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Do cancer incidence and mortality rates differ among ethnicities in Canada?

by Jeremiah Hwee and Evelyne Bougie

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Do cancer incidence and mortality rates differ among ethnicities in Canada?

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ABSTRACT

Background

Cancer incidence rates have been shown to vary by ethnicity, and the increasing awareness of and interest in reporting ethnic health inequalities have been growing internationally. The objective of this study was to assess cancer incidence and mortality rates by ethnicity in Canada.

Methods

The study used the 2006 Canadian Census Health and Environment Cohort, linked to the Canadian Cancer Registry and the Canadian Vital Statistics—Death Database, to determine cancer cases and mortality from 2006 to 2016. Ethnicity was categorized as non-Indigenous North American (NINA); European; Caribbean; Latin, Central and South American (LCSA); African; East Asian; South Asian; and West Central Asian and Middle Eastern.

Results

Europeans had the highest standardized incidence rates, while NINA had the highest mortality rates. Rates varied substantially by ethnicity and immigrant status. The top three cancers accounted for 46.5% to 61.9% of all new cancers, while the top three cancer deaths accounted for 36.1% to 61.9% of all deaths. The distribution of cancers within the top 10 cancers and the top 10 cancer deaths also differed; e.g., stomach cancer was found to be more prevalent in the East Asian, LCSA, African and Caribbean groups. Non-immigrant African males had the highest cancer incidence rates, and non-immigrant South Asian females had the highest mortality rates.

Conclusion

There is considerable variability in cancer incidence and cancer mortality rates by ethnicity, and this study addresses the knowledge gap in Canada in this area. Establishing baseline indicators, such as cancer rates by ethnicity, is essential to understanding the differences within the diverse Canadian population and to informing targeted interventions that may help reduce health inequalities.

AUTHORS

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What is already known on this subject?

- Cancer incidence and mortality rates have been shown to differ by ethnicity in some countries, but little information is available on these differences in Canada.

What does this study add?

- There is substantial variation in cancer incidence, cancer mortality and the distribution of cancer types by ethnicity in Canada. The study found that non-immigrant African males had the highest cancer incidence rate, and non-immigrant South Asian females had the highest cancer mortality rates.

Cancer is expected to be the leading cause of death and the largest barrier to increasing life expectancy throughout the world in the 21st century.¹ According to the World Health Organization, cancer is the leading or second-leading cause of death before the age of 70 in over 53% of countries worldwide and among the top four causes of death in another 22 countries. Cancer incidence and mortality continue to rise around the world. The factors contributing to this rise are complex, and they include differences in the distribution of the prevalence of risk factors and other socioeconomic factors. Furthermore, these differences likely contribute to the differences that countries around the world have shown in mortality rates and cancer incidence.²⁻⁷

Substantial variation exists worldwide in the most commonly diagnosed cancers, and in the leading causes of death from cancer,¹ and this variation could lead to differences within Canada across ethnic groups. There are 10 different most commonly diagnosed cancers among males and 5 different most commonly diagnosed cancers among females worldwide. Similarly, there are nine different leading causes of death from cancer in males and six among females worldwide. Not only do cancer incidence and mortality rates differ between countries, but differences exist within countries by ethnicity. In the United States, Asian and Pacific Islander males had the lowest cancer incidence rates, while non-Hispanic Black males had 85% higher cancer rates than non-Hispanic White males.⁸ In Scotland, the South Asian Indian population had the lowest cancer incidence rates, with the country's Chinese population having moderately higher rates, and the White Scottish population having the highest cancer rates.⁶

One-third of Canada's population is expected to belong to a non-White ethnic group by 2031.⁹ Previous Canadian and European studies have reported that South Asian females were more likely to be diagnosed with breast cancer at a later stage, and were less likely to be screened for breast cancer.^{10,11} While mammography use in the past two years among Asian females aged 50 to 69 in Canada was lower than that among females born in North America, more research is needed to determine the underlying factors contributing to the reported variations.^{12,13}

In the United States, Black males were twice as likely to die from prostate cancer compared with White males, and elderly Black males were substantially less likely to have the prostate-specific antigen for prostate cancer screening compared with elderly White males, after controlling for socioeconomic status and comorbid conditions.^{1,14} Other studies have also reported that African males have higher rates of prostate cancer.^{8,15,16} In Scotland, South Asians had the lowest overall cancer rates, while the White Scottish population had the highest cancer rates.⁶ In the United States, Asian and Pacific Islanders also had the lowest cancer and cancer mortality rates.¹

Cultural differences in the dietary intake of fruits and vegetables and pathophysiological differences in the effects of tobacco use across ethnicities have been shown to influence cancer risk.¹⁷⁻¹⁹ About 33% to 37% of cancers can be attributed to extrinsic factors, including environmental factors, behavioural and lifestyle factors, socioeconomic factors, and infections.^{20,21} The extrinsic factors of smoking and obesity continue to be the top contributors to cancer, with both smoking and obesity rates and their association with cancer shown to differ across ethnicities.^{22,23}

Previous reports have shown significant differences in the number of cigarettes smoked daily and in the proportion of daily or occasional smokers between different ethnic groups in Canada, with Caucasian immigrants and individuals born in Canada shown to have the highest average of cigarettes smoked daily among all ethnic groups.²⁴ Tobacco smoking has been linked to 25 different cancers, with strong associations to the risk of liver cancer, bladder and kidney cancers, pancreas cancer, and lymphoma.^{25,26}

The prevalence of overweight and obesity in Canada has also been shown to vary by ethnicity, with White Canadians having the highest prevalence of obesity, at 17%, and of being overweight, at 52%.²⁷ In contrast, Southeast Asians and South Asians had the lowest prevalence of obesity, from 3% to 8%, and of overweight, from 22% to 40%.²⁸ After adjustment for other major risk factors, such as age, smoking, alcohol intake, physical activity and total caloric intake, being overweight or obese was linked to increased cancer risk in Canada and other parts of the world.^{29,30} Being obese or overweight may account for as much as 33% of excess cancers.

When considering the factor of alcohol intake, a study of Ontario adults found a higher prevalence of self-reported lifetime, current and high-risk drinking among Canadian and European ethnic groups compared with other ethnic groups, such as South Asians, Southeast Asians and East Asians.^{31,32} Alcohol intake has been linked to an increased risk of developing multiple cancers, including breast, pancreatic, colorectal, oral, esophagus, stomach, liver and other cancers.³³⁻³⁵ Put together, these major differences in risk factors for cancer (smoking, obesity and alcohol intake) likely contribute significantly to the differences in cancer incidence and cancer mortality across ethnic groups.

