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Does geography matter in mortality? An analysis of potentially avoidable mortality by remoteness index in Canada

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Does geography matter in mortality? An analysis of potentially avoidable mortality by remoteness index in Canada

by Rajendra Subedi, T. Lawson Greenberg and Shirin Roshanafshar

Abstract

Background: The avoidable mortality rate is a key indicator of overall health and health care utilization. However, the avoidable mortality rate may differ by the relative remoteness of a community. Avoidable mortality rates specific to remote areas cannot be investigated unless there is a clear geographic classification of remoteness. Therefore, this research uses a newly developed remoteness index to explore the geographic variability of avoidable mortality in Canada.

Data and methods: The remoteness index, Canadian Vital Statistics—Death Database (2011 to 2015), and the 2016 Census of Population are used to understand the geographic variability of preventable and treatable mortality rates in Canada. Descriptive and multivariate data analysis techniques are used to test the hypothesis that remoteness is one of the statistically significant predictors of avoidable mortality rates in Canada.

Results: There is a clear gradient of preventable and treatable mortality rates by relative remoteness. The preventable and treatable mortality rates are significantly higher in more remote areas than in easily accessible areas. The remoteness index is a good predictor of both preventable and treatable causes of mortality for low-Aboriginal census subdivisions but not for high-Aboriginal census subdivisions in Canada.

Interpretation: Both preventable and treatable mortality rates vary significantly by remoteness, despite Canada's universal health care system. The remoteness of Canadian communities may have affected health care delivery and utilization.

Keywords: Remoteness, preventable mortality, treatable mortality, health status, health outcome, income, education, Aboriginal population

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Despite the tremendous amount of ongoing research, the mechanism of urban–rural health disparities is not fully understood in Canada. Although rural and remote location in itself may not necessarily lead to poor health, it may influence other socioeconomic, environmental and occupational health determinants. There is noticeable heterogeneity within and between rural communities in Canada in terms of socioeconomic and geographic characteristics.¹ However, in general, people who live in rural communities have limited access to health care services and have worse health outcomes than their urban counterparts.^{2,3} This may lead to disproportionate mortality rates between urban and rural communities.

A 2012 Canadian Institute for Health Information (CIHI) report claimed that people who live in rural and disadvantaged areas experience a higher burden of ambulatory-care-sensitive conditions, such as asthma, chronic obstructive pulmonary disease, diabetes, high blood pressure and heart disease.⁴ Studies have established an association between poor health status and the lifestyle, culture, geography and environment in rural areas.^{1,5,6} Other studies have compared health status and health care needs along the urban–rural continuum.^{1,7,8} Rural and remote areas are also distinguished by more CSDs with a higher proportion of Aboriginal population than in urban areas.⁹ Avoidable mortality is higher in First Nations adults¹⁰ and Inuit.¹¹ Remoteness can therefore be compounded by the proportion of Aboriginal population in that area. Urban–rural variation in mortality from chronic diseases and major causes of deaths has been studied in other countries, including the United States,¹² Australia¹³ and China.¹⁴ However, due to blurred urban-rural and

remote classification, no studies in Canada have compared potentially avoidable mortality by relative remoteness.

The potentially avoidable (hereafter avoidable) mortality is a subset of premature mortality that takes place under the age of 75. The avoidable mortality is defined as “untimely deaths that should not occur in the presence of timely and effective health care, including prevention.”¹⁵ Avoidable mortality represents over 70% of total deaths of individuals younger than age 75 in Canada^{10,15} and consists of two subgroups: preventable mortality and treatable mortality. “Preventable mortality” refers to deaths that could be prevented through primary preventative actions in incidence reduction, such as immunization, smoking reduction and seatbelt use. “Treatable mortality” refers to deaths that could be treated through secondary and tertiary prevention efforts, such as effective screening and treatment of an existing disease.¹⁵ The concepts of preventable and treatable mortality have been adopted widely as performance indicators of broader health systems in countries such as Australia, the United Kingdom, Italy and the United States.^{16,17} Previous studies have shown that timely and effective intervention may reduce mortality rates significantly.^{15,18}

Conversely, literature also shows that socioeconomic status is the most consistent predictor of health status, and therefore a good predictor of morbidity and mortality.^{15,19,20} While some authors have argued that level of education is an important social determinant of health,^{21,22} others have established an association between income and individual-level health risk factors.²²⁻²⁴ There are multiple studies on sex differences in mortality. In general, because of their engagement in more risky behaviour, men are known to have higher mortality rates than women for the majority of the leading causes of death.²⁵ However, there

is not enough evidence on how avoidable mortality rates vary by sex and by remoteness to draw formal conclusions in this regard.

The majority of previous studies have used the Statistical Area Classification (SAC) and have defined “urban” through the combination of Census Metropolitan Areas (CMA) and Census Agglomerations (CA).¹ Statistics Canada has defined urban areas as population centres with a population of at least 1,000 and a density of 400 persons per square kilometre.²⁶ However, no clear distinction is made between urban, rural and remote areas in Canada. Therefore, researchers and health system planners have identified a need for a pan-Canadian approach to make a clear distinction between urban, rural and remote areas in order to measure health care inequalities in Canada.²⁷

In response to this call, a group of researchers from Statistics Canada recently developed a remoteness index (RI) and assigned a value to each census subdivision (CSD).²⁸ This index measures the relative remoteness of Canadian communities (CSDs) on the basis of their size and their proximity to surrounding population centres. Although the RI is a continuous scale, one of its strengths is that it can be easily categorized for the classification of Canadian communities by their relative remoteness. This study uses the new RI classification to distinguish rural and remote areas from urban areas in Canada.

The main objective of this research is to examine major causes of both preventable and treatable mortality by relative remoteness of Canadian communities. Furthermore, it explores the interrelationship between remoteness and avoidable mortality while taking into account three important variables: average household income after-tax, the proportion of postsecondary graduates and the proportion of Aboriginal population by CSD. The central analytical questions in this paper are the following:

- How do avoidable mortality rates vary by relative remoteness of Canadian communities?

- What is the contribution of the remoteness index in determining avoidable mortality rates when the effects of income, education and Aboriginal population are taken into account?

Data and methods

This research used three data sources produced by Statistics Canada. The first data source, the Canadian Vital Statistics – Death Database (CVSD) for the years 2011 to 2015, is an administrative database containing a collection of annual demographics and cause-of-death information in Canada.²⁹ Death data are collected from the provincial and territorial vital statistics offices, where deaths that occur in those jurisdictions are registered.²⁹ The mortality database was used to create a subset of premature deaths, which in turn was used to create the avoidable mortality database. The International Classification of Disease, 10th edition (ICD-10), codes associated with the CVSD were used to classify avoidable deaths into preventable and treatable causes of death according to the standard classification method developed by the CIHI¹⁵ (see Appendix A).

The second data source used in this research was the census subdivision RI, which was developed by a team of researchers at Statistics Canada in 2017.²⁸ The index value for each CSD ranges from 0 to 1, where “0” represents the most accessible areas and “1” represents the most remote areas. The CSD-level RI scores were classified into five mutually exclusive categories according to the RI values, population size, number of CSDs in each class, and natural break points in the distribution of the RI score (see Appendix B). On the basis of these criteria, the five classes were defined as “easily accessible areas,” “accessible areas,” “less accessible areas,” “remote areas” and “very remote areas.” However, to understand its relationship with avoidable mortality rates, the RI in a scale of 0 to 1 was used as a continuous predictor variable in the multiple regression models.

