary= inlist(main,1) if !missing(main)               //boolean primary breadwinner
            gen urban= inlist(pop_cntr,2,3,4) if !missing(main)         //boolean urban based on pop centre
            replace urban= 0 if !inlist(sac_type,1,2,3)                 //code non-CMA/CA as non-urban
            gen hhsize_adj= sqrt(hhsize)                                //adjusted household size

//generate income varibale
            generate hhatinc_adj = hhatinc/hhsize_adj

//drop unecessary observations
            keep if private          //reduce to private dwellings using questionnaire type
            keep if primary          //reduce to household level by selecting for main breadwinner
            keep if urban            //reduce to urban observations

//collapse to DA level
            collapse (sum) pop=hhsize pop_adj=hhsize_adj total_hhatinc=hhatinc            ///
                        (count) obs=hhatinc_adj (median) income=hhatinc_adj               ///
                        (first) prov cma csd [pw=weight], by(da)

//drop observations with less than 250 pop in DA for vetting reasons
            drop if pop<250
```

```
//save use data
	keep prov cma csd da income

	compress
	save ".\Data\NHS - 2011 - MASTER.dta", replace

end

* X. control
*------------------------------------------------------------------------------------------------------------------------
//reduce NHS data
	reduce_data
```

```
/*==================================================================================
	MTHIC - Avoidable Mortality
==================================================================================
Programmer: Anousheh Marouzi
Task: generate population counts at national, provincial, CMA, and DA level (to use as denominator when
	calculating mortality rates in other do-files) and calculate age-standardization and standard error
	indicators.
Date started: 20th May, 2021
Last edited: 12th Nov, 2021
==================================================================================
	Details
----------------------------------------------------------------------------------
steps
	0. setup
	1. open and harmonize Census 2011
	2. open and harmonize correspondence file
	3. open and harmonize Census 2016 and change 2016da to 2011da using
	   correspondence file
	4. calculate population counts between years 2011 and 2016
	5. calculate age-standardization and standard error indicators

	X. control

inputs
	1. Census - 2011 - RDC - RAW
	2. Census - 2016 - RAW
	3. DA correspondence - 2011-16 - RAW.csv

outputs
	1. Census - 2011 - harm - woinst
	2. Census - 2011 - harm - winst
	3. Census - 2011 - harm - woinst - MASTER
	4. Census - 2011 - harm - winst - MASTER
	5. land correspondence - 2011-16 - harm
	6. Census - 2016 - harm - woinst
	7. Census - 2016 - harm - winst
	8. Census - 2016 - harm - woinst - MASTER
	9. Census - 2016 - harm - winst - MASTER
	10. counts - between 2011-15 - `geo level' - woinst
	11. counts - between 2011-15 - `geo level' - winst
	12. stdw - w_se - `geo level' - 2011-15 - woinst - MASTER
	13. stdw - w_se - `geo level' - 2011-15 - winst - MASTER
==================================================================================*/
* 0. setup
*---------------------------------------------------------------------------------
//name project
	local projectname "Avoidable Mortality"
	local filename "DA counts (RDC) - stdw"

//global settings
	set more off, permanently
	clear all
```

```
//set directory
	cd "H:\Plante_6734\Avoidable Mortality"

//set ado path
	adopath + ".\ADO"

//open log
	capture log close main
	local date= subinstr(c(current_date)," ","",.)
	log using "./Log/`filename'_`date'.log", name(main) replace

//set graph scheme
	set scheme s1color


* 1. open and harmonize Census 2011
capture program drop harm_cens2011
program define harm_cens2011
*-----------------------------------------------------------------------------------------------------------------------------------
//set macros
	local inst winst woinst

//open dataset
	use ".\Data\Census - 2011 - RDC - RAW.dta", clear

//keep variables we need
	keep weight age prcdda cmaca_hh doctp

//generate prov variable
	tostring prcdda, replace
	gen prov= ustrleft(prcdda,2)

//recode variables
	gen pop_to74_rdc = 1 if age < 75
	gen pop_rdc = 1
	gen private = inlist(doctp,1,2,4,5,7,9) if !missing(doctp)

	rename prcdda da
	rename cmaca_hh cma

	destring da, replace
	destring prov, replace

//calculate weights for age standardization (national, prov, cma)
	//construct age group categories
		gen age_group = .
		replace age_group = 1 if inrange(age,0,4)
		replace age_group = 2 if inrange(age,5,9)
		replace age_group = 3 if inrange(age,10,14)
		replace age_group = 4 if inrange(age,15,19)
		replace age_group = 5 if inrange(age,20,24)
```

```
		replace age_group = 6 if inrange(age,25,29)
		replace age_group = 7 if inrange(age,30,34)
		replace age_group = 8 if inrange(age,35,39)
		replace age_group = 9 if inrange(age,40,44)
		replace age_group = 10 if inrange(age,45,49)
		replace age_group = 11 if inrange(age,50,54)
		replace age_group = 12 if inrange(age,55,59)
		replace age_group = 13 if inrange(age,60,64)
		replace age_group = 14 if inrange(age,65,69)
		replace age_group = 15 if inrange(age,70,74)
		replace age_group = 16 if inrange(age,75,79)
		replace age_group = 17 if inrange(age,80,84)
		replace age_group = 18 if inrange(age,85,89)
		replace age_group = 19 if age>=90

	//calculate and save for with and without institutional records separately
		foreach y of local inst{

		preserve
			if "`y'" == "woinst" {
				keep if private
			}

			//tabulate weighted pop counts with age groups
				egen all_count_nat_11= total(weight)
				bysort prov: egen all_count_prov_11= total(weight)
				bysort  cma: egen all_count_cma_11= total(weight)

				bysort age_group     : egen age_count_nat_11= total(weight)
				bysort age_group  cma: egen age_count_cma_11= total(weight)
				bysort age_group prov: egen age_count_prov_11= total(weight)

			//calculate population aged 0-74
				generate to74_w = pop_to74_rdc * weight

				egen to74_count_nat_11 = total(to74_w)
				bysort cma: egen to74_count_cma_11 = total(to74_w)
				bysort prov: egen to74_count_prov_11 = total(to74_w)

			//save for age-standardization indicator
				gen nat = 1

				compress
				save ".\Data\Census - 2011 - harm - `y'.dta", replace

			//clean up and save for between years counts calculation
				collapse (first) all_count_cma_11 all_count_nat_11			///
					all_count_prov_11 cma prov to74_count_cma_11		///
					to74_count_prov_11 to74_count_nat_11			///
					(sum) to74_count_da_11=pop_to74_rdc			///
					all_count_da_11=pop_rdc [pw=weight], by (da)
```

```
				//drop DA with less than 250 observations to adhere to vetting rules
					drop if all_count_da_11<250

					save ".\Data\Census - 2011 - harm - `y' - MASTER.dta", replace
			restore

			}
end

* 2. open and harmonize correspondense file
capture program drop harm_crsp
program define harm_crsp
*-----------------------------------------------------------------------------------------------------------------------------------
//open data
	import delimited using ".\Data\DA land area correspondence file - 2011-16 - RAW.csv", clear

//rename variables
	rename dauid2016adidu2016 da_16
	rename dauid2011adidu2011 da_11
	rename da_area_percentagead_pourcentage land

//recode land area to use it later as weight for DAs
	replace land = land/100

//collapse to drop duplicates and drop variables we don't need
	collapse (first) land da_11, by(da_16)		//no duplicates

//save
	save ".\Data\land correspondence - 2011-16 - harm.dta", replace
end

* 3. open and harmonize Census 2016 and change 2016da to 2011da using correspondence file
capture program drop harm_cens2016
program define harm_cens2016
*-----------------------------------------------------------------------------------------------------------------------------------
//set macros
	local inst winst woinst

//open data
	use ".\Data\Census - 2016 - RAW.dta", clear

//keep variables we need
	keep compw2 age prcdda pr cma doctp

//rename  variables
	rename compw2 weight
	rename prcdda da_16
	rename pr prov

//generate pop count younger than 75 and total
	gen to74_count_16 = 1 if age < 75
	gen all_count_16 = 1
```

```
	gen private = inlist(doctp,1,2,4,5,7,9,16,17,23,26) if !missing(doctp)

//construct age group categories
	gen age_group = .
	replace age_group = 1 if inrange(age,0,4)
	replace age_group = 2 if inrange(age,5,9)
	replace age_group = 3 if inrange(age,10,14)
	replace age_group = 4 if inrange(age,15,19)
	replace age_group = 5 if inrange(age,20,24)
	replace age_group = 6 if inrange(age,25,29)
	replace age_group = 7 if inrange(age,30,34)
	replace age_group = 8 if inrange(age,35,39)
	replace age_group = 9 if inrange(age,40,44)
	replace age_group = 10 if inrange(age,45,49)
	replace age_group = 11 if inrange(age,50,54)
	replace age_group = 12 if inrange(age,55,59)
	replace age_group = 13 if inrange(age,60,64)
	replace age_group = 14 if inrange(age,65,69)
	replace age_group = 15 if inrange(age,70,74)
	replace age_group = 16 if inrange(age,75,79)
	replace age_group = 17 if inrange(age,80,84)
	replace age_group = 18 if inrange(age,85,89)
	replace age_group = 19 if age>=90

//calculate and save for with and without institutional records separately
	foreach y of local inst{

	preserve
		if "`y'" == "woinst" {
		   keep if private
		}

		//tabulate weighted pop counts
			egen all_count_nat_16= total(weight)
			bysort prov: egen all_count_prov_16= total(weight)
			bysort  cma: egen all_count_cma_16= total(weight)

			bysort age_group     : egen age_count_nat_16= total(weight)
			bysort age_group  cma: egen age_count_cma_16= total(weight)
			bysort age_group prov: egen age_count_prov_16= total(weight)

		//save for age-standardization indicator
			gen nat = 1

			compress
			save ".\Data\Census - 2016 - harm - `y'.dta", replace


		//merge with correspondense file to translate 2016DA to 2011DA
			merge m:m da_16 using ".\Data\land correspondence - 2011-16 - harm.dta", nogen
```

```
			//generate new weight variable to consider land area percentage when changing 2016da to 
2011da
				gen weight_land = weight * land

			//collapse to DA to get DA counts
				collapse (first) all_count_cma_16 all_count_nat_16 all_count_prov_16		///
					cma prov (sum) all_count_da_16=all_count_16				///
					to74_count_da_16=to74_count_16 [pw=weight_land] , by (da_11)