The “healthy immigrant” effect has been shown to be present among the Canadian population. There is a clear survival advantage for recent immigrants, but the healthy immigrant effect advantage disappears over time the longer they reside in the host country.³⁶ With respect to cancer, recent immigrants are significantly less likely than non-immigrants to be diagnosed with any cancer and with the most common forms of cancer.³⁷

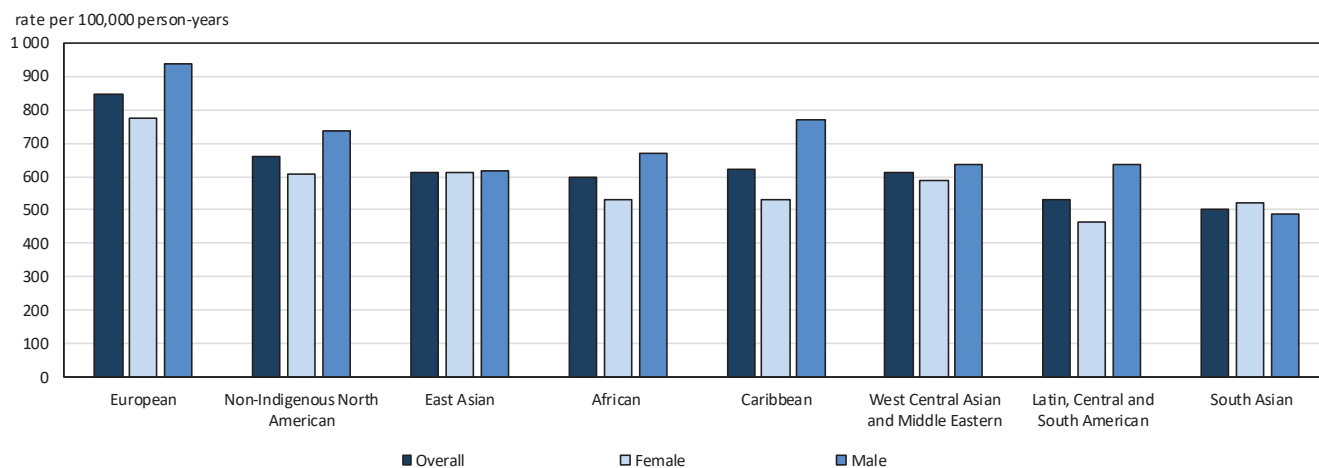
In Canada, there is a knowledge gap in the reporting of population health outcomes and health status, including cancer incidence and cancer mortality by ethnic group that is attributable to data availability.³⁸ Research in this area has traditionally focused on ethnicity among immigrants,^{39,40} and, while this is important, Canadian-born ethnic groups, including second-generation Canadians, have been under-researched. As of 2011, visible minorities represented 3 in 10 second-generation Canadians.⁴¹ This represents a knowledge gap for a large proportion of the population. This study was conducted prior to the excess deaths attributable to the COVID-19 pandemic. The objective was to assess the cancer incidence rate and cancer mortality rate among ethnic groups in Canada, according to cancer types.

Methods

Data sources

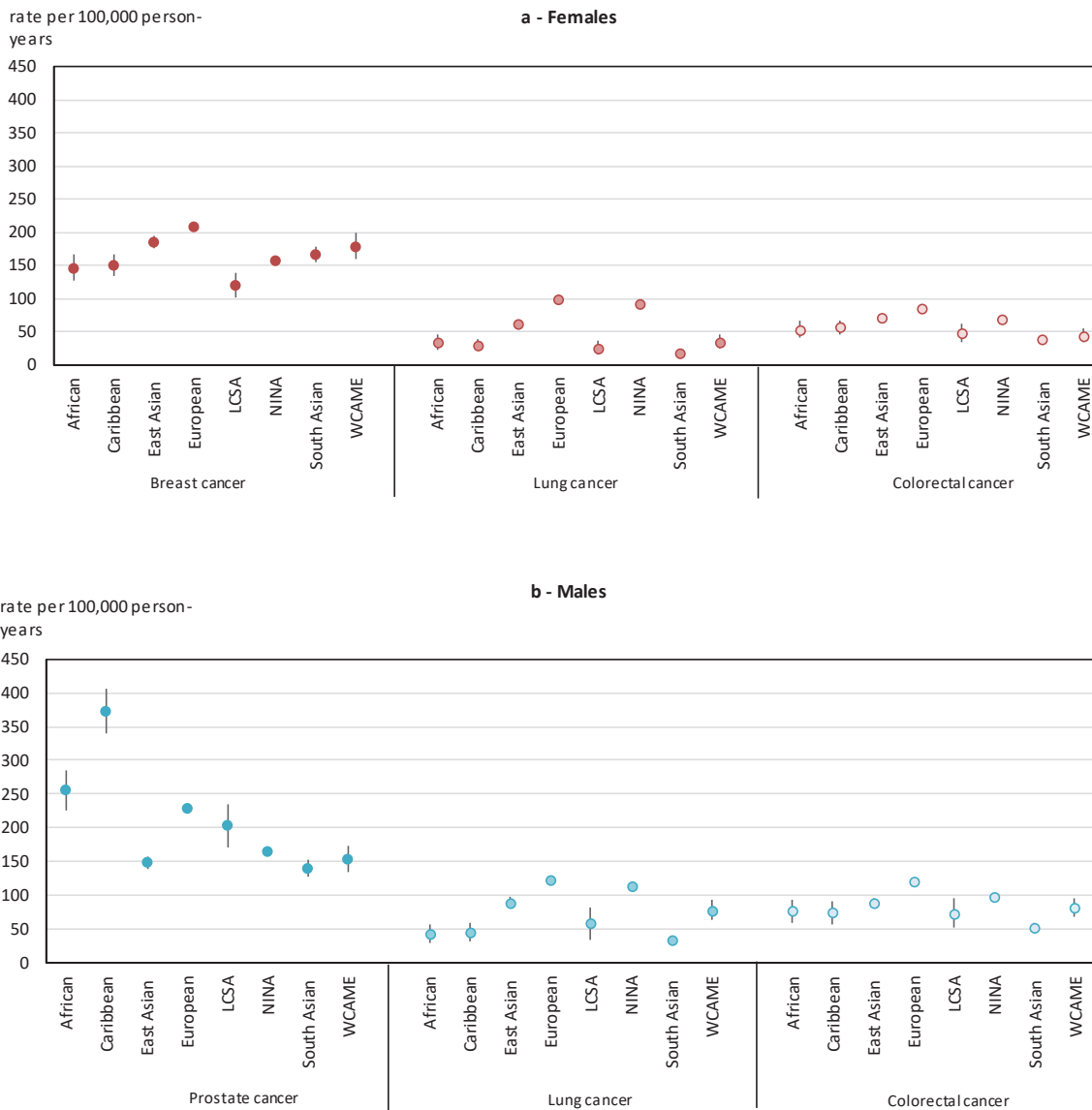
The study used the 2006 Canadian Census Health and Environment Cohort (CanCHEC) linked data. CanCHECs are population-based linked datasets that combine data from long-form census questionnaire respondents (or National Household Survey respondents) with data from health administrative datasets that include information on mortality, cancer, hospitalizations, ambulatory care and annual mailing-address postal codes.⁴² Successful linkage of cancer records to mortality records ranged from 99.1% to 99.8% between 2006 and 2016. The 2006 Census included questions on ethnic origins and sociodemographic characteristics. Information on cancer incidence was obtained through the linkage to the Canadian Cancer Registry (CCR). The CCR is a national, population-based registry that includes information about all newly diagnosed primary cancers since 1992. Cancer diagnoses are classified according to the International Classification of Diseases for Oncology, third edition (ICD-O-3). The International Agency for Research on Cancer (IARC) rules for multiple primaries were used for cases in the CCR. New primary cancers for the CanCHEC dataset were available up to 2016, and up to 2010 for Quebec residents. Data on cancer mortality (cause of death) were obtained from the Canadian Vital Statistics—Death Database (CVSD). The CVSD collects demographic and cause-of-death information annually from all vital statistics death registries in all of the provinces and territories in Canada. Data on deaths are received from the provinces and territories in which the deaths occurred and are regularly provided to Statistics Canada for inclusion in the CVSD. It contains all cause-of-death information for Canadian residents and non-residents who died in Canada from 1950 onwards.