The third data source, data tables from the 2016 Census of Population, were used to derive the proportion of the population with a postsecondary certificate, diploma or degree, proportion of Aboriginal population and the average annual household income after-tax for each CSD. A common-variable CSD unique identifier (CSDUID) was used to link CSD-level preventable and treatable mortality rates with the RI, along with the education, Aboriginal population and income variables. All the variables were used in four different multiple linear regression models to test the hypothesis that the remoteness index is a good predictor of both preventable and treatable mortality rates in Canada.

Studies have shown that Aboriginal populations in Canada have elevated health risks and higher premature mortality rates.^{30,31} Traditionally, the proportion of Aboriginal populations is higher in northern and remote communities in Canada.⁶ Therefore, the proportion of Aboriginal populations could also be a good predictor of higher preventable and treatable mortality rates in the rural and remote communities. However, due to strong correlation of the proportion of Aboriginal population and the RI, it was not possible to use them together in a single regression model. Consequently, CSDs were classified into two groups of low and high Aboriginal identity populations and regression analyses were performed separately for both groups. As applied by previous studies in Canada,^{32,33} CSDs where less than 33% of residents reported an Aboriginal identity on the 2016 Census of population were considered as “low-Aboriginal CSDs” and those CSDs where 33% or more of residents reported Aboriginal identity were considered as “high-Aboriginal CSDs”. Multiple linear regression models were used for both groups, and both the preventable and treatable mortality rates were used separately as outcome variables.

Analysis

This research used two types of data analysis strategies to answer the research

questions outlined above. First, descriptive data analysis techniques were used to understand the geographic variability of preventable and treatable mortality rates. The preventable and treatable mortality rates per 100,000 population for each remoteness class were used as outcomes of interest. The rates were calculated for groups of mortality causes (e.g., cancers, infections, injuries) and for specific mortality causes (e.g., breast cancer, pneumonia, falls). The direct standardization method was used to age-standardize all rates to the 2011 Census of Population with five-year age groupings. Next, the age-standardized mortality rates per 100,000 population were compared across all remoteness classes, for males and females and for population subgroups, by mortality cause. Since the mortality rates presented in the tables are the average rates for 2011 to 2015, 95% confidence intervals of the mean are also presented. The rates for each geographic region by disease category and sex were tested for statistical significance using one-way ANOVA and Tukey’s HSD test in SAS Enterprise Guide 7.1.

Second, multiple linear regression models were used to test whether

the differences in RI, education and income explain the higher preventable and treatable mortality rates for both low-Aboriginal and high-Aboriginal CSDs. The preventable and treatable mortality rates were used as outcome variables whereas the RI, education and income variables were used as predictor variables. The proportion of Aboriginal identity population by CSD was used as a filter variable to classify low-Aboriginal CSDs and high-Aboriginal CSDs. The assumptions of linearity of response and explanatory variables were tested using residual plots, whereas the assumption of non-multicollinearity was tested using the variance inflation factor.

Results

From 2011 to 2015, there were 483,114 premature deaths registered in Canada. Of those, 347,167 were avoidable – about 72% of total premature deaths in Canada. About 65% of total avoidable deaths were preventable, and 35% of those were treatable.

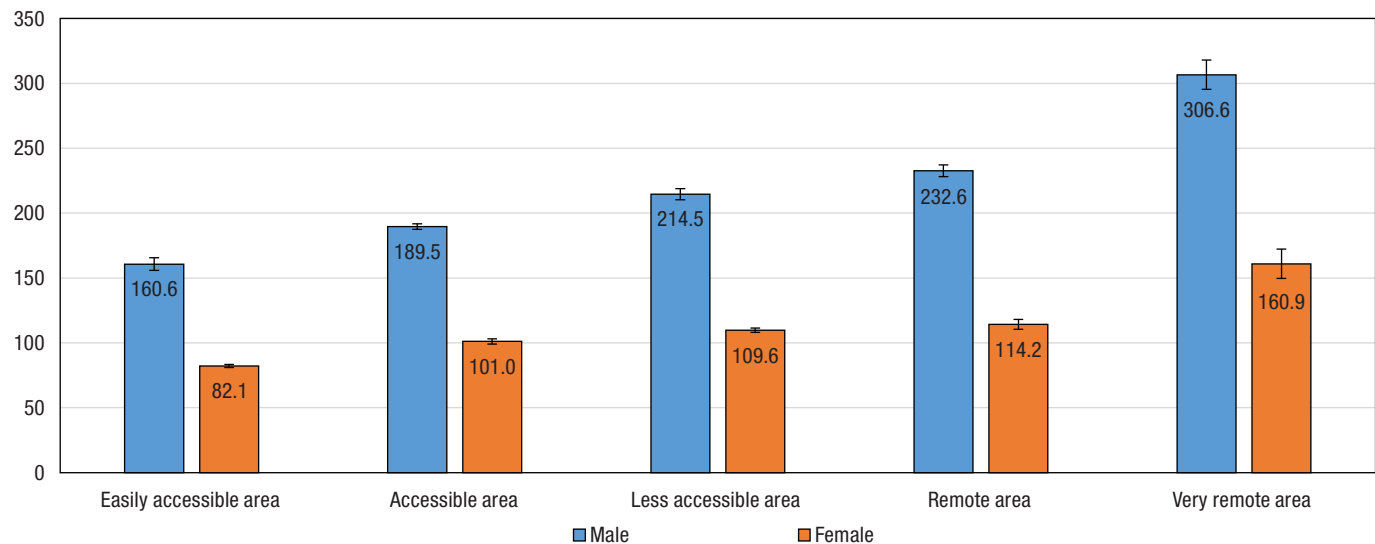
Preventable mortality rate

There was a clear geographic gradient of preventable mortality rates by remoteness for both sexes, and the rates were statistically significant for most geographic regions. The rates for males were almost double those for females, regardless of remoteness (Figure 1).

The age-standardized preventable mortality rate was calculated for eight broad disease groups, as defined by the CIHI (see Appendix A). In the easily accessible and accessible areas, the highest rate of preventable deaths was associated with cancer-related causes for both sexes. However, injury, including both intentional and unintentional injuries, was the leading cause of death for males in less accessible, remote and very remote areas, and for females in very remote areas (Table 1). Diseases of the circulatory system were the third major cause of preventable deaths for all remoteness categories and for both sexes. Most of the differences between remoteness categories and between males and females were statistically significant at the 95% confidence level. The top three causes of death alone accounted for

Figure 1
Preventable mortality rate by sex and relative remoteness

deaths per 100,000 population



Note: All rates were age standardized to the 2011 Census of Population with five-year age groupings, using the direct standardization method.
Source: Canadian Vital Statistics—Death Database 2011 to 2015 and Remoteness Index.