			//rename DA variable
				rename da_11 da

			//calculate population younger than 75 in each cma/prov and in Canada
				egen to74_count_nat_16 = total(to74_count_da_16)
				bysort cma: egen to74_count_cma_16 = total(to74_count_da_16)
				bysort prov: egen to74_count_prov_16 = total(to74_count_da_16)

			//collapse to DA and drop variables we don't need
				collapse (first) all_count_cma_16 all_count_nat_16 all_count_prov_16		///
					to74_count_nat_16 to74_count_cma_16 to74_count_prov_16 cma prov ///
					(sum) all_count_da_16 to74_count_da_16, by (da)

			//drop DA with less than 250 observations to adhere to vetting rules
				drop if all_count_da_16<250

			//clean up and save
				compress
				save ".\Data\Census - 2016 - harm - `y' - MASTER.dta", replace
		restore

		}
end

* 4. calculate population counts between years 2011 and 2016
capture program drop calc_btw_counts
program define calc_btw_counts
*---------------------------------------------------------------------------------------------------------------------------------------------
//set macros
		local level da cma prov nat
		local inst winst woinst

//calculate and save for with and without institutional records separately
		foreach y of local inst{

			//open Census 2011
				use ".\Data\Census - 2011 - harm - `y' - MASTER.dta", clear

			//merge with Census 2016
				merge 1:1 da using ".\Data\Census - 2016 - harm - `y' - MASTER.dta", nogen

			//generate national variable to collapse to it later
				gen nat = 1
```

```
			//calculate all counts for years 2012-15
				foreach x of local level {

			preserve
				//calculate the difference between 2011 and 2016
					gen dif5_11_16_`x' = (all_count_`x'_16 - all_count_`x'_11)/5
					gen dif5_to74_11_16_`x' = (to74_count_`x'_16 - to74_count_`x'_11)/5

				//construct national/provincial/municipal/da counts for years 2012-15
					foreach i of numlist 2/5 {
						gen all_count_`x'_1`i' = all_count_`x'_11 + (`i' - 1) *
dif5_11_16_`x'
						gen to74_count_`x'_1`i' = to74_count_`x'_11 +			///
							(`i' - 1) * dif5_to74_11_16_`x'
					}
				//collapse and save
					collapse all_count_`x'_11 all_count_`x'_12 all_count_`x'_13		///
						all_count_`x'_14 all_count_`x'_15 to74_count_`x'_11		///
						to74_count_`x'_12 to74_count_`x'_13 to74_count_`x'_14		///
						to74_count_`x'_15, by (`x')

					save ".\Data\counts - between 2011-15 - `x' - `y'.dta", replace
			restore

			}
		}
end

* 5. calculate age-standardization and standard error indicators
capture program drop calc_stdw_wse
program define calc_stdw_wse
*------------------------------------------------------------------------------------------------------------------------
//set macros
		local level cma prov nat
		local inst winst woinst

//calculate and save for with and without institutional records and geo level separately
		foreach y of local inst{
			foreach x of local level{
			//open between years data
				use ".\Data\counts - between 2011-15 - `x' - `y'.dta", clear

			//merge with 2011 and 2016 data
				merge 1:m `x' using ".\Data\Census - 2011 - harm - `y'.dta", nogen

				merge m:m age_group `x' using ".\Data\Census - 2016 - harm - `y'.dta", nogen

			//drop variables we don't need
				if "`x'" != "nat"{
					collapse (first) all_count_`x'_11 all_count_`x'_12			///
						all_count_`x'_13 all_count_`x'_14 all_count_`x'_15		///
```

```
				age_count_`x'_11 age_count_`x'_16 age_count_nat_11		///
				all_count_nat_11, by (`x' age_group)
		}

		if "`x'" == "nat"{
			collapse (first) all_count_`x'_11 all_count_`x'_12			///
			all_count_`x'_13 all_count_`x'_14 all_count_`x'_15			///
			age_count_`x'_11 age_count_`x'_16, by (`x' age_group)
		}

	//calculate age group counts between years 2011 and 2016
		gen dif5_age_11_16_`x' = (age_count_`x'_16 - age_count_`x'_11)/5

		foreach i of numlist 2/5 {
			gen age_count_`x'_1`i' = age_count_`x'_11 + (`i' - 1) * dif5_age_11_16_`x'
		}

	//for each year
		foreach i of numlist 1/5 {
			//construct age-standardization and standard error indicators
				gen stdw_`x'Xnat_1`i' =
(age_count_nat_11*all_count_`x'_1`i')/(age_count_`x'_1`i'*all_count_nat_11)
				gen w_se_`x'Xnat_1`i' =
(age_count_nat_11*age_count_nat_11)/(all_count_nat_11*all_count_nat_11*age_count_`x'_1`i')
		}

	//collapse and save
		collapse (first) w_se_`x'Xnat_11 w_se_`x'Xnat_12			///
		w_se_`x'Xnat_13 w_se_`x'Xnat_14 w_se_`x'Xnat_15				///
		stdw_`x'Xnat_11 stdw_`x'Xnat_12 stdw_`x'Xnat_13				///
		stdw_`x'Xnat_14 stdw_`x'Xnat_15 age_count_`x'_11			///
		age_count_`x'_12 age_count_`x'_13 age_count_`x'_14			///
		age_count_`x'_15, by(age_group `x')

		save ".\Data\stdw - w_se - `x' - 2011-15 - `y' - MASTER.dta", replace
	}
}
end

* X. control
*--------------------------------------------------------------------------------------------------------------------------
//harmonize Census 2011
	harm_cens2011

//harmonize correspondence file
	harm_crsp

//harmonize Census 2016
	harm_cens2016

//calculate between years counts
	calc_btw_counts
```

```
//calculate age-standardization and SE weights
        calc_stdw_wse
```

```
/*==============================================================================
	MTHIC - Avoidable Mortality
================================================================================

Programmer: Anousheh Marouzi
Task: Open VSD 2011-2015 and keep place of usual residence and cause of death. Delete institutional records.
	Harmonize and append 2011-2015. Create frequency tables.
Date started: 17th May, 2021
Last edited: Jan 18, 2022
================================================================================
	Details
================================================================================
steps
	0. setup
	1. identify postal codes with institutional death records
	2. open and reduce VSD 2011-2015
	3. append VSD 2011-2015
	4. delete institutional records and prepare to use in PCCF+
	5. create frequency tables
	6. export frequency tables

	X. control

inputs
	1. VSD - 2011 - RAW
	2. VSD - 2012 - RAW
	3. VSD - 2013 - RAW
	4. VSD - 2014 - RAW
	5. VSD - 2015 - RAW
	6. VSD inst - 2011 - RAW
	7. VSD inst - 2012 - RAW
	8. VSD inst - 2013 - RAW
	9. VSD inst - 2014 - RAW
	10. VSD inst - 2015 - RAW

outputs
	1. VSD - 2011 - harm
	2. VSD - 2012 - harm
	3. VSD - 2013 - harm
	4. VSD - 2014 - harm
	5. VSD - 2015 - harm
	6. VSD - 2011-15 - appended
	7. VSD inst - 2011 - reduced
	8. VSD inst - 2012 - reduced
	9. VSD inst - 2013 - reduced
	10. VSD inst - 2014 - reduced
	11. VSD inst - 2015 - reduced
	12. VSD inst - 2011-15 - appended
	13. VSD - 2011-15 - MASTER
	14. freq - `geo level'

==============================================================================*/
```

```
* 0. setup
*--------------------------------------------------------------------------------------------------------------------------------------
//name project
	local projectname "Avoidable Mortality"
	local filename "VSD 2011-15 harm"

//global settings
	set more off, permanently
	clear all

//set directory
	cd "H:\Plante_6734\Avoidable Mortality"

//set ado path
	adopath + ".\ADO"

//open log
	capture log close main
	local date= subinstr(c(current_date)," ","",.)
	log using "./Log/`filename'_`date'.log", name(main) replace

//set graph scheme
	set scheme s1color


* 1. identify postal codes with institutional death records
capture program drop identify_inst
program define identify_inst
*--------------------------------------------------------------------------------------------------------------------------------------

//open and reduce CVSD_inst for years 2011 to 2015
	foreach i of numlist 1/5{
		use ".\Data\VSD inst - 201`i' - RAW.dta", clear

		//reduce data
			collapse (first) instflag, by(pcode)

		//save
			save ".\Data\VSD inst - 201`i' - reduced.dta", replace
	}

//append CVSD_inst 2011 to 2015
	//open first dataset
		use ".\Data\VSD inst - 2011 - reduced.dta", clear

	//append CVSD 2011-2015
		foreach i of numlist 2/5 {
			append using ".\Data\VSD inst - 201`i' - reduced.dta"
		}

	//collapse to pcode
		collapse (first) instflag, by(pcode)
```

```
	//save
		save ".\Data\VSD inst - 2011-15 - appended.dta", replace
end

* 2. open and reduce VSD 2011-2015
capture program drop reduce_cvsd
program define reduce_cvsd
*----------------------------------------------------------------------------------------------------------------------------------
//open CVSD 2011 to 2015 and reduce data
	foreach i of numlist 1/5{
		use ".\Data\VSD - 201`i' - RAW.dta", clear

	//reduce data
		keep event_year sex age_code age_value residence_province_3digit	///
			residence_postalcode death_cause_4digits

	//recode age variable
		destring age_value, replace
		destring age_code, replace

		//replace minutes and hours to years
			replace age_value=0 if age_code==1
			replace age_value=0 if age_code==2
			replace age_value=0 if age_code==3
			replace age_value=0 if age_code==4

		drop age_code

	//drop death occured outside of Canada
		destring residence_province_3digit, replace
		drop if  residence_province_3digit <910

	//rename variables
		rename event_year year
		rename age_value age
		rename residence_province_3digit prov
	//	rename residence_censusdivision cd
	//	rename residence_censussubdivision csd
		rename residence_postalcode pcode
		rename death_cause_4digits ICD_10
	//	rename placeofdeath_locality inst

	//clean up and save
		compress
		save ".\Data\VSD - 201`i' - harm.dta", replace
	}

end


* 3. append VSD 2011-2015
```

```
capture program drop append_cvsd
program define append_cvsd
*-------------------------------------------------------------------------------------------------------------------------------------
//open first dataset
	use ".\Data\VSD - 2011 - harm.dta", clear

//append CVSD 2011-2015
	foreach i of numlist 2/5 {
		append using ".\Data\VSD - 201`i' - harm.dta"
	}

//recode sex
	replace sex="male"   if sex=="1"
	replace sex="female" if sex=="2"

//clean up and save
	compress
	save ".\Data\VSD - 2011-15 - appended.dta", replace