Figure 1
Age-standardized cancer incidence rate, by ethnicity and sex, Canada, 2006 to 2016



Note: New primary cancers for the Canadian Census Health and Environment Cohort dataset were available up to 2010 for Quebec residents.
Source: 2006 Canadian Census Health and Environment Cohort linked to Canadian Cancer Registry (2006 to 2016).

Figure 2
Top three new cancer cases, by sex and ethnicity, Canada, 2006 to 2016



Notes: NINA represents non-Indigenous North American; WCAME represents West Central Asian and Middle Eastern; and LCSA represents Latin, Central and South American. New primary cancers for the Canadian Census Health and Environment Cohort dataset were available up to 2010 for Quebec residents.
Source: 2006 Canadian Census Health and Environment Cohort linked to Canadian Cancer Registry (2006 to 2016).

Study population

This study used the 2006 Census of Population, which was conducted on May 16, 2006, when 20% of households received both the short- and long-form questionnaires that included questions related to education, ethnicity, income, mobility and employment. The institutional population at the time of the census was not eligible for the study cohort. Institutional residents are defined as people living in an institution, for example, nursing homes, penitentiaries or group homes.

Ethnicity definition

Ethnicity refers to the ethnic or cultural origins of a person’s ancestors and should not be confused with citizenship or nationality.⁴³ The census asked respondents, “What were the ethnic or cultural origins of this person’s ancestors?”, and a person could have reported one or more ethnicities. Ethnicity was categorized according to the following mutually inclusive groups: non-Indigenous North American (NINA); European; Caribbean; Latin, Central and South American (LCSA); African; East Asian; South Asian; and West Central Asian and Middle Eastern (WCAME) (see Appendix Table 1). People who

Table 1
Distribution of cancer cases among top 10 cancer types, by ethnicity and sex, Canada, 2006 to 2016

Cancer types	European	Non-Indigenous North American	East Asian	West Central Asian and Middle Eastern			African Caribbean	Latin, Central and South American
				South Asian	percent	percent			percent
Females								
Breast	25.5	25.6	30.5	32.4	31.0	30.6	28.9	29.1
Lung	13.8	15.6	9.2	3.4	5.2	5.0	5.8	4.4
Colorectal	11.8	11.5	11.5	6.5	7.9	9.7	10.4	9.4
Uterus	6.5	5.7	7.1	9.5	6.0	5.8	7.2	7.6
Non-Hodgkin Lymphoma	5.4	5.0	3.5	4.9	5.7	6.3	5.6	6.2
Melanoma	3.9	3.3	...	...	...	...	...	...
Thyroid	3.8	4.0	9.7	12.6	12.8	10.9	8.9	12.6
Ovary	3.0	2.9	3.1	4.4	3.4	3.1	...	4.2
Leukemia	2.6	2.5	...	2.7	...	2.7	2.6	2.8
Bladder	2.5	2.5	...	...	2.8	...	...	...
Stomach	...	...	3.0	...	2.5	...	2.3	2.6
Pancreas	...	...	2.3	...	...	2.6	...	...
Cervix	...	...	2.0	...	...	...	2.4	...
Oral	...	...	...	2.3	...	...	...	...
Kidney	...	...	...	1.9	2.6	...	...	3.5
Multiple myeloma	...	...	...	...	...	1.8	3.3	...
Males								
Prostate	24.3	22.4	23.0	27.3	22.9	36.1	46.5	31.9
Lung	13.6	15.9	13.4	6.9	11.0	6.2	5.8	7.1
Colorectal	13.1	13.4	15.2	10.7	12.9	11.2	9.5	9.9
Bladder	7.3	6.9	3.9	5.5	8.0	4.8	3.4	3.1
Non-Hodgkin Lymphoma	6.4	5.7	5.7	8.6	8.7	6.7	5.1	5.6
Melanoma	4.3	3.6	...	...	...	...	...	...
Kidney	3.5	3.6	3.4	3.6	3.8	2.9	2.9	8.1
Leukemia	3.4	3.5	...	4.9	4.1	3.4	...	4.0
Oral	3.1	3.1	4.1	3.9	2.4	...	...	...
Pancreas	2.6	2.5	...	...	...	2.9	2.4	3.4
Liver	...	...	5.9	...	...	3.2	...	...
Stomach	...	...	3.5	...	...	3.1	2.8	3.7
Thyroid	...	...	3.5	3.3	3.1	...	2.2	...
Brain and central nervous system	...	...	...	2.8	...	...	...	...
Testis	...	...	...	...	2.5	...	...	2.7
Multiple myeloma	...	...	...	...	...	...	2.8	0.0

... not applicable (not in the top 10 types for this category)

Note: New primary cancers for the Canadian Census Health and Environment Cohort dataset were available up to 2010 for Quebec residents.