Does geography matter in mortality? An analysis of potentially avoidable mortality by remoteness index in Canada • Research Article**Table 1****Age-standardized preventable mortality rate per 100,000 population, by sex and grouped-cause of death (2011 to 2015 average)**

Sex	Cause of death	Easily accessible area			Accessible area			Less accessible area			Remote area			Very remote area		
		ASMR	95% confidence interval		ASMR	95% confidence interval		ASMR	95% confidence interval		ASMR	95% confidence interval		ASMR	95% confidence interval	
			from	to		from	to		from	to		from	to		from	to
Male	Cancer	56.4	53.2	59.6	58.5	56.7	60.2	65.6	62.2	69.0	63.9	60.0	67.8	76.4	68.8	83.9
	Injuries	39.4	38.7	40.2	56.3	54.0	58.6	66.1	62.6	69.5	84.6	80.7	88.6	125.8	114.6	137.0
	Diseases of the circulatory system	31.4	29.8	33.0	36.4	34.0	38.9	40.2	38.9	41.6	42.1	37.9	46.4	49.6	46.3	52.9
	Diseases of the respiratory system	11.4	10.7	12.0	13.6	12.3	14.8	16.4	15.8	17.0	14.3	12.6	16.1	17.4	12.8	21.9
	Alcohol and drug use disorders	9.4	8.9	9.9	12.0	10.7	13.2	12.3	11.6	13.0	13.9	11.7	16.2	17.2	13.5	20.8
	Others	4.9	4.6	5.3	5.9	5.6	6.2	6.6	6.1	7.1	7.6	6.6	8.5	11.4	10.1	12.6
	Infections	4.5	4.0	4.9	3.8	3.4	4.1	4.1	3.4	4.9	3.1	2.5	3.6	5.6	3.7	7.5
	Diseases of the digestive system	3.2	2.9	3.5	3.1	2.7	3.5	3.2	2.6	3.9	3.0	2.2	3.8	3.3	1.9	4.8
Female	Cancer	36.3	35.3	37.4	40.7	38.8	42.6	42.9	40.6	45.1	41.0	37.1	44.9	48.6	43.3	53.8
	Injuries	15.3	14.7	15.9	22.4	21.3	23.6	24.5	22.2	26.7	30.4	27.7	33.1	50.0	41.8	58.2
	Diseases of the circulatory system	13.1	12.7	13.5	15.6	15.0	16.2	16.9	16.1	17.7	16.9	15.3	18.4	22.3	18.0	26.6
	Diseases of the respiratory system	7.9	7.5	8.4	10.4	9.8	11.0	11.7	11.0	12.3	10.6	8.9	12.2	14.6	9.2	20.0
	Alcohol and drug use disorders	3.1	2.9	3.3	4.7	4.0	5.3	5.1	4.1	6.2	5.8	4.8	6.8	10.7	5.7	15.7
	Others	2.5	2.3	2.7	3.3	2.7	3.8	4.1	3.7	4.5	4.8	4.1	5.6	7.8	5.5	10.1
	Infections	2.3	2.1	2.5	2.3	2.0	2.7	2.4	2.1	2.7	2.4	1.5	3.3	4.6	1.8	7.3
	Diseases of the digestive system	1.5	1.4	1.7	1.7	1.4	2.0	2.1	1.7	2.6	2.3	1.4	3.2	2.4	1.9	3.0

ASMR = Age-standardized mortality rates

Note: All rates were age-standardized to the 2011 Census of Population with five-year age groupings, using the direct standardization method.

Source: Canadian Vital Statistics—Death Database 2011 to 2015 and Remoteness Index.

Table 2**Age-standardized preventable mortality rate per 100,000 population for top 10 major causes of death, by sex (2011 to 2015 average)**

Sex	Cause of death	Easily accessible area			Accessible area			Less accessible area			Remote area			Very remote area		
		ASMR	95% confidence interval		ASMR	95% confidence interval		ASMR	95% confidence interval		ASMR	95% confidence interval		ASMR	95% confidence interval	
			from	to		from	to		from	to		from	to		from	to
Male	Lung cancer	34.2	31.1	37.3	35.1	33.5	36.8	43.0	38.9	47.1	41.5	37.7	45.3	51.1	45.0	57.2
	Ischaemic heart disease [†]	22.9	21.7	24.2	26.8	25.4	28.2	29.2	27.9	30.4	30.6	27.4	33.7	36.8	35.5	38.0
	Suicide and self-inflicted injuries	15.1	14.6	15.6	19.5	17.1	21.8	21.9	19.7	24.1	26.8	24.5	29.2	45.5	39.2	51.8
	COPD	9.2	8.7	9.6	11.1	9.7	12.5	14.3	13.5	15.0	12.0	10.6	13.4	15.4	11.0	19.7
	Alcohol-related diseases	9.0	8.5	9.5	11.4	10.2	12.6	11.7	11.0	12.4	13.2	11.1	15.2	16.4	12.8	20.0
	Accidental poisonings	7.1	5.4	8.7	8.9	7.4	10.3	9.9	8.7	11.0	10.0	9.0	11.0	15.3	11.7	19.0
	Liver cancer	6.7	6.2	7.2	6.0	5.6	6.5	5.3	4.8	5.8	5.7	4.7	6.7	6.0	4.1	7.9
	Transport accidents	6.0	5.4	6.5	12.9	11.6	14.2	17.7	17.0	18.4	25.3	21.5	29.2	28.5	19.9	37.1
	Oesophagus cancer	5.1	4.8	5.3	6.9	6.4	7.3	6.8	5.7	8.0	6.6	5.6	7.7	5.2	3.8	6.6
	Diabetes	4.8	4.4	5.1	5.6	5.3	5.9	6.4	5.7	7.0	7.3	6.5	8.2	11.1	9.7	12.5
Female	Lung cancer	28.0	26.9	29.0	32.3	30.6	34.1	34.4	32.8	36.1	33.3	30.0	36.6	38.4	32.4	44.3
	Ischaemic heart disease	7.3	7.1	7.5	8.5	8.0	9.0	9.1	8.4	9.9	9.6	8.6	10.5	12.4	9.8	15.0
	COPD	7.1	6.5	7.6	9.4	8.9	9.9	10.8	10.1	11.5	9.6	8.1	11.2	13.7	8.6	18.8
	Suicide and self-inflicted injuries	5.3	4.8	5.9	6.5	6.1	7.0	6.8	5.7	7.9	8.9	6.8	11.1	16.1	12.8	19.4
	Cerebrovascular diseases	3.3	3.1	3.5	3.8	3.5	4.1	4.4	4.0	4.7	3.9	3.3	4.5	6.3	5.6	7.0
	Accidental poisonings	2.9	2.5	3.4	4.4	3.6	5.1	5.3	4.6	6.0	5.1	3.3	6.9	9.3	8.3	10.2
	Alcohol-related diseases	2.9	2.7	3.1	4.3	3.7	4.9	4.8	3.8	5.7	5.3	4.3	6.2	10.3	5.5	15.1
	Liver cancer	2.6	2.4	2.8	2.5	2.1	2.9	2.7	2.0	3.3	2.2	1.4	3.0	3.5	2.7	4.3
	Diabetes	2.3	2.2	2.5	3.1	2.6	3.6	3.8	3.5	4.1	4.5	3.7	5.3	7.6	5.7	9.5
	Transport accidents	2.2	1.9	2.5	4.7	3.7	5.7	6.1	5.0	7.2	7.7	7.0	8.5	10.2	4.8	15.6

ASMR = Age-standardized mortality rates

† Please note that ischaemic heart disease is classified as both a preventable and treatable cause of mortality. Therefore, the preventable deaths caused by ischaemic heart disease are only 50% of the total deaths from this cause.