//prepare to use in PCCF+ for mortality rates municipal level
	drop if missing(pcode)

	generate ID =_n
	tostring ID, replace

	save ".\Data\VSD - 2011-15 - appended - pccf input.dta", replace
end


* 4. delete institutional records and prepare to use in PCCF+
capture program drop drop_inst
program define drop_inst
*------------------------------------------------------------------------------------------------------------------------------------
//open dataset
	use ".\Data\VSD - 2011-15 - appended.dta", replace

//merge with VSD inst data
	merge m:1 pcode using ".\Data\VSD inst - 2011-15 - appended.dta"			///
		,nogen keep(1 3) //only 14 obs were not matched

//delete institutional records
	keep if missing(instflag)

//generate ID to use in PCCF+
	generate ID =_n
	tostring ID, replace

//delete missing variables
	drop if missing(pcode)

//clean up and save
	compress
```

```
	save ".\Data\VSD - 2011-15 - MASTER.dta", replace

//save a dataset for using in PCCF+
	keep ID pcode
	save ".\Data\PCCF\pccf_input.dta", replace
end


* 5. create frequency tables
capture program drop freq_tab
program define freq_tab
*------------------------------------------------------------------------------------------------------------------------------------
//set macros
	local level cma prov nat
	local ind all prem AM pre tre

	local preventable ///
			A00 A01 A02 A03 A04 A05 A06 A07 A08 A09 A35 A36 A37 A39 A403	///
			A413 A492 A80 B01 B05 B06 J09 J10 J11 J13 J14 G000 G001		///
			A50 A51 A52 A53 A54 A55 A56 A57 A58 A59 A60 A63 A64			///
			B15 B16 B17 B18 B19 B20 B21 B22 B23 B24					///
			C00 C01 C02 C03 C04 C05 C06 C07 C08 C09 C10 C11 C12 C13 C14		///
			C15 C16 C22 C33 C34 C43 C44						///
			I01 I02 I05 I06 I07 I08 I09 I71 I26 I80 I829					///
			J40 J41 J42 J43 J44 C45 J60 J61 J62 J63 J64 J66 J67 J68 J69		///
			J70 J82 J92								///
			K73 K740 K741 K742 K746 A33						///
			H31.1 P V W X								///
			Y10 Y11 Y12 Y13 Y14 Y15 Y16 Y17 Y18 Y19 Y20 Y21 Y22 Y23 Y24 Y25	///
			Y26 Y27 Y28 Y29 Y30 Y31 Y32 Y33 Y34					///
			Y870 Y00 Y01 Y02 Y03 Y04 Y05 Y06 Y07 Y08 Y09 Y871			///
			F10 G312 G621 I426 K292 K70 K852 K860					///
			F11 F12 F13 F14 F15 F16 F18 F19						///
			D50 D51 D52 D53								///
			Y4 Y5 Y60 Y61 Y62 Y63 Y64 Y65 Y66 Y69 Y7 Y80 Y81 Y82 Y83 Y84

	local treatable ///
			A16 A17 A18 A19 B90 J65 A38 A481 A491					///
			A400 A401 A402 A404 A405 A406 A407 A408 A409				///
			A410 A411 A412 A414 A415 A416 A417 A418 A419				///
			B50 B51 B52 B53 B54							///
			G002 G003 G008 G009 A46 L03	J12 J15 J16 J18				///
			C18 C19C20 C21 C50 C53 C54 C55 C62 C67 C73 C81				///
			C910 C911 C921								///
			D1 D2 D30 D31 D32 D33 D34 D35 D36					///
			I10 I11 I12 I13 I15							///
			J45 J47 J20 J22 J00 J01 J02 J03 J04 J05 J06				///
			J3 J80 J81 J85 J86							///
			J90 J93 J94 J98								///
			K25 K26 K27 K28 K35 K36 K37 K38 K40 K41 K42 K43 K44 K45 K46		///
			K80 K81 K82 K83 K850 K851 K853 K858 K859				///
			K861 K862 K863 K868 K869						///
```

```
                    N00 N01 N02 N03 N04 N05 N06 N07 N17 N18 N19 N13 N20 N21 N23         ///
                    N35 N40 N341 N70 N71 N72 N73 N750 N751 N764 N766 N25                ///
                    Q O                                                                 ///
                    E00 E01 E02 E03 E04 E05 E06 E07 E24 E25 E27 E740 E742               ///
                    G40 G41 M86

        //causes which are 50% treatable and 50% preventable
        local pre_tre ///
                    I60 I61 I62 I63 I64 I67 I69 I20 I21 I22 I23 I24 I25 I70 I739    ///
                    E10 E11 E12 E13 E14

        local avoidable `preventable' `treatable' `pre_tre'

//create frequency tables for mortality rates at different geo levels
        foreach x of local level{
                foreach y of local ind{
                //open data
                    if "`x'" != "cma" {
                        use ".\Data\VSD - 2011-15 - appended.dta", clear

                        //recode province variable to match Census data
                            tostring prov, replace
                            replace prov = subinstr(prov,"9","",1)
                            destring prov, replace

//                          destring year, replace

                        //merge with VSD inst data
                            merge m:1 pcode using ".\Data\VSD inst - 2011-15 - appended.dta"
///
                                ,nogen keep(1 3)

                        //generate national variable to be used later
                            gen nat = 1

                        //save
                            save ".\Data\VSD - prov - 2011-15 - MASTER.dta", replace
                    }

                    if "`x'" == "cma" {
                        //import pccf output to get cmas
                            import delimited ".\Data\PCCF\for cma rates\out.csv", clear

                            keep id pcode cma
                            rename id ID
                            tostring ID, replace

                        //merge with death data
                            merge 1:1 ID using ".\Data\VSD - 2011-15 - appended - pccf
input.dta", nogen

                        //merge with VSD inst data
```

```
                    merge m:1 pcode using ".\Data\VSD inst - 2011-15 - appended.dta" ///
                        ,nogen keep(1 3)

                //keep the eight most populous cities
                    keep if inlist(cma,421,462,505,535,602,825,835,933)

                //save
                    save ".\Data\VSD - cma - 2011-15 - MASTER.dta", replace
            }


//identify all_cause mortalities
        if "`y'" == "all" {
                generate all = 1
                generate all_inst = 1 if !missing(instflag)
                generate all_f = 1 if sex =="female"
                generate all_m = 1 if sex =="male"
                generate all_age = age
        }

//identify premature mortalities
        if "`y'" == "prem"{
                generate prem = 1 if age<75
                generate prem_inst = 1 if age<75 & !missing(instflag)
                generate prem_f = 1 if age<75 & sex =="female"
                generate prem_m = 1 if age<75 & sex =="male"
                generate prem_age = age if age<75
        }


//prepare data to identify AM, treatable and preventable mortality rates
        //generate younger than 45 years old
                generate age45=1 if age<45
                replace age45=0 if missing(age45)


//identify avoidable mortalities
        if "`y'" == "AM"{

        //drop males with breast cancer
                drop if inlist(ICD_10, "C50") & sex == "male"
        //drop persons 45 years or older with specific leukemia
                drop if inlist(ICD_10, "C910", "C911", "C921") & age45 == 0

                generate AM = .
                generate AM_inst = .
                generate AM_f = .
                generate AM_m = .
                generate AM_age = .

                foreach z of local avoidable{
```

```
					replace AM = 1 if regexm(ICD_10, "^`z'") & age<75
					replace AM_inst = 1 if regexm(ICD_10, "^`z'") & age<75 & 
!missing(instflag)
					replace AM_f = 1 if regexm(ICD_10, "^`z'") & age<75 & sex == 
"female"
					replace AM_m = 1 if regexm(ICD_10, "^`z'") & age<75 & sex == 
"male"
					replace AM_age = age if regexm(ICD_10, "^`z'") & age<75
				}

			}

		//identify preventable mortalities
			if "`y'" == "pre"{

			//drop males with breast cancer
				drop if inlist(ICD_10, "C50") & sex == "male"
			//drop persons 45 years or older with specific leukemia
				drop if inlist(ICD_10, "C910", "C911", "C921") & age45 == 0

				generate pre = .
				generate pre_inst = .
				generate pre_f = .
				generate pre_m = .
				generate pre_age = .

				foreach z of local preventable{
					replace pre = 1 if regexm(ICD_10, "^`z'") & age<75
					replace pre_inst = 1 if regexm(ICD_10, "^`z'") & age<75 & 
!missing(instflag)
					replace pre_f = 1 if regexm(ICD_10, "^`z'") & age<75 & sex == 
"female"
					replace pre_m = 1 if regexm(ICD_10, "^`z'") & age<75 & sex == 
"male"
					replace pre_age = age if regexm(ICD_10, "^`z'") & age<75
				}

				foreach z of local pre_tre{
					replace pre = 0.5 if regexm(ICD_10, "^`z'") & age<75
					replace pre_inst = 0.5 if regexm(ICD_10, "^`z'") & age<75 & 
!missing(instflag)
					replace pre_f = 0.5 if regexm(ICD_10, "^`z'") & age<75 & sex == 
"female"
					replace pre_m = 0.5 if regexm(ICD_10, "^`z'") & age<75 & sex == 
"male"
					replace pre_age = age if regexm(ICD_10, "^`z'") & age<75
				}

			}

		//identify treatable mortalities
			if "`y'" == "tre"{
```

```
				//drop males with breast cancer
					drop if inlist(ICD_10, "C50") & sex == "male"
				//drop persons 45 years or older with specific leukemia
					drop if inlist(ICD_10, "C910", "C911", "C921") & age45 == 0

					generate tre = .
					generate tre_inst = .
					generate tre_f = .
					generate tre_m = .
					generate tre_age = .

					foreach z of local treatable{
						replace tre = 1 if regexm(ICD_10, "^`z'") & age<75
						replace tre_inst = 1 if regexm(ICD_10, "^`z'") & age<75 &
!missing(instflag)
						replace tre_f = 1 if regexm(ICD_10, "^`z'") & age<75 & sex ==
"female"
						replace tre_m = 1 if regexm(ICD_10, "^`z'") & age<75 & sex ==
"male"
						replace tre_age = age if regexm(ICD_10, "^`z'") & age<75
					}

					foreach z of local pre_tre{
						replace tre = 0.5 if regexm(ICD_10, "^`z'") & age<75
						replace tre_inst = 0.5 if regexm(ICD_10, "^`z'") & age<75 &
!missing(instflag)
						replace tre_f = 0.5 if regexm(ICD_10, "^`z'") & age<75 & sex ==
"female"
						replace tre_m = 0.5 if regexm(ICD_10, "^`z'") & age<75 & sex ==
"male"
						replace tre_age = age if regexm(ICD_10, "^`z'") & age<75
					}
				}