Source: 2006 Canadian Census Health and Environment Cohort linked to Canadian Cancer Registry (2006 to 2016).

reported more than one ethnicity may be included in more than one group. The grouping follows standard categories from the Census Dictionary and is expected to illustrate differences in cancer rates around the world.^{1,43}

Cancer definition

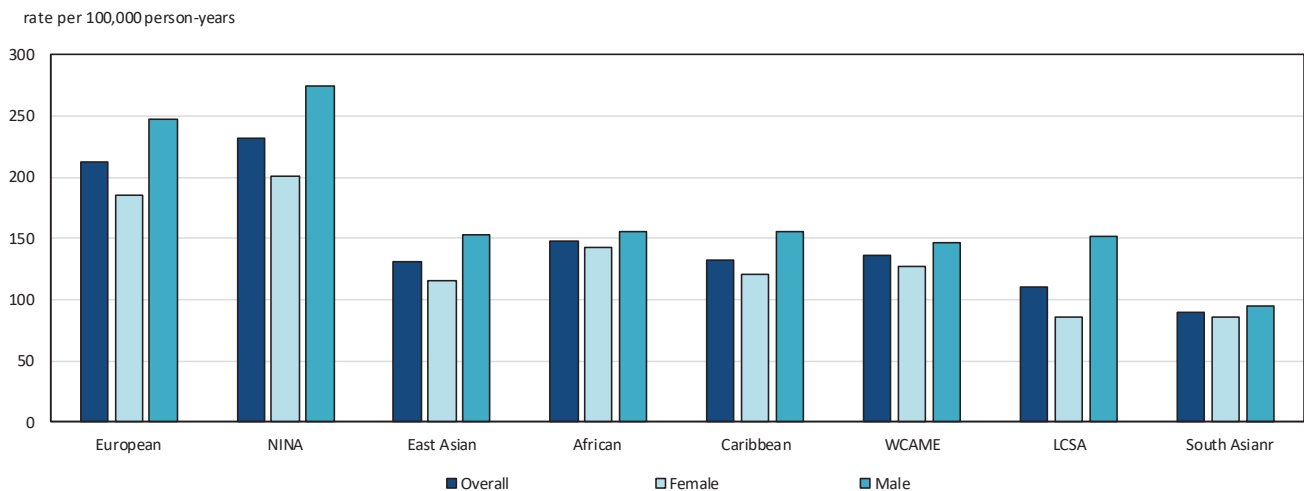
Cancer incidence and cancer mortality rates were estimated at the population level by ethnicity in Canada. These two indicators can serve as a baseline for the health states of different ethnicities in relation to cancer cases. These were defined using the ICD-O-3. New cancer cases were defined as those occurring from 2006 to 2016. The IARC rules for multiple primaries were used for cancer cases from the CCR for all provinces and territories. Cancer deaths are those that result from a form of cancer that is certified by a physician as the primary underlying cause of death. Mortality data covered the period from 2006 to 2016. The term cancer deaths was defined using the International Statistical Classification of Diseases and

Related Health Problems, 10th edition. Cancer types and deaths by cancer type are outlined in Appendix Table 2. Non-malignant cancers were excluded.

Statistical analysis

Cancer cases and deaths were classified by sex, five-year age group, ethnicity and cancer type. Rates of cancer for each category were calculated by dividing the number of cases or deaths in each category by the respective population number of person-years of follow-up from 2006 to 2016, or until a death was recorded. Sex- and age-standardized rates were calculated using the direct method, by weighting the age-specific rates for each five-year age group according to the 2011 Canadian standard population age distribution. Cancer rates have been shown to differ by sex and, thus, require sex-specific estimates. Age groups were then categorized into ranges (0 to 39, 40 to 54, 55 to 64, 65 to 74, and 75 and older) to distinguish between childhood, adolescent and young-adult, and adult cancers. To

Figure 3
Age-standardized cancer mortality rate, by ethnicity and sex, Canada, 2006 to 2016



Notes: NINA represents non-Indigenous North American; WCAME represents West Central Asian and Middle Eastern; and LCSA represents Latin, Central and South American.
Source: 2006 Canadian Census Health and Environment Cohort linked to Canadian Vital Statistics—Death Database (2006 to 2016).

account for the differences in linkage rates and for the representativeness of the 2006 CanCHEC, weights were created from the existing census to adjust for non-linkage. Bootstrap weights were also applied to account for variance.

Results

There were 5,871,337 people included in the cohort, the average age ranging from 28.5 years for African ethnicities to 39.9 years for European ethnicities (Appendix Table 3). Age distribution differed by ethnicity, with more people aged 55 years and older in the European and NINA groups. The proportion of people reporting only one ethnicity ranged from 55.4% to 86.3%. Specifically, 62.1% of people self-identified as European, 32.5% as NINA, 6.3% as East Asian, 3.9% as South Asian, 1.8% as WCAME, 1.6% as African, 1.5% as belonging to the Caribbean group, and 1.2% as LCSA. People in the East Asian, South Asian, WCAME, Caribbean, African and LCSA groups were mostly immigrants. More than 44% of LCSAs and NINAs reported more than one ethnicity, and more than one-third of people in the African and Caribbean groups reported more than one ethnicity.

Cancer incidence

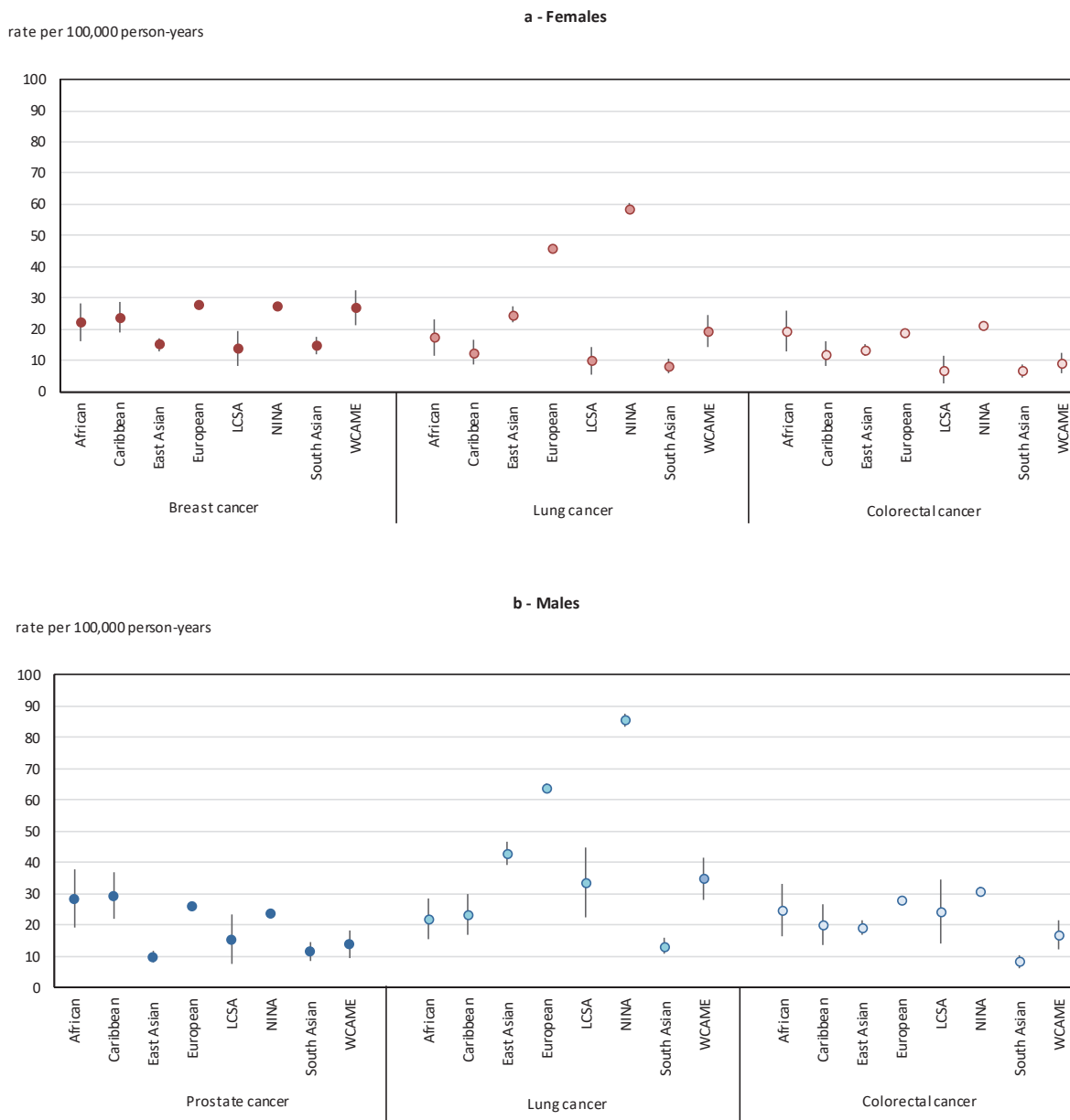
Figure 1 shows that Europeans had the highest cancer incidence rates across both sexes and in most age groups. Among females, Europeans had the highest rates, while LCSAs had the lowest rates. Similarly, among males, Europeans had the highest rates, while South Asians had the lowest overall cancer incidence rates.