Note: All rates were age-standardized to the 2011 Census of Population with five-year age groupings, using the direct standardization method.

Source: Canadian Vital Statistics—Death Database 2011 to 2015 and Remoteness Index.

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almost 80% of preventable mortality in each remoteness category.

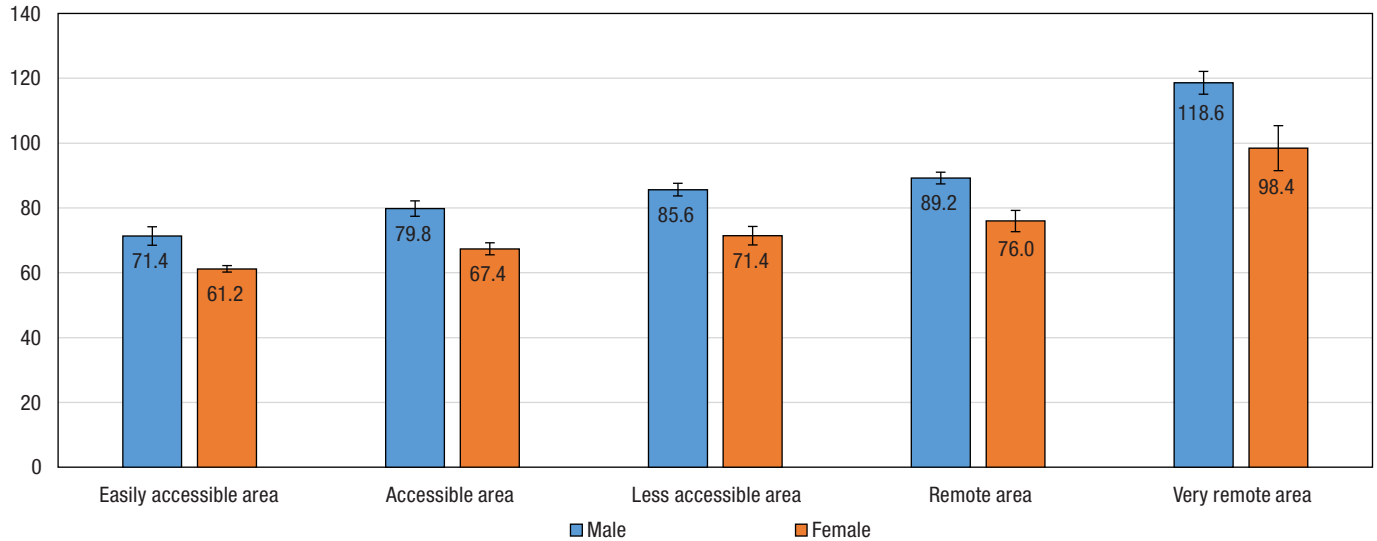
A further analysis was done to understand the top 10 disease-specific preventable causes of death by remoteness categories. For all remoteness

categories and for both sexes, lung cancer was the leading cause of death, followed by ischaemic heart disease. Death by suicide and self-inflicted injuries, and alcohol-related diseases were more common in remote and very

remote areas than in easily accessible areas. Suicide and self-inflicted injuries were the second major causes of preventable deaths in very remote areas, and the rate was more than three times higher in very remote areas than in easily access-

Figure 2
Treatable mortality rate by sex and relative remoteness

deaths per 100,000 population



Note: All rates were age standardized to the 2011 Census of Population with five-year age groupings, using the direct standardization method.
Source: Canadian Vital Statistics—Death Database 2011 to 2015 and Remoteness Index.

Table 3
Age-standardized treatable mortality rate per 100,000 population, by sex and grouped-cause of death (2011 to 2015 average)

Sex	Cause of death	Easily accessible area			Accessible area			Less accessible area			Remote area			Very remote area			
		ASMR	95% confidence interval		ASMR	95% confidence interval		ASMR	95% confidence interval		ASMR	95% confidence interval		ASMR	95% confidence interval		
			from	to		from	to		from	to		from	to		from	to	
Male	Diseases of the circulatory system	30.2	28.8	31.6	35.8	34.5	37.2	38.6	36.9	40.2	39.7	35.5	43.9	49.1	46.1	52.0	
	Cancer	17.7	17.0	18.4	19.3	18.1	20.5	19.3	18.0	20.6	18.8	17.0	20.5	23.9	22.5	25.2	
	Maternal and infant causes	6.2	6.0	6.5	6.3	6.0	6.6	7.0	6.6	7.4	7.8	6.1	9.4	11.4	9.3	13.6	
	Infections	6.0	5.7	6.3	6.2	5.8	6.5	6.3	5.5	7.0	7.0	5.2	8.9	12.2	8.8	15.5	
	Others	5.8	5.4	6.2	6.6	6.3	6.9	7.5	6.8	8.2	8.6	7.6	9.6	12.3	10.5	14.2	
	Diseases of the genitourinary system	2.2	1.9	2.4	2.2	1.8	2.6	3.0	2.5	3.5	3.2	1.9	4.6	4.2	2.1	6.2	
	Diseases of the digestive system	2.0	1.9	2.0	2.1	1.8	2.5	2.4	2.0	2.7	2.8	2.1	3.4	2.9	1.8	4.1	
	Diseases of the respiratory system	1.3	1.1	1.4	1.3	1.1	1.6	1.7	1.3	2.0	1.3	0.2	2.4	2.6	1.1	4.1	
	Female	Cancer	32.7	32.1	33.4	33.9	32.6	35.3	34.1	32.8	35.4	36.9	34.0	39.9	40.8	36.7	44.9
		Diseases of the circulatory system	12.0	11.8	12.2	14.3	13.6	14.9	15.8	15.1	16.4	15.7	15.4	16.0	21.9	17.7	26.1
Maternal and infant causes		5.5	5.1	5.8	6.1	5.3	6.9	6.6	5.4	7.8	6.7	5.5	8.0	7.9	6.5	9.2	
Infections		4.2	3.9	4.5	4.9	4.3	5.4	5.2	4.4	6.0	6.0	4.4	7.5	9.1	7.3	11.0	
Others		3.1	3.0	3.3	4.0	3.5	4.4	4.6	4.3	4.9	5.4	4.7	6.1	9.1	7.1	11.1	
Diseases of the genitourinary system		1.4	1.3	1.5	1.7	1.4	1.9	2.1	1.9	2.4	2.2	1.4	2.9	3.6	1.9	5.3	
Diseases of the digestive system		1.3	1.1	1.4	1.4	1.1	1.7	1.7	1.4	2.0	1.5	0.8	2.2	2.9	1.4	4.4	
Diseases of the respiratory system		1.0	0.9	1.1	1.2	1.0	1.5	1.3	0.9	1.8	1.5	1.3	1.8	3.1	2.2	4.1	

ASMR = Age-standardized mortality rates

Note: All rates were age-standardized to the 2011 Census of Population with five-year age groupings, using the direct standardization method.

Source: Canadian Vital Statistics—Death Database 2011 to 2015 and Remoteness Index.

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ible areas. Transport accidents increased significantly along with remoteness, and were the fourth major cause of preventable death for males in all remoteness categories except easily accessible areas.