			//generate a variable for mortality category
				gen mortality_type = "`y'"

			//calculate death counts in each mortality category
				collapse (first) mortality_type (sum) total_death=`y'				///
					total_inst_death=`y'_inst female=`y'_f male=`y'_m		///
					(mean)age_mean=`y'_age (sd)age_sd=`y'_age, by ( year `x')

			//save
				save ".\Data\freq - `x' - `y'.dta", replace
			}
		}


//append frequency tables of different mortality types at different geo levels
		//set macros
			local mtype prem AM pre tre
			local level cma prov nat
```

```
	//append freq tables at different geo levels
	foreach x of local level{

		//open first dataset
			use ".\Data\freq - `x' - all.dta", clear

		//append freq tables
			foreach y of local mtype{
				append using ".\Data\freq - `x' - `y'.dta"
			}

		//save
			save ".\Data\freq - appended - `x'.dta", replace
	}

/*/reshape frequency tables
	foreach x of local level{
		//open data
			use ".\Data\freq - appended - `x'.dta", clear

		//recode mortality type for using xpose command later
			replace mortality_type = "1" if mortality_type == "all"
			replace mortality_type = "2" if mortality_type == "prem"
			replace mortality_type = "3" if mortality_type == "AM"
			replace mortality_type = "4" if mortality_type == "pre"
			replace mortality_type = "5" if mortality_type == "tre"

			destring mortality_type, replace

		//round for vetting reasons
			replace total_death = round(total_death, 5)
			replace total_inst_death = round(total_inst_death, 5)
			replace female = round(female, 5)
			replace male = round(male, 5)

		//reshape dataset
			reshape wide total_death total_inst_death female male age_mean,		///
				i(mortality_type) j(`x')

		//transpose dataset
			xpose, clear varname

		//rename variables
			rename v1 all_cause_mortality
			rename v2 premature_mortality
			rename v3 avoidable_mortality
			rename v4 preventable_mortality
			rename v5 treatable_mortality

			rename _varname freq
```

```
		//generate geo level variable and recode charachteristics variable
			local prov_c 10 11 12 13 24 35 46 47 48 59 60 61 62
			local cma_c 421 462 505 535 602 825 835 933

			if "`x'" == "prov"{
				generate prov = substr(freq,-2,2)

				foreach c of local prov_c {
					replace freq = subinstr(freq,"`c'","",1)
				}
			}

			if "`x'" == "cma"{
				generate cma = substr(freq,-3,3)

				foreach c of local cma_c {
					replace freq = subinstr(freq,"`c'","",1)
				}
			}

		//order and save
			if "`x'" == "cma" {
				order cma freq
			}

			if "`x'" == "prov" {
				order prov freq
			}

			if "`x'" == "nat" {
				order freq
			}

			drop in 1

			save ".\Data\freq - `x'.dta", replace
	}*/
end

* 6. export frequency tables
capture program drop release_freq
program define release_freq
*------------------------------------------------------------------------------------------------------------------------------
//set macros
	local level cma prov nat

//export in excel
	foreach x of local level{
		//open data
			use ".\Data\freq - appended - `x'.dta", clear

		//define lables for provinces
```

```
			if "`x'" == "prov" {
				destring prov, replace
				label define provinces 10 "NFL"				///
							11 "PEI"				///
							12 "NS"				///
							13 "NB"				///
							24 "Quebec"				///
							35 "ON"				///
							46 "Manitoba"				///
							47 "SK"				///
							48 "Alberta"				///
							59 "BC"				///
							60 "Yukon"				///
							61 "NWT"				///
							62 "Nunavut"

				label values prov provinces
			}

		//define lables for cmas
			if "`x'" == "cma" {
				destring cma, replace
				label define cities 421 "Quebec"				///
						462 "Montreal"				///
						505 "Ottawa - Gatineau"				///
						535 "Toronto"				///
						602 "Winnipeg"				///
						825 "Calgary"				///
						835 "Edmonton"				///
						933 "Vancouver"

				label values cma cities
			}

		//export
			export excel using ".\Data\to release\freq - `x'.xls",			///
				firstrow(variables) sheet("`x' frequency") replace
	}

end


* X. Control
*------------------------------------------------------------------------------------------------------------------------------------
//identify institutional death pcodes
	identify_inst

//reduce cvsd
	reduce_cvsd

//append cvsd
	append_cvsd
```

```
//delete institutional deaths
        drop_inst

//create frequency tables
        freq_tab

//release frequency tables
        release_freq
```

```
/*==============================================================================
	MTHIC - Avoidable Mortality
================================================================================
Programmer: Anousheh Marouzi
Task: merge VSD, NHS, and Census into one dataset. calculate all-cause, premature, potentially avoidable,
	preventable, and treatable mortality rates at DA, cma, provincial, and national levels in Canada.
start date: May 18th, 2021
last update: November 9th, 2021
================================================================================
	Details
--------------------------------------------------------------------------------
Steps
	0. setup
	1. merge NHS with 2011-2015 VSD, pccf output, and Census 2011-16 (pop counts) to be used in DA-
level MR calculation
	2. calculate DA-level age-standardized mortality rates (all-cause, premature, avoidable, preventable,
treatable)
	3. calculate national/provincial/municipal age-standardized mortality rates
	4. calculate Standard Error
	5. merge mortality rates and SEs for each geo level  and calculate 95% Confidence Interval
	6. export mortality rates for release

	X. control

inputs
	1. outt.csv
	2. VSD - 2011-15 - MASTER
	3. NHS - 2011 - MASTER
	4. counts - between 2011-15 - `level'
	5. stdw - w_se - prov - 2011-15 - MASTER
	6. stdw - w_se - cma - 2011-15 - MASTER
	7. VSD - 2011-15 - appended
	8. out.csv
	9. VSD - 2011-15 - appended - pccf input

outputs
	1. VSD NHS Census - 2011-2015 - MASTER
	2. death and pop counts - DA - `geo level' - `mortality indicator'
	3. DA - `mortality indicator' rates - `geo level'
	4. VSD Census stdw - prov - 2011-15 - MASTER
	5. VSD Census stdw - cma - 2011-15 - MASTER
	6. death and pop counts - `geo level' - `mortality indicator'
	7. `mortality indicator' rates - `geo level'
==============================================================================*/

* 0. setup
*-------------------------------------------------------------------------------
//name project
	local projectname "Avoidable Mortality"
	local filename "calc AM - MCA"

//global settings
```

```
	set more off, permanently
	clear all

//set directory
	cd "H:\Plante_6734\Avoidable Mortality"

//set global
	set more off, permanently

//set ADO path
	adopath + ".\ADO\acround"

//set log
	capture log close main
	local date = subinstr(c(current_date)," "," ",.)
	log using "./log/`filename'_`date'.log", name(main) replace

//set graph scheme
	set scheme s1color


* 1. merge NHS with 2011-2015 VSD, pccf output, and Census 2011-16 (pop counts) to be used in DA-level
MR calculation
capture program drop merge_data
program define merge_data
*---------------------------------------------------------------------------------------------------------------------------
//open PCCF+ output for VSD 2011-2015 (without institutional obs)
	import delimited ".\Data\PCCF\outt.csv", clear

	//keep variables we need
		keep id dauid pr cma csduid

	//rename variables
		rename id ID
		rename dauid da
		rename pr prov
		rename csduid csd

		tostring ID, replace

//merge with VSD - 2011-2015 - harm (without institutional obs)
	merge 1:1 ID using ".\Data\VSD - 2011-15 - MASTER.dta", nogen

	//drop missing observations
		drop if missing(da)

	//keep variables we need
		keep ID da prov csd cma age sex ICD_10 year

	//rename variables
		rename ID id
```

```
//merge with NHS - harm (income and quintiles)
        merge m:1 da using ".\Data\NHS - 2011 - MASTER.dta", nogen keep(1 3)

//merge with Census (DA counts)
        merge m:1 da using ".\Data\counts - between 2011-15 - da - woinst.dta"///
                , nogen keep(1 3)

//clean up and save
        compress
        save ".\Data\VSD NHS Census - 2011-2015 - MASTER.dta", replace

end


* 2. calculate DA-level age-standardized mortality rates (all-cause, premature, avoidable, preventable, treatable)
capture program drop calc_da_mr
program define calc_da_mr
*------------------------------------------------------------------------------------------------------------------------------------
//set macros
        //avoidable, treatable, and preventable causes of death
                local preventable ///
                        A00 A01 A02 A03 A04 A05 A06 A07 A08 A09 A35 A36 A37 A39 A403        ///
                        A413 A492 A80 B01 B05 B06 J09 J10 J11 J13 J14 G000 G001             ///
                        A50 A51 A52 A53 A54 A55 A56 A57 A58 A59 A60 A63 A64                 ///
                        B15 B16 B17 B18 B19 B20 B21 B22 B23 B24                             ///
                        C00 C01 C02 C03 C04 C05 C06 C07 C08 C09 C10 C11 C12 C13 C14         ///
                        C15 C16 C22 C33 C34 C43 C44                                         ///
                        I01 I02 I05 I06 I07 I08 I09 I71 I26 I80 I829                        ///
                        J40 J41 J42 J43 J44 C45 J60 J61 J62 J63 J64 J66 J67 J68 J69         ///
                        J70 J82 J92                                                         ///
                        K73 K740 K741 K742 K746 A33                                         ///
                        H31.1 P V W X                                                       ///
                        Y10 Y11 Y12 Y13 Y14 Y15 Y16 Y17 Y18 Y19 Y20 Y21 Y22 Y23 Y24 Y25     ///
                        Y26 Y27 Y28 Y29 Y30 Y31 Y32 Y33 Y34                                 ///
                        Y870 Y00 Y01 Y02 Y03 Y04 Y05 Y06 Y07 Y08 Y09 Y871                   ///
                        F10 G312 G621 I426 K292 K70 K852 K860                               ///
                        F11 F12 F13 F14 F15 F16 F18 F19                                     ///
                        D50 D51 D52 D53                                                     ///
                        Y4 Y5 Y60 Y61 Y62 Y63 Y64 Y65 Y66 Y69 Y7 Y80 Y81 Y82 Y83 Y84

                local treatable ///
                        A16 A17 A18 A19 B90 J65 A38 A481 A491                               ///
                        A400 A401 A402 A404 A405 A406 A407 A408 A409                        ///
                        A410 A411 A412 A414 A415 A416 A417 A418 A419                        ///
                        B50 B51 B52 B53 B54                                                 ///
                        G002 G003 G008 G009 A46 L03    J12 J15 J16 J18                      ///
                        C18 C19C20 C21 C50 C53 C54 C55 C62 C67 C73 C81                      ///
                        C910 C911 C921                                                      ///
                        D1 D2 D30 D31 D32 D33 D34 D35 D36                                   ///
                        I10 I11 I12 I13 I15                                                 ///
                        J45 J47 J20 J22 J00 J01 J02 J03 J04 J05 J06                         ///
                        J3 J80 J81 J85 J86                                                  ///
```