Incidence rates for the top three cancers for both sexes varied by ethnicity (Figure 2). Among females, Europeans had the highest rates of breast, lung and colorectal cancer. Among males, the Caribbean group had the highest incidence rate of prostate cancer, and Europeans had the highest incidence rates of lung and colorectal cancer.

The distribution of the top 10 cancers among males and females differed by ethnicity (Table 1). Among females, there were five different cancers among the top three cancers by ethnicity. The top three cancers varied, accounting for from 48.3% of all cancers in Caribbean females to 54.4% of all cancers in South Asian females. Breast cancer was the top cancer, and lung and bronchus, colorectal, and thyroid cancers alternated among the top three cancers. Uterine cancer reached the top three cancers among South Asian females. There were 15 different cancers in the top 10 cancers by ethnicity, accounting for from 77.5% of all cancers in Caribbean females to 82.4% of all cancers in LCSA females. Pancreatic cancer reached the top 10 among Africans and East Asians. Multiple myeloma was prevalent in African and Caribbean females. Melanoma was prevalent in only NINA and European females. Cervical and stomach cancers reached the top 10 cancers among Caribbean and East Asian females.

Among males, there were five different cancers in the top three cancers by ethnicity. The top three cancers varied, accounting for from 46.5% of all cancers in South Asian males to 61.9% of all cancers in Caribbean males. Prostate cancer was the most common cancer, with lung and bronchus cancer, colorectal cancer, non-Hodgkin lymphoma, and kidney and renal pelvis cancer alternating among the top three cancers across the different ethnicities. There were 16 different cancers in the top 10 cancers by ethnicity, accounting for from 77.3% of all

Figure 4
Top three age-standardized cancer mortality causes, by sex and ethnicity



Notes: Rate per 100,000 person-years. NINA represents non-Indigenous North American; WCAME represents West Central Asian and Middle Eastern; and LCSA represents Latin, Central and South American.

Source: 2006 Canadian Census Health and Environment Cohort linked to Canadian Vital Statistics—Death Database (2006 to 2016).

cancers in South Asian males to 83.5% of all cancers in Caribbean males. Melanoma was among the top 10 for both NINA and European males, but not for any other ethnicity. Liver cancer represented a high proportion of cancers among East Asian males and African males. Stomach cancer was prevalent among African, Caribbean, LCSA and East Asian males. Brain and central nervous system cancers reached the top 10 among South Asian males only.

Cancer mortality

Figure 3 shows the variation in mortality rates by ethnicity, with NINAs having the highest cancer mortality rates across both sexes. South Asian females had the lowest cancer mortality rates, closely followed by LCSA females. South Asian males had the lowest overall cancer mortality rate.

Breast cancer mortality was highest among European females and lowest among LCSA females (Figure 4). NINA females had the highest lung and colorectal cancer mortality rate. While

Table 2
Distribution of cancer deaths among top 10 cancer types, by ethnicity and sex, Canada, 2006 to 2016

Cancer types	percent							
	European	Non-Indigenous North American	East Asian	South Asian	West Central Asian and Middle Eastern	African	Caribbean	Latin, Central and South American
Females								
Lung	25.0	29.0	20.8	9.1	14.9	11.5	10.2	11.8
Breast	14.4	13.7	14.2	18.8	22.6	20.7	21.7	18.2
Colorectal	10.4	10.6	11.7	7.9	8.6	12.1	10.0	7.5
Pancreas	5.9	5.7	6.9	6.2	4.9	7.7	7.1	5.3
Ovary	5.0	4.5	4.8	8.2	5.8	4.7	...	7.5
Non-Hodgkin lymphoma	3.5	3.2	3.8	4.7	4.4	6.2	5.3	...
Leukemia	3.3	2.9	2.5	...	4.0	2.4	...	6.4
Uterus	2.9	2.2	3.5	5.2	4.4	5.6	7.8	6.4
Brain and central nervous system	2.5	2.5	...	4.8	4.0	...	3.5	2.7
Stomach	2.0	1.9	6.0	3.3	4.4	3.6	4.0	5.9
Liver	...	...	2.8	...	...	...	...	...
Oral	...	...	...	3.7	...	...	...	...
Multiple myeloma	...	...	...	...	...	2.4	4.4	3.7
Cervix	...	...	...	...	...	...	2.9	...
Males								
Lung	26.2	31.7	26.3	15.6	23.7	16.4	16.7	22.9
Colorectal	11.2	11.4	13.1	8.6	11.3	13.5	12.3	12.6
Prostate	10.5	7.9	6.1	9.8	8.2	12.9	16.7	7.9
Pancreas	5.8	5.4	5.4	7.5	5.0	8.8	5.8	6.1
Bladder	4.1	3.5	...	...	5.0	...	...	...
Leukemia	3.9	3.6	3.1	5.7	6.0	5.0	4.9	2.8
Non-Hodgkin lymphoma	3.9	3.6	4.5	6.9	5.6	4.4	6.0	2.8
Esophagus	3.7	3.5	...	...	...	...	4.1	...
Stomach	3.0	2.8	5.2	3.4	3.2	3.5	6.3	7.9
Kidney	2.8	...	...	...	...	3.5	3.0	2.8
Brain and central nervous system	...	2.8	2.3	5.4	5.8	5.3	3.8	3.7
Liver	...	...	8.3	4.0	2.8	5.3	...	3.3
Oral	...	...	3.9	4.5	...	...	...	...
Multiple myeloma	...	...	...	...	...	...	4.1	...