Treatable mortality rate

Data analysis shows that about 25% of all premature deaths and about 35% of all avoidable deaths from 2011 to 2015 in Canada were treatable. Treatable mortality rates varied significantly by relative remoteness and were higher for remote areas than for more accessible areas, regardless of sex. Differences were noticeable for all remoteness categories; treatable mortality rates were higher for males than for females, but the gaps were slimmer than those observed in regard to preventable mortality rates (Figure 2).

Treatable mortality rates were calculated for grouped causes of death to

understand the geographic variability. Treatable mortality rates increased as remoteness increased for both males and females, and the differences were statistically significant. For males, diseases of the circulatory system were the leading treatable cause of death, followed by cancer. In contrast, cancer was the leading treatable cause of death for females, followed by diseases of the circulatory system (Table 3). This finding was consistent across all remoteness categories.

The findings in Table 3 were further investigated by calculating the disease-specific treatable mortality rates for the top 10 major causes of death (Table 4). There was a clear geographic variation for most of the treatable causes of death. For all geographies, ischaemic heart disease was the leading cause of treatable mortality among males whereas breast cancer was the leading cause

of treatable mortality among females. Colorectal cancer was the second major cause of treatable mortality for both sexes.

Multivariate analyses

The findings of four separate linear regression models are summarized together in Table 5. The first model represents the preventable mortality rates for low-Aboriginal CSDs (n = 3,573; RI range 0 to 0.82) and the second model represents preventable mortality rates for high-Aboriginal CSDs (n = 769; RI range 0.09 to 1). The first model shows that the RI and income were statistically significant predictors of preventable mortality rates at 95% confidence level but not the education. However, the second model shows that, education and income are significant predictors of preventable mortality rates at 95% confidence level (Table 5). These results indicate

Table 4

Age-standardized treatable mortality rate per 100,000 population for top 10 major causes of death, by sex (2011 to 2015 average)

Sex	Cause of death	Easily accessible area			Accessible area			Less accessible area			Remote area			Very remote area		
		ASMR	95% confidence interval		ASMR	95% confidence interval		ASMR	95% confidence interval		ASMR	95% confidence interval		ASMR	95% confidence interval	
			from	to		from	to		from	to		from	to		from	to
Male	Ischaemic heart disease [†]	22.9	21.7	24.2	26.8	25.4	28.2	29.2	27.9	30.4	30.6	27.4	33.7	36.8	35.5	38.0
	Colorectal cancer	13.4	12.8	14.1	14.6	13.8	15.3	14.5	13.6	15.4	14.0	12.0	16.0	19.4	18.2	20.7
	Diabetes	4.8	4.4	5.1	5.6	5.3	5.9	6.4	5.7	7.0	7.3	6.5	8.2	11.1	9.7	12.5
	Cerebrovascular diseases	4.5	4.2	4.7	5.1	4.7	5.6	5.6	5.1	6.2	5.8	4.6	7.0	8.1	6.7	9.4
	Complications of perinatal period	3.6	3.5	3.7	3.1	2.6	3.6	3.3	2.8	3.8	4.4	3.6	5.3	6.1	4.2	7.9
	Pneumonia	3.4	3.1	3.6	3.6	3.2	3.9	3.6	3.1	4.1	3.7	2.9	4.6	7.4	4.8	10.0
	Bladder cancer	3.1	3.0	3.2	3.5	3.1	3.8	3.4	2.8	4.0	3.4	3.0	3.8	2.5	1.5	3.4
	Congenital malformations, deformations and chromosomal anomalies	2.6	2.4	2.9	3.1	2.9	3.4	3.7	3.4	4.0	3.3	2.3	4.3	5.4	3.4	7.3
	Hypertensive heart diseases	2.3	1.9	2.7	3.4	2.6	4.2	3.2	2.5	4.0	2.7	1.6	3.8	3.8	2.9	4.6
	Sepsis	2.2	1.9	2.4	2.2	1.9	2.5	2.2	1.9	2.5	2.4	0.8	4.0	3.4	2.0	4.8
Female	Breast cancer	17.0	16.6	17.4	17.2	17.0	17.5	16.5	15.3	17.6	18.3	15.7	20.9	17.6	14.2	21.1
	Colorectal cancer	8.7	8.5	8.9	9.6	8.6	10.7	9.8	9.1	10.5	10.5	8.2	12.9	13.8	11.3	16.3
	Ischaemic heart disease	7.3	7.1	7.5	8.5	8.0	9.0	9.1	8.4	9.9	9.6	8.6	10.5	12.4	9.8	15.0
	Uterus cancer	3.5	3.0	3.9	3.2	2.7	3.6	3.3	2.8	3.8	3.3	2.1	4.4	3.4	1.9	5.0
	Cerebrovascular diseases	3.3	3.1	3.5	3.8	3.5	4.1	4.4	4.0	4.7	3.9	3.3	4.5	6.3	5.6	7.0
	Complications of perinatal period	3.0	2.8	3.2	2.9	2.4	3.5	3.1	2.2	4.1	3.3	2.5	4.0	4.1	3.6	4.7
	Diabetes	2.3	2.2	2.5	3.1	2.6	3.6	3.8	3.5	4.1	4.5	3.7	5.3	7.6	5.7	9.5
	Congenital malformations, deformations and chromosomal anomalies	2.3	2.2	2.5	3.1	2.7	3.5	3.2	2.6	3.8	3.2	2.4	4.1	3.4	2.2	4.7
	Pneumonia	2.2	2.0	2.4	2.7	2.2	3.1	3.0	2.8	3.2	2.9	2.0	3.9	4.6	3.2	5.9
	Cervical cancer	1.8	1.6	2.0	2.0	1.8	2.1	2.4	1.9	3.0	2.6	1.4	3.8	4.1	2.2	5.9

ASMR = Age-standardized mortality rates

[†] Please note that ischaemic heart disease is classified as both a preventable and treatable cause of mortality. Therefore, the preventable deaths caused by ischaemic heart disease are only 50% of the total deaths from this cause.

Note: All rates were age-standardized to the 2011 Census of Population with five-year age groupings, using the direct standardization method.

Source: Canadian Vital Statistics—Death Database 2011 to 2015 and Remoteness Index.

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that remoteness is an important factor of preventable mortality for low-Aboriginal CSDs, whereas education is an important factor of preventable mortality for high-Aboriginal CSDs. The income variable is a statistically significant predictor of preventable mortality for both low-Aboriginal and high-Aboriginal CSDs.

The positive parameter estimate for the RI (89.18) in the first model indicates that the preventable mortality rate increases along with the increased remoteness, whereas the negative parameter estimate for the income in the first model (-0.98), and for both income and education in the

second model (-2.66; -3.44) indicate that preventable mortality rate decreases with increased average household income after-tax and increased proportion of postsecondary graduates (Table 5).

The findings for treatable mortality rates in the third and fourth models are similar to that of preventable mortality. Similar to the previous models, only education and income are statistically significant predictors of treatable mortality rate at 95% confidence level for high-Aboriginal CSDs (n = 3,412; RI range 0.09 to 1). However, all three variables (RI, education and income) are statistically significant predictors of treatable mortality rate at 95% confidence level for low-Aboriginal CSDs (n = 672; RI range 0 to 0.82). These findings also indicate that relative remoteness is a determinant of treatable mortality for low-Aboriginal CSDs but not for the high-Aboriginal CSDs. The positive value of the parameter estimate for the RI (63.85) in the third model indicates that the treatable mortality rate increases along with remoteness, whereas the negative parameter estimates for education and income in the third (-0.98; -0.18), and also in the fourth model (-1.95; -3.33) indicate that the treatable mortality rate decreases along with the increased average household income and the proportion of postsecondary graduates.