```
                    J90 J93 J94 J98                                                       ///
                    K25 K26 K27 K28 K35 K36 K37 K38 K40 K41 K42 K43 K44 K45 K46           ///
                    K80 K81 K82 K83 K850 K851 K853 K858 K859                              ///
                    K861 K862 K863 K868 K869                                              ///
                    N00 N01 N02 N03 N04 N05 N06 N07 N17 N18 N19 N13 N20 N21 N23           ///
                    N35 N40 N341 N70 N71 N72 N73 N750 N751 N764 N766 N25                  ///
                    Q O                                                                   ///
                    E00 E01 E02 E03 E04 E05 E06 E07 E24 E25 E27 E740 E742                 ///
                    G40 G41 M86

        //causes which are treatable and preventable
            local pre_tre ///
                    I60 I61 I62 I63 I64 I67 I69 I20 I21 I22 I23 I24 I25 I70 I739          ///
                    E10 E11 E12 E13 E14

            local avoidable `preventable' `treatable' `pre_tre'


        //mortality indicators and geographic level by which we want to compare inequality later
            local level cma prov nat
            local ind all prem AM pre tre


//calculate mortality rates at different geo levels
        foreach x of local level{
          foreach y of local ind{

//open dataset
        use ".\Data\VSD NHS Census - 2011-2015 - MASTER.dta", clear

        //construct age group categories to merge with age-standardization later
            gen age_group = .
            replace age_group = 1 if inrange(age,0,4)
            replace age_group = 2 if inrange(age,5,9)
            replace age_group = 3 if inrange(age,10,14)
            replace age_group = 4 if inrange(age,15,19)
            replace age_group = 5 if inrange(age,20,24)
            replace age_group = 6 if inrange(age,25,29)
            replace age_group = 7 if inrange(age,30,34)
            replace age_group = 8 if inrange(age,35,39)
            replace age_group = 9 if inrange(age,40,44)
            replace age_group = 10 if inrange(age,45,49)
            replace age_group = 11 if inrange(age,50,54)
            replace age_group = 12 if inrange(age,55,59)
            replace age_group = 13 if inrange(age,60,64)
            replace age_group = 14 if inrange(age,65,69)
            replace age_group = 15 if inrange(age,70,74)
            replace age_group = 16 if inrange(age,75,79)
            replace age_group = 17 if inrange(age,80,84)
            replace age_group = 18 if inrange(age,85,89)
            replace age_group = 19 if age>=90
```

```
//drop observations with missing income (excluding urban areas) and da counts
	drop if missing(income)

	foreach i of numlist 1/5{
		drop if missing(all_count_da_1`i') & year == "201`i'"
	}

//generate national variable to use levelsof command later
	generate nat = 1

//prepare data to calculate AM, treatable and preventable mortality rates
	//generate younger than 45 years old
		generate age45=1 if age<45
		replace age45=0 if missing(age45)

	  //merge with age-standardization indicators
			if "`x'" != "cma"{
				destring year, replace
				merge m:1 age_group `x' using ".\Data\stdw - w_se - `x' - 2011-15 - woinst - 
MASTER.dta", nogen
			}

			if "`x'" == "cma" {
				destring year, replace
				merge m:1 age_group `x' using ".\Data\stdw - w_se - `x' - 2011-15 - woinst - 
MASTER.dta", nogen

				//keep the eight most populous cities
					keep if inlist(cma,421,462,505,535,602,825,835,933)
			}

		//set age-standardization indicator
			local stdw "stdw_`x'Xnat"

			//generate ONE age-standardization var for all years
				gen `stdw' = .

				foreach i of numlist 1/5{
					replace `stdw' = `stdw'_1`i' if year == 201`i'
				}

	//identify all_cause mortalities
		if "`y'" == "all" {
			generate all = 1
		}

	//identify premature mortalities
		if "`y'" == "prem"{
			generate prem = 1 if age<75
		}

//identify avoidable mortalities
```

```
	if "`y'" == "AM"{
		generate AM = .
		foreach z of local avoidable{
			replace AM = 1 if regexm(ICD_10, "^`z'") & age<75
		}

		//replace AM for males with breast cancer
			replace AM=0 if inlist(ICD_10, "C50") & sex == "male"
		//replace AM for persons 45 years or older with specific leukemia
			replace AM=0 if inlist(ICD_10, "C910", "C911", "C921") & age45 == 0
	}

//identify preventable mortalities
	if "`y'" == "pre"{
		generate pre = .
		foreach z of local preventable{
			replace pre = 1 if regexm(ICD_10, "^`z'") & age<75
		}

		foreach z of local pre_tre{
			replace pre = 0.5 if regexm(ICD_10, "^`z'") & age<75
		}

		//replace pre for males with breast cancer
			replace pre=0 if inlist(ICD_10, "C50") & sex == "male"
		//replace pre persons 45 years or older with specific leukemia
			replace pre=0 if inlist(ICD_10, "C910", "C911", "C921") & age45 == 0
	}

//identify treatable mortalities
	if "`y'" == "tre"{
		generate tre = .
		foreach z of local treatable{
			replace tre = 1 if regexm(ICD_10, "^`z'") & age<75
		}

		foreach z of local pre_tre{
			replace tre = 0.5 if regexm(ICD_10, "^`z'") & age<75
		}

		//replace tre for males with breast cancer
			replace tre=0 if inlist(ICD_10, "C50") & sex == "male"
		//replace pre persons 45 years or older with specific leukemia
			replace tre=0 if inlist(ICD_10, "C910", "C911", "C921") & age45 == 0

	}

//calculate and age-standardize numerators
	if "`y'" == "all" {
		collapse (first) `x' all_count_da_11 all_count_da_12				///
			all_count_da_13 all_count_da_14 all_count_da_15				///
			income (sum) all [pw=`stdw'], by (year da)
```

```
		}

		if "`y'" != "all" {
			collapse (first) `x' to74_count_da_11 to74_count_da_12				///
				to74_count_da_13 to74_count_da_14 to74_count_da_15			///
				income (sum) `y' [pw=`stdw'], by (year da)
		}

	//save
		save ".\Data\death and pop counts - DA - `x' - `y'.dta", replace
		}
}


//calculate mortality RATES
	foreach x of local level{
		foreach y of local ind{
			//open dataset contaning numerators and denominators
				use ".\Data\death and pop counts - DA - `x' - `y'.dta", clear

			//generate denominator and round numerator and denominator
				if "`y'" == "all"{
					generate tot_pop_nr = .

					foreach i of numlist 1/5{
					   destring year, replace
						replace tot_pop_nr = all_count_da_1`i' if year == 201`i'
					}

				//round numerator and denominator
					generate tot_pop = tot_pop_nr
					drop tot_pop_nr

					generate tot_death = all

					//calculate rates
						generate r_all = (tot_death/tot_pop) *100000

					//get an average of mortality rates in years 2011-15
						bysort da: egen r_all_11to15_mean = mean(r_all)

					//get an average of population counts in DAs in years 2011-15 to be
used as weigh when calculating concentration indices
				gen tot_pop_da_11to15_mean = (all_count_da_11 +			///
					all_count_da_12 + all_count_da_13 + all_count_da_14 +	///
					all_count_da_15)/5
				}

				if "`y'" != "all"{
					generate tot_pop_0to74_nr = .

					foreach i of numlist 1/5{
```

```
					destring year, replace
						replace tot_pop_0to74_nr = to74_count_da_1`i' if year ==
201`i'
					}

				//round numerator and denominator
					generate tot_pop_0to74 = tot_pop_0to74_nr
					drop tot_pop_0to74_nr

					generate tot_`y'_death = `y'

					//calculate rates
						generate r_`y' = (tot_`y'_death / tot_pop_0to74) *100000

					//get an average of mortality rates in years 2011-15 (numerator)
						bysort da: egen r_`y'_11to15_mean = mean(r_`y')

					//get an average of population counts in DAs in years 2011-15 to be
used as weigh when calculating concentration indices
						gen tot_pop_da_0to74_11to15_mean =
(to74_count_da_11 +	///
							to74_count_da_12 + to74_count_da_13 +
to74_count_da_14 +	///
							to74_count_da_15)/5
			}

			//save
				save ".\Data\DA - rates - `y' - `x'.dta", replace
		}
	}

end


* 3. calculate national/provincial/municipal age-standardized MRs
capture program drop calc_mr
program define calc_mr
*-----------------------------------------------------------------------------------------------------------------------------------
//set macros
	local level cma prov nat
	local ind all prem AM pre tre

	local preventable ///
			A00 A01 A02 A03 A04 A05 A06 A07 A08 A09 A35 A36 A37 A39 A403	///
			A413 A492 A80 B01 B05 B06 J09 J10 J11 J13 J14 G000 G001	///
			A50 A51 A52 A53 A54 A55 A56 A57 A58 A59 A60 A63 A64	///
			B15 B16 B17 B18 B19 B20 B21 B22 B23 B24	///
			C00 C01 C02 C03 C04 C05 C06 C07 C08 C09 C10 C11 C12 C13 C14	///
			C15 C16 C22 C33 C34 C43 C44	///
			I01 I02 I05 I06 I07 I08 I09 I71 I26 I80 I829	///
			J40 J41 J42 J43 J44 C45 J60 J61 J62 J63 J64 J66 J67 J68 J69	///
			J70 J82 J92	///
```