... not applicable (not in the top 10 types for this category)

Source: 2006 Canadian Census Health and Environment Cohort linked to Canadian Vital Statistics—Death Database (2006 to 2016).

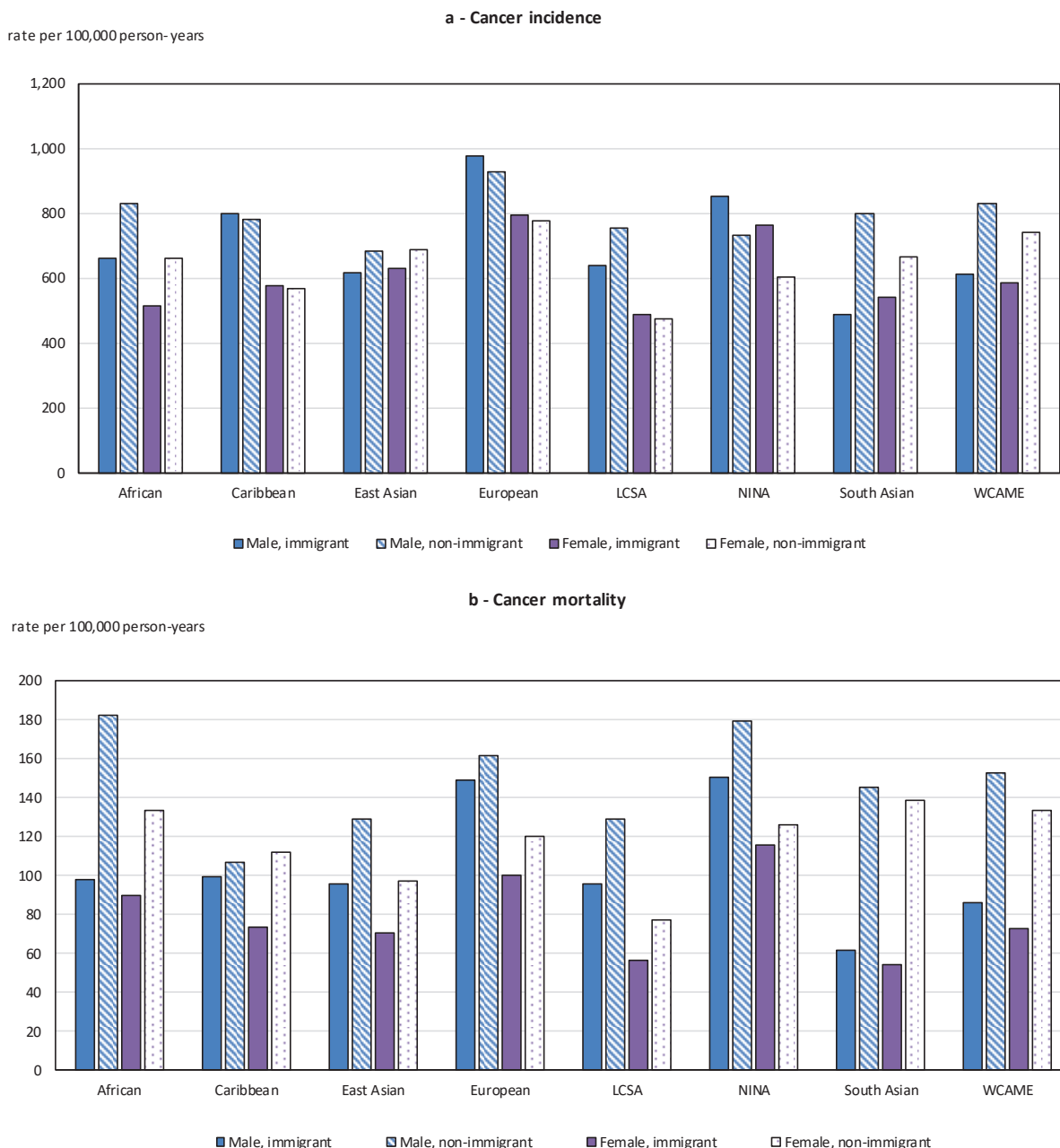
South Asian females had the lowest lung and colorectal cancer rates, NINA males had the highest lung and colorectal cancer mortality rates. Caribbean males had the highest prostate cancer mortality rate, at 29.4 per 100,000 people.

The distribution of the top 10 cancer deaths among males and females differed by ethnicity (Table 2). Among females, there were four different types of cancers among the top three cancer deaths by ethnicity. The top three cancer deaths varied, accounting for from 36.1% of all cancer deaths in South Asian females to 53.3% of all cancer deaths in NINA females. The top cause of death from cancer among females varied between lung and bronchus cancer and breast cancer. The other common cause of death from cancer was colorectal cancer, and deaths from ovarian cancer approached the top three for South Asian females. There were 14 different cancers among the top 10 cancers by ethnicity, accounting for from 71.9% of all cancer deaths in South Asian females to 78.1% of all cancer deaths in WCAME females. The top 10 causes of death from cancer were consistent across the different ethnicities; however, multiple myeloma reached the top 10 among African, Caribbean and LCSA females. Deaths from cervical cancer reached the top 10 among Caribbean females, while deaths from liver cancer

reached the top 10 among East Asian females, and deaths from oral cancer reached the top 10 among South Asian females.

Among males, there were five different cancers in the top three cancer deaths by ethnicity. The top three cancer deaths varied, accounting for from 46.5% of all cancer deaths in South Asian males to 61.9% of all cancer deaths in Caribbean males. Lung cancer was the top cause of deaths from cancer, with colorectal cancer and prostate cancer rounding out the top three for most ethnicities. Deaths from stomach cancer reached the top three among LCSAs, and deaths from liver cancer reached the top three among East Asian males. There were 14 different cancers in the top 10 cancer deaths by ethnicity, accounting for from 71.5% of all cancer deaths in South Asian males to 79.7% of all cancer deaths in Caribbean males. Most of the top 10 cancer deaths were consistent among ethnicities, with kidney and renal pelvis cancer, brain and central nervous system cancer, multiple myeloma, oral cancer, and liver cancer reaching the top 10 causes of death from cancer.

Figure 5
Age-standardized cancer incidence and mortality rates, by ethnicity, sex and immigrant status, Canada, 2006 to 2016



Notes: NINA represents non-Indigenous North American; WCAME represents West Central Asian and Middle Eastern; and LCSA represents Latin, Central and South American. New primary cancers for the Canadian Census Health and Environment Cohort dataset were available up to 2010 for Quebec residents.
Source: 2006 Canadian Census Health and Environment Cohort linked to Canadian Cancer Registry (2006 to 2016) and to Canadian Vital Statistics—Death Database (2006 to 2016).