Discussion

The results of the descriptive analysis indicate that there is significant variation in the preventable and treatable mortality rates by relative remoteness of Canadian communities. Although the health care system in Canada is publicly funded, there seems to be geographic variation in terms of health care policy, access and utilization. This variation has led to disproportionate mortality rates in remote communities. Higher preventable and treatable mortality rates in the relatively remote areas could be attributed to geographic barriers, limited health care services, unmet health care needs, and historical and environmental factors that shape the socioeconomic status of Aboriginal rural communities in Canada.²

The proportion of Aboriginal populations is higher in remote CSDs in Canada. However, the model did not show a significant relationship between mortality and the RI in CSDs with a high proportion of Aboriginal people. This could be a result of a smaller sample size and a distribution bias toward higher values of RI in the CSDs with a high proportion of Aboriginal people. For CSDs with a low proportion of Aboriginal people, the majority with 84% of all CSDs, the RI was a significant predictor of both preventable and treatable mortality rates.

The higher mortality rates reported in remote communities could be a combination of both geographic remoteness

What is already known on this subject?

- According to the Canadian Institute for Health Information, approximately 72% of premature deaths in Canada are considered avoidable.
- Avoidable mortality has been used as an indicator of health policy, health care delivery and health care utilization.
- In Canada, avoidable mortality rates vary significantly by province and territory, and by neighbourhood income level and sex.

What does this study add?

- The remoteness index can be used as a new dimension to measure the geographic variability of avoidable mortality in Canada.
- There is a clear gradient of both preventable and treatable mortality rates by relative remoteness of Canadian communities, with more remote communities having higher rates.
- The remoteness index is an important determinant of both preventable and treatable mortality rates for low-Aboriginal CSDs in Canada that takes into account education level and household income.

Table 5
Parameter estimates step-wise selection linear regression models

Model	Variable	CSDs with < 33% aboriginal population			CSDs with => 33% aboriginal population		
		Parameter estimate	Standard error	t-Value	Parameter estimate	Standard error	t-Value
Preventable Mortality	Intercept	199.90	14.57	13.72***	664.45	57.68	11.52***
	RI	89.18	16.68	5.35***	24.22	72.70	0.33
	Education	-0.14	0.23	-0.63	-3.44	0.98	-3.50***
	Income [†]	-0.98	0.12	-8.45***	-2.66	0.83	-3.21***
Treatable Mortality	Intercept	123.03	9.60	12.82***	423.23	45.84	9.23***
	RI	63.85	10.87	5.87***	67.78	59.23	1.14
	Education	-0.98	0.15	-6.54***	-1.95	0.81	-2.4**
	Income [†]	-0.18	0.08	-2.34*	-3.33	0.69	-4.80***

*significantly different from 0 (p < 0.05)

**significantly different from 0 (p < 0.01)

***significantly different from 0 (p < 0.001)

[†] Income calculated in thousands dollars

Source: Canadian Vital Statistics: Death Database 2011-2015, Remoteness Index, Canadian Census of Population 2016

and higher mortality rates observed in the Aboriginal population. However, the findings on Aboriginal population should be interpreted cautiously taking into account the broader historical context of colonization and racial discrimination that created present day health inequalities between Aboriginal and non-Aboriginal population.³⁴ In addition, intergenerational effects of residential school system, social isolation and inadequate health services, adversely affected physical, social, emotional and mental health and wellbeing of Aboriginal population, which are directly or indirectly related to higher mortality rates.^{34,35}

The preventable mortality rate for males was almost double than that for females. This indicates that females are more likely than their male counterparts to take preventive measures and utilize health care facilities. This finding is consistent with the literature, which shows differences between men and women in health care utilization.^{36,37}

Injury-related preventable deaths were higher than cancer-related deaths in remote and very remote areas. This finding is consistent with other literature that shows a higher risk of injuries in rural areas.^{31,38,39} The higher preventable mortality rates associated with injuries could also be associated with increased exposure through longer commutes and occupation for example and reduced access to health care facilities.³⁸

Diseases of the circulatory system were the leading cause of treatable mortality among males, and cancer was the leading cause of treatable mortality among females. A comparative study of Canada and Australia by Pong et al.⁷ found higher mortality rates caused by circulatory diseases among men living in rural areas of Canada. A study by

Shields and Wilkins⁴⁰ also found that, in Canada, men were more likely than women to die from heart disease. Both of those findings are consistent with this study's findings. Other studies have shown that breast cancer mortality rates have been declining in recent years due to increased screening and better treatment.⁴¹ However, breast cancer is still a leading cause of treatable mortality among women in Canada. The treatable mortality rates associated with diabetes were high for relatively remote communities among both males and females. Previous studies have shown higher mortality rates associated with diabetes for males than for females.⁴² However, there is no previous study allowing comparison of rates by relative remoteness.

This research established that remoteness classes can be used as new dimensions to measure geographic variability of avoidable mortality in Canada. In addition, this research contributes to the literature by establishing a relationship between remoteness and avoidable mortality. This is a novel research in Canada that has flagged possible issues and identified areas for more detailed investigation. Despite the interesting findings, this research has a few limitations. First, the RI classification is not a standard classification, but the authors' own classification of the continuous RI values. Second, the average household income is not adjusted for the cost of living; therefore, income is not a strong predictor of avoidable mortality compared to RI and education. Finally, the third limitation is related to the mortality database. The CVSD does not identify the individuals in the mortality database as Aboriginal or non-Aboriginal, which does not allow to make a separate analysis for Aboriginal and

non-Aboriginal population by remoteness. Having the actual number of deaths by Aboriginal population would have helped to identify whether or not the higher rate of mortalities reported in very remote communities were the results of remoteness.

Conclusion

Avoidable mortality is a key indicator of health behaviour, health policy and health care utilization. However, avoidable mortality is greatly affected by the geographic remoteness of a community, along with other socioeconomic characteristics of the population. This study used the newly developed RI, the Census of Population, and Canadian Vital Statistics data to explore the geographic variation of avoidable (preventable and treatable) mortality rates by relative remoteness of Canadian communities.