```
					K73 K740 K741 K742 K746 A33								///
					H31.1 P V W X								///
					Y10 Y11 Y12 Y13 Y14 Y15 Y16 Y17 Y18 Y19 Y20 Y21 Y22 Y23 Y24 Y25	///
					Y26 Y27 Y28 Y29 Y30 Y31 Y32 Y33 Y34							///
					Y870 Y00 Y01 Y02 Y03 Y04 Y05 Y06 Y07 Y08 Y09 Y871				///
					F10 G312 G621 I426 K292 K70 K852 K860						///
					F11 F12 F13 F14 F15 F16 F18 F19							///
					D50 D51 D52 D53										///
					Y4 Y5 Y60 Y61 Y62 Y63 Y64 Y65 Y66 Y69 Y7 Y80 Y81 Y82 Y83 Y84

	local treatable ///
					A16 A17 A18 A19 B90 J65 A38 A481 A491						///
					A400 A401 A402 A404 A405 A406 A407 A408 A409					///
					A410 A411 A412 A414 A415 A416 A417 A418 A419					///
					B50 B51 B52 B53 B54									///
					G002 G003 G008 G009 A46 L03	J12 J15 J16 J18					///
					C18 C19C20 C21 C50 C53 C54 C55 C62 C67 C73 C81				///
					C910 C911 C921										///
					D1 D2 D30 D31 D32 D33 D34 D35 D36							///
					I10 I11 I12 I13 I15									///
					J45 J47 J20 J22 J00 J01 J02 J03 J04 J05 J06					///
					J3 J80 J81 J85 J86									///
					J90 J93 J94 J98										///
					K25 K26 K27 K28 K35 K36 K37 K38 K40 K41 K42 K43 K44 K45 K46		///
					K80 K81 K82 K83 K850 K851 K853 K858 K859					///
					K861 K862 K863 K868 K869								///
					N00 N01 N02 N03 N04 N05 N06 N07 N17 N18 N19 N13 N20 N21 N23		///
					N35 N40 N341 N70 N71 N72 N73 N750 N751 N764 N766 N25			///
					Q O												///
					E00 E01 E02 E03 E04 E05 E06 E07 E24 E25 E27 E740 E742			///
					G40 G41 M86

	//causes which are treatable and preventable
	local pre_tre ///
					I60 I61 I62 I63 I64 I67 I69 I20 I21 I22 I23 I24 I25 I70 I739		///
					E10 E11 E12 E13 E14

	local avoidable `preventable' `treatable' `pre_tre'

//calculate age-standardized mortality rates at different geo levels
	foreach x of local level{
		foreach y of local ind{
		//open data
			if "`x'" != "cma" {
				use ".\Data\VSD - 2011-15 - appended.dta", clear

				//construct age group categories to merge with age-standardization indicator
					gen age_group = .
					replace age_group = 1 if inrange(age,0,4)
					replace age_group = 2 if inrange(age,5,9)
					replace age_group = 3 if inrange(age,10,14)
					replace age_group = 4 if inrange(age,15,19)
```

```
replace age_group = 5 if inrange(age,20,24)
replace age_group = 6 if inrange(age,25,29)
replace age_group = 7 if inrange(age,30,34)
replace age_group = 8 if inrange(age,35,39)
replace age_group = 9 if inrange(age,40,44)
replace age_group = 10 if inrange(age,45,49)
replace age_group = 11 if inrange(age,50,54)
replace age_group = 12 if inrange(age,55,59)
replace age_group = 13 if inrange(age,60,64)
replace age_group = 14 if inrange(age,65,69)
replace age_group = 15 if inrange(age,70,74)
replace age_group = 16 if inrange(age,75,79)
replace age_group = 17 if inrange(age,80,84)
replace age_group = 18 if inrange(age,85,89)
replace age_group = 19 if age>=90

//recode province variable to match Census data
tostring prov, replace
replace prov = subinstr(prov,"9","",1)
destring prov, replace

destring year, replace

//merge with population counts to get denominators
gen nat = 1

merge m:1 `x' using ".\Data\counts - between 2011-15 - `x' -
winst.dta", nogen

//merge with age-standardization indicators
merge m:1 age_group `x' using ".\Data\stdw - w_se - `x' - 2011-15
- winst - MASTER.dta", nogen

//save
save ".\Data\VSD Census stdw - `x' - 2011-15 - MASTER.dta",
replace
}

if "`x'" == "cma" {
//import pccf output to get cmas
import delimited ".\Data\PCCF\for cma rates\out.csv", clear

keep id pcode cma
rename id ID
tostring ID, replace

//merge with death data
merge 1:1 ID using ".\Data\VSD - 2011-15 - appended - pccf
input.dta", nogen

//construct age group categories to merge with age-standardization indicator
gen age_group = .
```

```
					replace age_group = 1 if inrange(age,0,4)
					replace age_group = 2 if inrange(age,5,9)
					replace age_group = 3 if inrange(age,10,14)
					replace age_group = 4 if inrange(age,15,19)
					replace age_group = 5 if inrange(age,20,24)
					replace age_group = 6 if inrange(age,25,29)
					replace age_group = 7 if inrange(age,30,34)
					replace age_group = 8 if inrange(age,35,39)
					replace age_group = 9 if inrange(age,40,44)
					replace age_group = 10 if inrange(age,45,49)
					replace age_group = 11 if inrange(age,50,54)
					replace age_group = 12 if inrange(age,55,59)
					replace age_group = 13 if inrange(age,60,64)
					replace age_group = 14 if inrange(age,65,69)
					replace age_group = 15 if inrange(age,70,74)
					replace age_group = 16 if inrange(age,75,79)
					replace age_group = 17 if inrange(age,80,84)
					replace age_group = 18 if inrange(age,85,89)
					replace age_group = 19 if age>=90

				//merge with population counts to get denominators
					merge m:1 cma using ".\Data\counts - between 2011-15 - cma -
winst.dta", nogen

				//merge with age-standardization indicators
					destring year, replace
					merge m:1 age_group `x' using ".\Data\stdw - w_se - `x' - 2011-15
- winst - MASTER.dta", nogen

				//keep the eight most populous cities
					keep if inlist(cma,421,462,505,535,602,825,835,933)

				//save
					save ".\Data\VSD Census stdw - cma - 2011-15 - MASTER.dta",
replace
			}


	//prepare data to calculate AM, treatable and preventable mortality rates
		//generate younger than 45 years old
			generate age45=1 if age<45
			replace age45=0 if missing(age45)

	//set age-standardization indicator at different geo levels
		local stdw "stdw_`x'Xnat"

		//generate ONE age-standardization car for all years
			gen `stdw' = .
			foreach i of numlist 1/5{
				replace `stdw' = `stdw'_1`i' if year == 201`i'
			}
```

```
//identify all_cause mortalities
	if "`y'" == "all" {
		generate all = 1
	}

//identify premature mortalities
	if "`y'" == "prem"{
		generate prem = 1 if age<75
	}

//identify avoidable mortalities
	if "`y'" == "AM"{
	//drop males with breast cancer
		drop if inlist(ICD_10, "C50") & sex == "male"
	//drop persons 45 years or older with specific leukemia
		drop if inlist(ICD_10, "C910", "C911", "C921") & age45 == 0

		generate AM = .
		foreach z of local avoidable{
			replace AM = 1 if regexm(ICD_10, "^`z'") & age<75
		}
	}

//identify preventable mortalities
	if "`y'" == "pre"{
	//drop males with breast cancer
		drop if inlist(ICD_10, "C50") & sex == "male"
	//drop persons 45 years or older with specific leukemia
		drop if inlist(ICD_10, "C910", "C911", "C921") & age45 == 0

		generate pre = .
		foreach z of local preventable{
			replace pre = 1 if regexm(ICD_10, "^`z'") & age<75
		}

		foreach z of local pre_tre{
			replace pre = 0.5 if regexm(ICD_10, "^`z'") & age<75
		}
	}

//identify treatable mortalities
	if "`y'" == "tre"{
	//drop males with breast cancer
		drop if inlist(ICD_10, "C50") & sex == "male"
	//drop persons 45 years or older with specific leukemia
		drop if inlist(ICD_10, "C910", "C911", "C921") & age45 == 0

		generate tre = .
		foreach z of local treatable{
			replace tre = 1 if regexm(ICD_10, "^`z'") & age<75
		}
```

```
				foreach z of local pre_tre{
					replace tre = 0.5 if regexm(ICD_10, "^`z'") & age<75
				}
			}

		//calculate and age-standardize numerators
			if "`y'" == "all" {
				collapse (first) all_count_`x'_11 all_count_`x'_12					///
					all_count_`x'_13 all_count_`x'_14 all_count_`x'_15				///
					(sum) all [pw=`stdw'], by (year `x')
			}

			if "`y'" != "all" {
				collapse (first) to74_count_`x'_11 to74_count_`x'_12					///
					to74_count_`x'_13 to74_count_`x'_14 to74_count_`x'_15			///
					(sum) `y' [pw=`stdw'], by (year `x')
			}

		//save
			save ".\Data\death and pop counts - `x' - `y'.dta", replace
			}
		}


	//calculate mortality RATES
		foreach x of local level{
			foreach y of local ind{
				//open dataset contaning numerators and denominators
					use ".\Data\death and pop counts - `x' - `y'.dta", clear

				//generate denominator and round numerator and denominator
					if "`y'" == "all"{
						generate total_population_nr = .

						foreach i of numlist 1/5{
							replace total_population_nr = all_count_`x'_1`i' if year ==
	201`i'
						}

						generate total_population = round(total_population_nr, 5)
						drop total_population_nr
						generate total_death = round(all, 5)

						//calculate rates
							generate all_mortality_rate =
	(total_death/total_population) *100000
					}

					if "`y'" != "all"{
						generate total_population_aged_0to74_nr = .
```

```
                                        foreach i of numlist 1/5{
                                                replace total_population_aged_0to74_nr = 
to74_count_`x'_1`i' if year == 201`i'
                                        }

                                        generate total_population_aged_0to74 = 
round(total_population_aged_0to74_nr, 5)
                                        drop total_population_aged_0to74_nr

                                        generate total_`y'_death = round(`y', 5)
                                        //calculate rates
                                                generate `y'_mortality_rate = (total_`y'_death / 
total_population_aged_0to74) *100000

                        }

                        //save
                                save ".\Data\rates - `y' - `x'.dta", replace

                }
        }

end


* 4. calculate Standard Error
capture program drop calc_se
program define calc_se
*---------------------------------------------------------------------------------------------------------------------------------
//set macros
        local level cma prov nat

        local ind all prem AM pre tre

        local preventable ///
                        A00 A01 A02 A03 A04 A05 A06 A07 A08 A09 A35 A36 A37 A39 A403      ///
                        A413 A492 A80 B01 B05 B06 J09 J10 J11 J13 J14 G000 G001          ///
                        A50 A51 A52 A53 A54 A55 A56 A57 A58 A59 A60 A63 A64              ///
                        B15 B16 B17 B18 B19 B20 B21 B22 B23 B24                          ///
                        C00 C01 C02 C03 C04 C05 C06 C07 C08 C09 C10 C11 C12 C13 C14      ///
                        C15 C16 C22 C33 C34 C43 C44                                      ///
                        I01 I02 I05 I06 I07 I08 I09 I71 I26 I80 I829                     ///
                        J40 J41 J42 J43 J44 C45 J60 J61 J62 J63 J64 J66 J67 J68 J69      ///
                        J70 J82 J92                                                      ///
                        K73 K740 K741 K742 K746 A33                                      ///
                        H31.1 P V W X                                                    ///
                        Y10 Y11 Y12 Y13 Y14 Y15 Y16 Y17 Y18 Y19 Y20 Y21 Y22 Y23 Y24 Y25  ///
                        Y26 Y27 Y28 Y29 Y30 Y31 Y32 Y33 Y34                              ///
                        Y870 Y00 Y01 Y02 Y03 Y04 Y05 Y06 Y07 Y08 Y09 Y871                ///
                        F10 G312 G621 I426 K292 K70 K852 K860                            ///
                        F11 F12 F13 F14 F15 F16 F18 F19                                  ///
                        D50 D51 D52 D53                                                  ///
```