Sensitivity analyses

Since ethnicity and immigrant status are often related, and each has been shown to be associated with health outcomes, a sensitivity analysis was conducted to assess the differences in cancer rates between ethnicities by immigrant status. The stratified analysis by immigrant status and sex shows that non-immigrant incidence and mortality cancer rates were generally

higher than the rates for immigrants (Figure 5). For ethnicities with a larger proportion of immigrants, namely the East Asian, South Asian, WCAME, Caribbean, African and LCSA groups, the non-immigrant incidence and mortality rates were much higher than those for the immigrant group. Non-immigrant African males and females had 25% to 30% higher incidence rates compared with immigrant African males and females. Non-immigrant African males had an 86% higher mortality

rate, and non-immigrant African females had a 49% higher mortality rate, compared with immigrant African males and females, respectively. Cancer mortality in non-immigrant Caribbean females was 53% higher compared with immigrant Caribbean females. Non-immigrant East Asian males and females had slightly higher incidence rates and up to 38% higher mortality rates compared with immigrant East Asians. Non-immigrant Europeans and non-immigrant NINAs had 9% to 20% higher mortality rates compared with immigrant Europeans and immigrant NINAs, respectively. Non-immigrant NINA males and females had 14% to 21% lower cancer incidence rates compared with immigrant NINA males and females, respectively. Non-immigrant LCSA males had 18% higher cancer incidence rates compared with immigrant LCSA males, and non-immigrant LCSA males and females had 34% to 36% higher mortality rates compared with immigrant LCSA males and females, respectively. Cancer incidence rates for non-immigrant South Asian females and males were 23% to 64% higher than for immigrant South Asian females and males. Non-immigrant South Asian females and males had 1.4 times to 1.6 times higher cancer mortality rates compared with immigrant South Asian females and males, respectively. Non-immigrant WCAME females and males had 26% to 36% higher cancer incidence rates, and 77% to 83% higher cancer mortality rates, compared with immigrant WCAME females and males. Non-immigrant South Asian males and females no longer had the lowest cancer incidence and mortality rates. Rather, non-immigrant South Asian females and non-immigrant African males had the highest rate of overall cancer mortality among females and males.

Discussion

To the knowledge of the authors, this is the first Canadian study to report ethnic variability in cancer incidence and mortality. Disaggregating cancer rates in the Canadian population is essential to understanding the differences within the diverse Canadian population and to informing prevention, diagnosis and treatment.

Europeans had the highest cancer incidence rates, and NINAs had the highest cancer mortality rates. Certain cancers, such as stomach cancer, were more prevalent in the East Asian, LCSA, African and Caribbean groups. Non-immigrant cancer rates for the East Asian, South Asian, WCAME, Caribbean, African and LCSA groups were much higher than the comparable immigrant cancer rates; for example, non-immigrant African males had the highest cancer incidence rates among males, while non-immigrant South Asian females had the highest cancer mortality rates among females. This study found that cancer rates varied by ethnicity, with certain cancers being more prevalent among some groups, and with non-immigrant groups having higher rates compared with immigrant groups.

Europeans and NINAs had the highest cancer incidence rates and cancer mortality rates, and this likely reflects their increased exposure to the primary cancer risk factors, namely smoking,

obesity and alcohol intake. Europeans and NINAs are the groups with the largest proportion of second- and third-generation Canadians, and studies that report on “native-born Canadians” are likely describing this group.⁴⁴ Native-born Canadians have the highest average of daily cigarette smoking among all of the ethnic groups.²⁴ White Canadians also have the highest prevalence of obesity, at 17%, and of overweight, at 52%.²⁷ Furthermore, Europeans and White Canadians had the highest rates of lifetime, current and high-risk drinking and consumed more alcohol than did other ethnicities.^{31,32}

The lower breast cancer incidence rates among South Asian females found in this study could be explained by another study that found that South Asian females were less likely to be screened for breast cancer compared with the general population.¹⁰ Furthermore, the higher overall cancer mortality rate among non-immigrant South Asian females could be explained by their higher likelihood of having a diagnosis of later-stage breast cancer than the general population.^{10,11} Another study also found that Asian females aged 50 to 69 years were less likely to have received a mammogram than North American females.^{12,13} More research is needed to determine the underlying factors contributing to the reported variations, since the evidence for the underuse of cancer services, treatment completion and follow-up remains mixed.^{12,13}

The higher rate of prostate cancer and prostate cancer mortality found in Caribbean and African males in this study is similar to that seen in the United States, where Black males are twice as likely to die from prostate cancer as White males.^{1,14} Other studies have also reported higher rates of prostate cancer among African males.^{8,15,16} This study also found that non-immigrant African males had the highest overall cancer mortality, closely followed by non-immigrant NINA males. Future studies will need to examine sociodemographic factors, behavioural factors, access to care and other factors that are contributing to the higher mortality rates.

In this study, East Asians consistently had low rates of cancer, but this was not the case for the non-immigrant South Asian population. East Asians have been reported to have lower cancer rates in other countries.¹ However, a previous study from Scotland found that South Asians had lower overall cancer rates compared with the general population,⁶ and this may be attributable to a healthy immigrant effect within Scottish South Asians. In the current study, an observed healthy immigrant effect may also explain the low cancer rates for the South Asian population.

Variations in the top cancers and the top causes of death from cancer by ethnicity are similar to those in other studies and likely reflect differences in the underlying baseline risks, social and economic transition periods, and cultural differences.^{1,2} Cultural differences in diet, smoking, obesity, behaviour and lifestyle, as well as socioeconomic factors, have all been reported to differ by ethnicity and have significant effects on cancer incidence rates and cancer mortality rates.¹⁷⁻²³

In this study, the lower incidence and mortality rates among immigrants reflect the healthy immigrant effect. When non-immigrants were compared with immigrants of the same ethnicity, the survival advantage for immigrants was lost and may have disappeared as this group resided longer in the host country.³⁶ This study also found that immigrants, in general, have lower rates of cancer incidence compared with non-immigrants of the same ethnicity. This likely reflects a combination of the healthy immigrant effect and the fact that recent immigrants are less likely than non-immigrants to be diagnosed with any cancer and with the most common forms of cancer.³⁷

There are limitations of this study to consider. First, it was unable to compare ethnic groups directly, because of the mutually inclusive categories. Second, its objectives were to estimate cancer incidence and mortality rates by ethnicity and to characterize the differences in cancer rates by ethnicity. Finally, overall cancer rates describe what happens to large groups of people and provide a picture in time of the burden of cancer on that group.

Future research should focus on carrying out direct comparisons between ethnicities and a more careful investigation of the factors contributing to the variations in cancer incidence and mortality rates. Future studies should also examine ethnic group differences and assess other differences within each of the ethnicities. Data on the incidence of cancer cases from Quebec were unavailable from 2010 onwards, and data for people living in institutions were not included in the CanCHEC. These factors reduce the generalizability of the results of the study across Canada. Nevertheless, this analysis used sample weights to

create estimates that should be generalizable to the non-institutionalized population.