The results indicate that there is a clear gradient of both preventable and treatable mortality rates by remoteness for both sexes. Regardless of the declining overall avoidable mortality rates in Canada, preventable and treatable mortality rates were substantially higher in more remote areas than in easily accessible areas. Preventable and treatable mortality rates were significantly higher for males than for females, regardless of remoteness. However, the gender gap was smaller for treatable mortality rates. The RI was positively correlated with Aboriginal population. Therefore, despite being a statistically significant predictor of both preventable and treatable mortality rates for low-Aboriginal CSDs, RI was not a significant predictor of mortalities for high-Aboriginal CSDs. ■

References

- Lavergne MR, Kephart G. Examining variations in health within rural Canada. *Rural and Remote Health* 2012; 12(1848): 1-13.
- Sibley LM, Weiner JP. An evaluation of access to health care services along the rural-urban continuum in Canada. *BMC Health Service Research* 2011; 11(20): 1-11.
- Fleet R, Bussières S, Tounkara FK, et al. Rural versus urban academic hospital mortality following stroke in Canada. *Plos One* 2018; 13(1): 1-11.
- Canadian Institute for Health Information (CIHI). *Disparities in Primary Health Care Experience Among Canadians with Ambulatory Care Sensitive Conditions*. Ottawa, 2012. Available at: https://secure.cihi.ca/free_products/PHC_Experiences_AiB2012_E.pdf
- Pampalon R, Martinez J, Hamel D. Does living in rural areas make a difference for health in Quebec? *Health & Place* 2006; 12: 421-435.
- Morrison KT, Buckeridge DL, Xiao Y, Moghadas SM. The impact of geographic location of residence on disease outcome among Canadian First Nations populations during the 2009 influenza A(H1N1) pandemic. *Health & Place* 2014; 26: 53-59.
- Pong RW, DesMeules M, Lagacé C. Rural-urban disparities in health: How does Canada fare and how does Canada compare with Australia? *Australian Journal of Rural Health* 2009; 17: 58-64.
- Herbert R. Canada's health care challenge: Recognizing and addressing the health needs of rural Canadians. *Lethbridge Undergraduate Research Journal* 2007; 2(1): 1-8.
- Statistics Canada. *Aboriginal Peoples Highlight Table*, 2016. Available at: <https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/hltfst/abo-aut/Table.cfm?Lang=Eng&S=99&O=A&RPP=25>
- Park J, Tjepkema M, Goedhuis N, Pennock J. Avoidable mortality among First Nations adults in Canada: A cohort analysis. *Health Reports* 2015; 26(8): 10-16.
- Peters PA. An age-and cause-decomposition of differences in life expectancy between residents of Inuit Nunangat and residents of the rest of Canada, 1989 to 2008. *Health Reports* 2013; 24(12): 3-9.
- Singh KG, Siahpush M. Widening urban-rural disparities in all-cause mortality and mortality from major causes of death in the USA, 1969-2009. *Journal of Urban Health* 2014; 91(2): 272-292.
- Chondur R, Li QS, Guthridge S, Lawton P. Does relative remoteness affect chronic disease outcomes? Geographic variation in chronic disease mortality in Australia, 2002-2006. *Australian and New Zealand Journal of Public Health* 2014; 38(2): 117-121.
- Wang C, Zhang Z, Zhou M, et al. Different response of human mortality to extreme temperatures (MoET) between rural and urban area: A multi-scale study across China. *Health and Place* 2018; 50: 119-129.
- Canadian Institute for Health Information (CIHI). *Health Indicators* 2012. Available at: https://secure.cihi.ca/free_products/health_indicators_2012_en.pdf
- Nolte E, McKee M. Variations in amenable mortality—Trends in 16 high-income nations. *Health Policy* 2011; 103(1): 47-52.
- Quercioli C, Messina G, Basu S, et al. The effect of health care delivery privatisation on avoidable mortality: Longitudinal cross-regional results from Italy, 1993-2003. *Journal of Epidemiology and Community Health* 2012; 67(2): 132-8.
- James PD, Wilkins R, Detsky AS, et al. Avoidable mortality by neighbourhood income in Canada: 25 years after the establishment of universal health insurance. *Journal of Epidemiology and Community Health* 2007; 61(4): 287-96.
- Avendano M, Kunst AE, Huisman M, et al. Socioeconomic status and ischaemic heart disease mortality in 10 western European population during 1990s. *Heart* 2006; 92(4): 461-467.
- Mitra D, Shaw A, Tjepkema M. Social determinants of lung cancer incidents in Canada: A 13-year prospective study. *Health Reports* 2015; 26(6): 12-20.
- Brunello G, Fort M, Schneeweis N, Winter-Ebmer R. The casual effect of education on health: What is the role of health behaviors? *Health Economics* 2016; 25(3): 314-336.
- Winkleby MA, Jatulis DE, Frank E, Fortmann SP. Socioeconomic status and health: how education, income, and occupation contribute to risk factors for cardiovascular disease. *American Journal of Public Health* 1992; 82(6): 816-822.
- McGrail KM, Doorslaer EV, Ross NA, Sanmartin C. Income-related health inequality in Canada and the United States: A decomposition analysis. *American Journal of Public Health* 2009; 99(10): 1856-63.
- Pickett KE, Wilkinson RG. Income inequality and health: A casual review. *Social Science & Medicine* 2015; 128: 316-326.
- Courtenay WH. Constructions of masculinity and their influence on men's well-being: A theory of gender and health. *Social Science & Medicine* 2000; 50: 1385-1401.
- Statistics Canada, *Population Centre and Rural Area Classification* 2016. Ottawa, 2016. Available at: <http://www.statcan.gc.ca/eng/subjects/standard/pcrac/2016/introduction>.
- Canadian Institute for Health Information (CIHI). *In Pursuit of Health Equity: Defining Stratifiers for Measuring Health Inequality*. Ottawa, 2018. Available at: <https://www.cihi.ca/sites/default/files/document/defining-stratifiers-measuring-health-inequalities-2018-en-web.pdf>
- Alasia A, Bédard F, Bélanger J, et al. *Measuring remoteness and accessibility - A set of indices for Canadian communities*. Statistics Canada, Ottawa, 2017. Available at: <https://www150.statcan.gc.ca/n1/pub/18-001-x/18-001-x2017002-eng.htm>
- Statistics Canada, *Canadian vital statistics death database: Data dictionary and user guide*. Health Statistics Division, Statistics Canada, Ottawa, 2014. Available at: <http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3233#a4>
- Allard YE, Wilkins R, Berthelot JM. Premature mortality in health regions with high Aboriginal populations. *Health Reports* 2004; 15(1): 51-75.
- Brussoni M, George MA, Jin A, Lalonde CE, McCormick R. Injuries to Aboriginal populations living on-and off-reserve in metropolitan and non-metropolitan areas in British Columbia, Canada: Incidence and trends, 1986-2010. *BMC Public Health* 2016; 16: 1-9.
- Bougie E, Finès P, Oliver LN, Kohen DE. Unintentional injury hospitalizations and socio-economic status in areas with a high percentage of First Nations identity residents. *Health Reports* 2014; 25(2): 3-12.
- Oliver LN, Kohen DE. Unintentional injury hospitalizations among children and youth in areas with a high percentage of Aboriginal identity residents: 2001/2002 to 2005/2006. *Health Reports* 2012; 23(3): 3-11.
- Carrière G, Bougie E, Kohen D. Acute care hospitalizations for mental and behavioural disorders among First Nations people. *Health Reports* 2018; 29(6):11-19.
- Gracey M, King M. Indigenous health part I: Determinants and disease patterns. *Lancet* 2009; 374:65-75.
- Bertakis KD, Azari R, Helms JL, et al. Gender differences in the Utilization of health care services. *Journal of Family Practice* 2000; 49(2): 147-152.
- Redondo-Sendino A, Guallar-Castillon P, Bangeas JR, Rodriguez-Artalejo F. Gender differences in the utilization of health-care services among the older adult population of Spain. *BMC Public Health* 2006; 16(6):155-163.