```
                Y4 Y5 Y60 Y61 Y62 Y63 Y64 Y65 Y66 Y69 Y7 Y80 Y81 Y82 Y83 Y84


        local treatable ///
                A16 A17 A18 A19 B90 J65 A38 A481 A491                               ///
                A400 A401 A402 A404 A405 A406 A407 A408 A409                        ///
                A410 A411 A412 A414 A415 A416 A417 A418 A419                        ///
                B50 B51 B52 B53 B54                                                 ///
                G002 G003 G008 G009 A46 L03    J12 J15 J16 J18                      ///
                C18 C19C20 C21 C50 C53 C54 C55 C62 C67 C73 C81                      ///
                C910 C911 C921                                                      ///
                D1 D2 D30 D31 D32 D33 D34 D35 D36                                   ///
                I10 I11 I12 I13 I15                                                 ///
                J45 J47 J20 J22 J00 J01 J02 J03 J04 J05 J06                         ///
                J3 J80 J81 J85 J86                                                  ///
                J90 J93 J94 J98                                                     ///
                K25 K26 K27 K28 K35 K36 K37 K38 K40 K41 K42 K43 K44 K45 K46         ///
                K80 K81 K82 K83 K850 K851 K853 K858 K859                            ///
                K861 K862 K863 K868 K869                                            ///
                N00 N01 N02 N03 N04 N05 N06 N07 N17 N18 N19 N13 N20 N21 N23         ///
                N35 N40 N341 N70 N71 N72 N73 N750 N751 N764 N766 N25                ///
                Q O                                                                 ///
                E00 E01 E02 E03 E04 E05 E06 E07 E24 E25 E27 E740 E742               ///
                G40 G41 M86

        //local causes which are  treatable and  preventable
        local pre_tre ///
                I60 I61 I62 I63 I64 I67 I69 I20 I21 I22 I23 I24 I25 I70 I739        ///
                E10 E11 E12 E13 E14

        local AM `preventable' `treatable' `pre_tre'

//start calculation for each geo level
        foreach x of local level{
            foreach y of local ind{
            //open data
                use ".\Data\VSD Census stdw - `x' - 2011-15 - MASTER.dta", clear

            //prepare data to count AM, treatable and preventable mortalities
                if "`y'" == "AM" | "`y'" == "pre" | "`y'" == "tre" {
                //generate younger than 45 years old
                    generate age45=1 if age<45
                    replace age45=0 if missing(age45)
                //drop males with breast cancer
                    drop if inlist(ICD_10, "C50") & sex == "male"
                //drop persons 45 years or older with specific leukemia
                    drop if inlist(ICD_10, "C910", "C911", "C921") & age45 == 0

            //calculate SE in provinces and cmas
                //identify different types of mortalities
                    generate AM = .
                        foreach z of local AM{
```

```
                    replace AM = 1 if regexm(ICD_10, "^`z'") & age<75
                }

            generate pre = .
                foreach z of local preventable{
                    replace pre = 1 if regexm(ICD_10, "^`z'") & age<75
                }

                foreach z of local pre_tre{
                    replace pre = 0.5 if regexm(ICD_10, "^`z'") & age<75
                }

            generate tre = .
                foreach z of local treatable{
                    replace tre = 1 if regexm(ICD_10, "^`z'") & age<75
                }

                foreach z of local pre_tre{
                    replace tre = 0.5 if regexm(ICD_10, "^`z'") & age<75
                }
        }

preserve
    //merge with w_se for each geo level separately
        merge m:1 age_group `x'
    ///
            using ".\Data\stdw - w_se - `x' - 2011-15 - winst - MASTER.dta",      ///
            nogen keep(1 3)

    //generate ONE w_se variable
        generate w_se_`x' = .

        foreach i of numlist 1/5{
            replace w_se_`x' = w_se_`x'Xnat_1`i' if year == 201`i'
        }

//count all-cause and premature mortalities by age groups and year
    //identify different types of mortalities
        generate all = 1
        generate prem = 1 if age<75

    //generate ONE age_count to use in the SE formula
        generate age_count_nr = .
            foreach i of numlist 1/5{
                replace age_count_nr = age_count_`x'_1`i' if year == 201`i'
            }

    //calculate SE in provinces/cmas
        //collapse and count mortalities in each age group, year, and province/cma (i.e. Ami
in formula)
            collapse (first) w_se_`x' age_count_nr (sum) `y'_n=`y'                ///
                ,by(age_group year `x')
```

```
				//round for vetting reasons
					generate `y'_n_rnd = round(`y', 5)
					generate age_count_rnd = round(age_count_nr)

				//generate the "first" and "second" variables to be able to calculate SE later
					generate in1_se_`y'_`x' = w_se_`x' * `y'_n_rnd * (age_count_rnd -
`y'_n_rnd)
					bysort year `x': egen in2_se_`y'_`x'= total(in1_se_`y'_`x')

				//calculate SE
					generate se_`y'_`x' = sqrt(in2_se_`y'_`x')

			//clean and save
				collapse (first) se_`y'_`x', by(year `x')

				save "./Data/SE - `y' - `x'.dta", replace

		restore
			}
		}

end


* 5. merge mortality rates and SEs and calculate %95 CI
capture program drop merge_mr_se
program define merge_mr_se
*---------------------------------------------------------------------------------------------------------------------------------------
//set macros
	local se_level cma prov nat
	local ind all prem AM pre tre

//merge mortality rates with SE and calculate %95CI for each geo level
	foreach x of local se_level{
		foreach y of local ind{
		//open mortality data
			use "./Data/rates - `y' - `x'.dta", clear

		//merge with SE
			//crude and premature SE
			merge 1:1 `x' year using
			///
				"./Data/SE - `y' - `x'.dta", nogen

		//calculate %95CI
				generate ci_l_`y'_`x' = `y'_mortality_rate - (1.96 * se_`y'_`x')
				generate ci_u_`y'_`x' = `y'_mortality_rate + (1.96 * se_`y'_`x')

		//order
			if "`y'" == "all"{
				order year `x' `y'_mortality_rate total_death				///
```

```
                total_population se_`y'_`x' ci_l_`y'_`x' ci_u_`y'_`x'
        }

        if "`y'" != "all"{
            order year `x' `y'_mortality_rate total_`y'_death                ///
                total_population_aged_0to74 se_`y'_`x' ci_l_`y'_`x'          ///
                ci_u_`y'_`x'
        }

    //delete missing observations
        drop if `x' == 99

    //save
        save "./Data/rates - SE - `y' - `x'.dta", replace
    }
}

end


* 6. export mortality rates for release
capture program drop for_release
program define for_release
*-------------------------------------------------------------------------------------------------------------------------------
//set macros
    local level nat prov cma
    local ind all prem AM pre tre

//append for each geo level
    //harmonize datasets
        foreach x of local level{
            foreach y of local ind{
                //open data
                    use "./Data/rates - SE - `y' - `x'.dta", clear

                    if "`y'" != "all"{
                        rename total_`y'_death total_death
                        rename total_population_aged_0to74 total_population
                    }

                    rename `y'_mortality_rate ASDR
                    rename se_`y'_`x' se
                    rename ci_l_`y'_`x' ci_l
                    rename ci_u_`y'_`x' ci_u

                    gen death_type = "`y'"

                //save
                    save "./Data/rates - SE - `y' - `x' - to append.dta", replace
            }
        }
```

```
local ind prem AM pre tre

foreach x of local level{
	//open data
		use "./Data/rates - SE - all - `x' - to append.dta", clear

			foreach y of local ind{
				append using "./Data/rates - SE - `y' - `x' - to append.dta"
			}

		save "./Data/rates - SE - `x' - appended.dta", replace
}

foreach x of local level{

		use "./Data/rates - SE - `x' - appended.dta", clear

		if "`x'"=="prov" {

		//define labels for provinces
			label define provinces 10 "NFL"				///
						11 "PEI"				///
						12 "NS"					///
						13 "NB"					///
						24 "Quebec"				///
						35 "ON"					///
						46 "Manitoba"				///
						47 "SK"					///
						48 "Alberta"				///
						59 "BC"					///
						60 "Yukon"				///
						61 "NWT"				///
						62 "Nunavut"

			label values prov provinces
		}

		if "`x'"=="cma" {

		//keep the eight most populous cities in Canada
			keep if inlist(cma,421,462,505,535,602,825,835,933)

		//define lables for eight most populous cities in Canada
			label define cities 421 "Quebec"			///
					462 "Montreal"				///
					505 "Ottawa - Gatineau"			///
					535 "Toronto"				///
					602 "Winnipeg"				///
					825 "Calgary"				///
					835 "Edmonton"				///
					933 "Vancouver"
```

```
				label values cma cities
			}

			//drop missing observations
				drop if missing(year)

	//export
		export excel using "./Data/to release/rates - `x'.xls",				///
			firstrow(variables) sheet("`x' mortality rates") replace
		}

end


* X. Control
*----------------------------------------------------------------------------------------------------------------------------------------
//merge VSD and Census datasets
	merge_data

//calculate DA-level mortality rates
	calc_da_mr

//calculate mortality rates
	calc_mr

//calculate SE and 95%CI
	calc_se

//merge mortalities and SEs
	merge_mr_se

//export spreadsheets
	for_release
```

```
/*===============================================================================
	MTHIC - Avoidable Mortality
================================================================================
Programmer: Anousheh Marouzi
Task: calculate Concentration Index (CI) in Canada, in each province, and in each cma
start date: May 31st, 2021
last update: Nov 11th, 2021
================================================================================
	Details
--------------------------------------------------------------------------------
Steps
	0. setup
	1. calculate concentration index
	2. calculate confidence intervals and Standard Error
	3. Merge confidence intervals, SE, and concentration index
	4. prepare data to release

inputs
	1. mortality rates - cma - USE
	2. mortality rates - prov - USEo15
	3. mortality rates - nat - USE

outputs
	1. CI - `mortality indicator' - `geo level'
	2. CI - `geo level'.dta
	3. CI - `geo level'.xls