Does geography matter in mortality? An analysis of potentially avoidable mortality by remoteness index in Canada • Research Article

38. Kmet L, Macarthur C. Urban-rural differences in motor vehicle crash fatality and hospitalization rates among children and youths. *Accident Analysis & Prevention* 2006; 38(1): 122-127.
39. Burrows S, Auger N, Gamache P, Hamel D. Leading causes of unintentional Injury and Suicide Mortality in Canadian Adults Across the Urban-Rural Continuum. *Public Health Reports* 2013; 128(6): 443-453.
40. Shields M, Wilkins K. Smoking, smoking cessation and heart disease risk: A 16-year follow-up study. *Health Reports* 2013; 24(2): 12-22.
41. Navaneelan T, Janz T. Cancer in Canada: Focus on lung, colorectal, breast and prostate. *Health at a Glance* (Catalogue 82-624-X) Ottawa: Statistics Canada, 2011. Available at: <https://www150.statcan.gc.ca/n1/pub/82-624-x/2011001/article/11596-eng.htm>
42. Park J, Peters PA. Mortality from diabetes mellitus, 2004 to 2008: A multiple cause-of-death analysis. *Health Reports* 2014; 25(3): 12-16.

Appendices

Appendix A

Causes of death for preventable and treatable mortality indicator

Causes of death	ICD-10 codes	Preventable	Treatable
Enteritis and other diarrheal diseases	A00–A09	X	
Tuberculosis	A16–A19, B90, J65		X
Vaccine-preventable diseases	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	A38, A48.1, A49.1		X
Sepsis	A40 (except A40.3), A41 (except A41.3)		X
Malaria	B50–B54		X
Meningitis	G00.2, 3, 8, 9		X
Cellulitis	A46, L03		X
Pneumonia	J12, J15, J16, J18		X
Sexually transmitted infections, except HIV/AIDS	A50–A60, A63, A64	X	
Viral hepatitis	B15–B19	X	
HIV/AIDS	B20–B24	X	
Neoplasms			
Lip, oral cavity and pharynx cancer	C00–C14	X	
Esophageal cancer	C15	X	
Stomach cancer	C16	X	
Colorectal cancer	C18–C21		X
Liver cancer	C22	X	
Lung cancer	C33, C34	X	
Melanoma skin cancer	C43	X	
Non-melanoma skin cancer	C44	X	
Malignant neoplasm of breast	C50		X
Cervical cancer	C53		X
Uterus cancer	C54, C55		X
Testicular cancer	C62		X
Bladder cancer	C67		X
Thyroid cancer	C73		X
Hodgkin's disease	C81		X
Leukemia	C91.0, C91.1, C92.1		X
Benign neoplasms	D10–D36		X
Diseases of the circulatory system			
Rheumatic heart disease	I01, I02, I05–I09	X	
Hypertensive diseases	I10, I11–I13, I15		X
Cerebrovascular diseases	I60–I62, I63–I64, I67, I69	X (50%)	X (50%)
Ischaemic heart disease	I20–I25	X (50%)	X (50%)
Other atherosclerosis	I70, I73.9	X (50%)	X (50%)
Aortic aneurysm	I71	X	
Venous thromboembolism	I26, I80, I82.9	X	

Appendix A**Causes of death for preventable and treatable mortality indicator**

Causes of death	ICD-10 codes	Preventable	Treatable
Diseases of the respiratory system			
Chronic obstructive pulmonary disorders	J40–J44	X	
Asthma and bronchiectasis	J45, J47		X
Acute lower respiratory infections	J20, J22		X
Upper respiratory infections	J00–J06, J30–J39		X
Lung diseases due to external agents	C45, J60–J64, J66–J70, J82, J92	X	
Adult respiratory distress syndrome	J80		X
Pulmonary oedema	J81		X
Abscess of lung and mediastinum; prothorax	J85, J86		X
Other pleural disorders	J90, J93, J94		X
Other respiratory disorders	J98		X
Diseases of the digestive system			
Peptic ulcer disease	K25–K28		X
Diseases of appendix; hernia; disorders of gallbladder, biliary tract and pancreas	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)	K73, K74.0,1,2,6	X	
Diseases of the genitourinary system			
Nephritis and nephrosis	N00–N07		X
Renal failure	N17–N19		X
Obstructive uropathy, urolithiasis and prostatic hyperplasia	N13, N20, N21, N23 N35, N40		X
Inflammatory diseases of genitourinary system	N34.1, N70–N73, N75.0, N75.1, N76.4, N76.6		X
Disorders resulting from impaired renal tubular function	N25		X
Infant and maternal causes			
Complications of perinatal period	A33		X
	H31.1, P00–P96	X	
Congenital malformations, deformations and chromosomal anomalies	Q00–Q99		X
Pregnancy, childbirth and the puerperium	O00–O99		X
Unintentional injuries			
Transport accidents	V01–V99	X	
Falls	W00–W19	X	
Other external causes of accidental injury	W20–W64, W75–W99, X10–X39, X50–X59	X	
Drowning	W65–W74	X	
Fires and flames	X00–X09	X	
Accidental poisonings	X40–X49	X	
Injuries of undetermined intent			
Injuries of undetermined intent	Y10–Y34	X	

Appendix A Causes of death for preventable and treatable mortality indicator

Causes of death	ICD-10 codes	Preventable	Treatable
Intentional injuries			
Suicide and self-inflicted injuries	X60–X84, Y87.0	X	
Assault	X85–X99, Y00–Y09, Y87.1	X	
Alcohol and drug use disorders			
Alcohol-related diseases, excluding external causes	F10, G31.2, G62.1, I42.6, K29.2, K70, K85.2, K86.0	X	
Drug use disorders	F11–F16, F18, F19	X	
Nutritional, endocrine and metabolic disorders			
Nutritional deficiency anaemia	D50–D53	X	
Thyroid disorders	E00–E07		X
Diabetes mellitus	E10–E14	X (50%)	X (50%)
Adrenal disorders	E24, E25, E27		X
Congenital metabolic disorders	E74.0, E74.2		X
Neurological disorders			
Epilepsy	G40, G41		X
Disorders of musculoskeletal system			
Osteomyelitis	M86		X
Adverse effects of medical and surgical care			
Drugs, medicaments and biological substances causing adverse effects in therapeutic use	Y40–Y59	X	
Misadventures to patients during surgical and medical care	Y60–Y66, Y69	X	
Medical devices associated with adverse incidents in diagnostic and therapeutic use	Y70–Y82	X	
Surgical and other medical procedures as the cause of abnormal reaction	Y83, Y84	X	

Source: Canadian Institute for Health Information, Health Indicators 2012

Appendix B Classification of remoteness index (RI) by population, RI score and natural breaks in the distribution

Categories	RI score	Population (%)	CSD (%)	Logics
Easily accessible area	0.00 to <0.15	67.23	14.29	Natural break points were selected in such a way that all CSDs with a population greater than 100,000 fell in either the “easily accessible area” category or the “accessible area” category, and all CSDs with a population greater than 20,000 fell in the “easily accessible area,” “accessible area” or “less accessible area” category. CSDs with a population greater than 10,000 did not fall in the “very remote area” category.
Accessible area	0.15 to <0.29	19.15	20.64	
Less accessible area	0.29 to <0.40	8.89	29.84	
Remote area	0.40 to <0.50	3.14	17.57	
Very remote area	>= 0.50	1.59	17.63	