===============================================================================*/
* 0. setup
*-------------------------------------------------------------------------------
	//name project
		local projectname "Avoidable Mortality"
		local filename "calc CI - MCA"

	//global settings
		set more off, permanently
		clear all

	//set directory
		cd "H:\Plante_6734\Avoidable Mortality"

	//set global
		set more off, permanently

	//set ADO path
		adopath + ".\ADO\conindex"

	//set log
		capture log close main
		local date = subinstr(c(current_date)," "," ",.)
		log using "./log/`filename'_`date'.log", name(main) replace
```

```
	//set graph scheme
		set scheme s1color


* 1. calculate concentration index
capture program drop calc_ci
program define calc_ci
*--------------------------------------------------------------------------------------------------------------------------------------
//set macros
	local ind all prem AM pre tre
	local level cma prov nat

//calculate CI for each geo level and mortality indicator
	foreach x of local level{
	   foreach y of local ind{
			//open dataset
					use ".\Data\DA - rates - `y' - `x'.dta", clear

				//keep the eight most populous cmas
					if "`x'" == "cma" {
					   keep if inlist(cma,421,462,505,535,602,825,835,933)
					}

				//set weight and collapse to DA to be ready for CI calculation
					if "`y'" == "all" {
						local w_da_count tot_pop_da_11to15_mean

						collapse `x' r_all_11to15_mean tot_pop_da_11to15_mean
	///
							income, by(da)
					}

					if "`y'" != "all" {
						local w_da_count tot_pop_da_0to74_11to15_mean

						collapse `x' r_`y'_11to15_mean tot_pop_da_0to74_11to15_mean ///

							income, by(da)
					}

					//make weight variable integer to be able to use with conindex
						replace `w_da_count' = int(`w_da_count')

				//round for vetting reasons
					generate income_rnd = round(income, 5)

				//calculate CI
					levelsof `x', local(`x'_n)
					foreach z of local `x'_n{

			preserve
					//keep one value of geo level
```

```
					keep if `x' == `z'

				//drop observations with zero mean
					qui sum r_`y'_11to15_mean
					if r(mean) != 0 {
						//calculate CI
							conindex r_`y'_11to15_mean [fw=`w_da_count'],
rankvar(income_rnd) bounded limits(0 100000) truezero

						//prepare dataset to save
							generate CI_`y' = r(CI)

							collapse (first) `x' CI_`y'

						//save
							save ".\Data\CI\CI - `y' - `x' - `z'.dta", replace
					}
			restore

				}
		}
	}


//append CIs for each level and each outcome separately
	foreach x of local level{
		foreach y of local ind{
			//open a dataset to levelsof geo levels
				use ".\Data\DA - rates - `y' - `x'.dta", clear

			preserve
				levelsof `x', local(`x'_n)

				//create blank dataset
					drop _all
					generate `x' = .
					generate CI_`y' = .

				//append CI files
					foreach z of local `x'_n{
						append using ".\Data\CI\CI - `y' - `x' - `z'.dta"
					}

				//save
					save ".\Data\CI\CI - `y' - `x'.dta", replace
			restore

				}
		}
end

* 2. calculate confidence intervals and Standard Error
```

```
capture program drop calc_95ci
program define calc_95ci
*-------------------------------------------------------------------------------------------------------------------------------
//set macros
	local ind all prem AM pre tre
	local level nat prov cma

//bootstrap for each geo level and indicator
	foreach x of local level{
		foreach y of local ind{
		//open dataset
			use ".\Data\DA - rates - `y' - `x'.dta", clear

		//save macro for different values in a geo level
			levelsof `x', local(`x'_n)


		//set seed for bootstrapping
			set seed 123456

		//select bootstrap sample
			foreach i of numlist 1/1000{

				preserve
				//select bootstrap sample
					bsample, strata(`x')

				//save a temporary dataset
					save ".\Data\CI\bootstrap\CI - bs - temp.dta", replace

				//calculate CI
						foreach z of local `x'_n{

							//use temporary dataset
								use ".\Data\CI\bootstrap\CI - bs -
temp.dta", clear

							//set weight and collapse to DA to be ready for CI
calculation
								if "`y'" == "all" {
									local w_da_count
tot_pop_da_11to15_mean

									collapse `x' r_all_11to15_mean
			///

	tot_pop_da_11to15_mean income, by(da)
								}

								if "`y'" != "all" {
									local w_da_count
tot_pop_da_0to74_11to15_mean
```

```
collapse `x' r_`y'_11to15_mean ///
    tot_pop_da_0to74_11to15_mean income, by(da)
}

//make weight variable integer to be able to use with conindex
    replace `w_da_count' = int(`w_da_count')

//keep one value of geo level
    keep if `x' == `z'

//calculate concentration index where mortality rates average is not zero
    qui sum r_`y'_11to15_mean
    if r(mean) != 0 {

//calculate CI
    conindex r_`y'_11to15_mean [fw=`w_da_count'], rankvar(income) bounded limits(0 100000) truezero

//prepare dataset to save
    generate CI_`y' = r(CI)

    collapse (first) `x' CI_`y'
    }
//generate missing concentration index for areas with zero mean of mortality rates since conindex doesn't accept variables with zero mean
//  qui sum r_`y'_11to15_mean
    if r(mean) == 0 {
        //prepare dataset to save
            generate CI_`y' = .

            collapse (first) `x' CI_`y'

    }

//save
    save ".\Data\CI\bootstrap\CI - `y' - `x' - `z' - bs`i'.dta", replace
    }
        restore
    }
  }
}
```

```
//set macros
	local ind all prem AM pre tre
	local level nat prov cma

//append bootstrap estimates and calculate %95CI for each cma/prov and Canada
	foreach x of local level{
		foreach y of local ind{
			//open a dataset to levelsof geo levels
				use ".\Data\DA - rates - `y' - `x'.dta", clear

			//save macro for different values in a geo level
				levelsof `x', local(`x'_n)
				foreach z of local `x'_n {
				//open first bootstrap file
					use ".\Data\CI\bootstrap\CI - `y' - `x' - `z' - bs1.dta", clear

				//append CI-bs files
					foreach i of numlist 2/1000 {
						append using ".\Data\CI\bootstrap\CI - `y' - `x' - `z' -
bs`i'.dta"
					}

				//calculate confidence interval
					egen l_ci95_`y' = pctile(CI_`y'), p(5)
					egen u_ci95_`y' = pctile(CI_`y'), p(95)

				//calculate Standard Error
					egen CI_se_`y' = sd(CI_`y')

				//clean up and save
					collapse (first) `x' l_ci95_`y' u_ci95_`y' CI_se_`y'
					save ".\Data\CI\CI - `y' - `x' - `z' - 95ci.dta", replace
				}
		}
	}


//append calculated %95CI and SE for different values of geo levels (z)
	foreach x of local level{
		foreach y of local ind{
		//open a dataset to levelsof geo levels
			use ".\Data\DA - rates - `y' - `x'.dta", clear

			//save macro for different values in a geo level
				levelsof `x', local(`x'_n)

			//create blank dataset
				drop _all
				generate `x' = .
				generate l_ci95_`y' = .
				generate u_ci95_`y' = .
				generate CI_se_`y' = .
```

```
			//append CI files
				foreach z of local `x'_n{
					append using ".\Data\CI\CI - `y' - `x' - `z' - 95ci.dta"
				}

			//save
				save ".\Data\CI\CI - `y' - `x' - 95ci.dta", replace

		}
	}

end

* 3. Merge confidence intervals, SE, and concentration index
capture program drop merge_ci_95ci
program define merge_ci_95ci
*--------------------------------------------------------------------------------------------------------------------------------
//set macros
	local ind all prem AM pre tre
	local level cma prov nat

//merge concentration indices and confidence intervals
	foreach x of local level{
		foreach y of local ind{
		//open CI dataset
			use ".\Data\CI\CI - `y' - `x'.dta", clear

		//merge with 95%CI
			merge 1:1 `x' using ".\Data\CI\CI - `y' - `x' - 95ci.dta", nogen

		//round estimates
			replace CI_`y' =round(CI_`y',0.0001)
			replace CI_se_`y' =round(CI_se_`y',0.0001)

		//generate and rename variables to append later
			gen mtype = "`y'"
			rename CI_`y' CI
			rename CI_se_`y' CI_se
			rename l_ci95_`y' l_ci95
			rename u_ci95_`y' u_ci95

		//clear and save
			keep `x' mtype CI CI_se l_ci95  u_ci95

			save ".\Data\CI - 95ci - `y' - `x'.dta", replace
		}
	}

end

* 4. prepare data to release
```

```
capture program drop to_release
program define to_release
*-------------------------------------------------------------------------------------------------------------------------------------------
//set macros
	local ind prem AM pre tre
	local level nat prov cma

//append for each geo level
	foreach x of local level{
		//open the first dataset
			use ".\Data\CI - 95ci - all - `x'.dta", clear

		//append the rest
			foreach y of local ind{
				append using ".\Data\CI - 95ci - `y' - `x'.dta"
			}

//define lables
	if "`x'"=="prov" {
		//define labels for provinces
			label define provinces 10 "Newfoundland and Labrador"	///
						11 "Prince Edward Island"	///
						12 "Nova Scotia	///
						13 "New Brunswick"	///
						24 "Quebec"	///
						35 "Ontario"	///
						46 "Manitoba"	///
						47 "Saskatchewan"	///
						48 "Alberta"	///
						59 "British Columbia"	///
						60 "Yukon"	///
						61 "Northwest Territories"	///
						62 "Nunavut"

			label values prov provinces
	}

	if "`x'"=="cma" {
		//keep the eight most populous cities in Canada
			keep if inlist(cma,421,462,505,535,602,825,835,933)

		//define lables for eight most populous cities in Canada
			label define cities 421 "Quebec"	///
					462 "Montreal"	///
					505 "Ottawa - Gatineau"	///
					535 "Toronto"	///
					602 "Winnipeg"	///
					825 "Calgary"	///
					835 "Edmonton"	///
					933 "Vancouver"

			label values cma cities
```

```
        }

//export in excel
        export excel using ".\Data\to release\CI - `x'.xls", firstrow(variables) ///
                sheet("estimates") replace

        }

end


* X. Control
*-----------------------------------------------------------------------------------------------------------------------------------------
//calculate concentration index
        calc_ci

//calculate confidence intervals
        calc_95ci

//merge confidence intervals and concentration index
        merge_ci_95ci

//release results
        to_release
```