The CanCHEC has been found to underestimate mortality rates when compared with the rates from the official mortality tables for the total Canadian population.⁴² Infant mortality rates and mortality rates for older age groups (80 years and older) tended to be underestimated, while rates for other age groups (1 to 69 years old) were similar. This suggests that the results from this study may be conservative estimates of the actual cancer incidence and cancer mortality rates.

Conclusion

This is the first study in Canada to assess the distribution of rates of cancer incidence and cancer mortality by ethnicity throughout the country, using a census-linked population dataset of more than 5 million respondents. Rates of cancer incidence and cancer mortality differed substantially between different ethnicities. These differences likely reflect differences in cancer risk factors, in the use of screening tests, and in other preventive and treatment interventions. Population-based data on cancer incidence and mortality can be used to inform efforts to decrease the cancer burden among different ethnicities and to monitor progress in improving health outcomes.

Appendix Table 1
Ethnic origin groupings from 2006 Census of Population

Ethnicity category	Ethnic origin
African	<ul style="list-style-type: none"> · Central and West African origins (Akan, Angolan, Ashanti, Beninese, Burkinabe, Cameroonian, Chadian, Congolese, Gabonese, Gambian, Ghanaian, Guinean, Ibo, Ivorian, Liberian, Malian, Nigerian, Peulh, Senegalese, Sierra Leonean, · North African origins (Algerian, Berber, Coptic, Dinka, Egyptian, Libyan, Maure, Moroccan, Sudanese, Tunisian, other North · Southern and East African origins (Afrikaner, Amhara, Bantu, Burundian, Eritrean, Ethiopian, Harari, Kenyan, Malagasy, Mauritian, Oromo, Rwandan, Seychellois, Somali, South African, Tanzanian, Tigrian, Ugandan, Zambian, Zimbabwean, Zulu, · Other African origins (Black, other African origins)
East Asian	<ul style="list-style-type: none"> · Burmese, Cambodian (Khmer), Chinese, Filipino, Hmong, Indonesian, Japanese, Korean, Laotian, Malaysian, Mongolian, Singaporean, Taiwanese, Thai, Tibetan, Vietnamese, other East and Southeast Asian origins
South Asian	<ul style="list-style-type: none"> · Bangladeshi, Bengali, East Indian, Goan, Gujarati, Kashmiri, Nepali, Pakistani, Punjabi, Sinhalese, Sri Lankan, Tamil, other
West Central Asian and Middle Eastern	<ul style="list-style-type: none"> · Afghan, Arab, Armenian, Assyrian, Azerbaijani, Georgian, Iranian, Iraqi, Israeli, Jordanian, Kazakh, Kurd, Kuwaiti, Lebanese, Palestinian, Pashtun, Saudi Arabian, Syrian, Tajik, Tatar, Turk, Uighur, Uzbek, Yemeni, other West Central Asian and Middle Eastern origins
Caribbean	<ul style="list-style-type: none"> · Antiguan · Bahamian · Barbadian · Bermudan · Carib · Cuban · Dominican · Grenadian · Haitian · Jamaican · Kittitian/Nevisian · Martinican · Montserratian · Puerto Rican · St. Lucian · Trinidadian/Tobagonian · Vincentian/Grenadinian · West Indian · Other Caribbean origins
European	<ul style="list-style-type: none"> · British Isles (Channel Islander, Cornish, English, Irish, Manx, Scottish, Welsh, other British Isles origins) · French origins (Alsatian, Breton, French) · Eastern European origins (Bulgarian, Byelorussian, Czech, other Czechoslovakian, Estonian, Hungarian, Latvian, Lithuanian, Moldovan, Polish, Romanian, Russian, Slovak, Ukrainian, other Eastern European origins) · Northern European origins (Danish, Finnish, Icelandic, Norwegian, Swedish, other Northern European origins) · Southern European origins (Albanian, Bosnian, Croatian, Cypriot, Greek, Italian, Kosovar, Macedonian, Maltese, Montenegrin, Portuguese, Serbian, Sicilian, Slovenian, Spanish, Yugoslavian, other Southern European origins) · Western European origins (Austrian, Belgian, Dutch, Flemish, Frisian, German, Luxembourg, Swiss, other Western European origins) · Other European origins (Basque, Jewish, Roma (Gypsy), Slavic, other European origins)
Latin, Central and South American	<ul style="list-style-type: none"> · Aboriginal from Central/South · Argentinian · Belizean · Bolivian · Brazilian · Chilean · Colombian · Costa Rican · Ecuadorian · Guatemalan · Guyanese · Honduran · Maya · Mexican · Nicaraguan · Panamanian · Paraguayan · Peruvian · Salvadorean · Uruguayan · Venezuelan · Other Latin, Central and South American origins · Hispanic
Non-Indigenous North American	<ul style="list-style-type: none"> · Acadian · American · Canadian · New Brunswicker · Newfoundlander · Nova Scotian · Ontarian · Québécois · Other North American origins

Source: 2006 Census Dictionary (<https://www12.statcan.gc.ca/census-recensement/2006/ref/dict/index-eng.cfm>).

Appendix Table 2
Cancer definitions

Cancer type	ICD-O-3 code for incidence	ICD-10 code for mortality
Bladder	C67	C67
Brain and central nervous system	C70–C72	C70–C72
Breast	C50	C50
Cervix	C53	C53
Colorectal	C18–C20, C26.0	C18–C20, C26.0
Esophagus	C15	C15
Hodgkin lymphoma	Histology: 9650–9667	C81
Kidney and renal pelvis	C649, C659	C64, C65
Larynx	C32	C32
Leukemia	Type: 733, 9742, 9800, 9801, 9805–9809, 9820, 9826, 9831–9836, 9840, 9860, 9861, 9863, 9865–9867, 9869–9876, 9891, 9895–9898, 9910, 9911, 9920, 9930, 9931, 9940, 9945, 9946, 9948, 9963, 9964 Type 9811–9818, 9823, 9827, 9837 sites C42.0, C42.1, C42.4	C901, C91–C95
Liver	C220	C220, C222–C227
Lung and bronchus cancer	C34	C34
Melanoma	Type: 8720–8790 and site C44	C43
Multiple myeloma	Type: 9731, 9732, 9734	C900, C902
Non-Hodgkin lymphoma	Type 9590–9597, 9670–9719, 9724–9729, 9735, 9737, 9738 Type 9811–9818, 9823, 9827, 9837 all sites except C42.0, C42.1, C42.4	C82–C85, C963 ...
Oral	C0, C10–C14	C0, C10–C14
Ovary	C569	C56
Pancreas	C25	C25
Prostate	C619	C61
Stomach	C16	C16
Testis	C62	C62
Thyroid	C739	C73
Uterus	C54, C55	C54, C55

... not applicable

Sources: International Statistical Classification of Diseases for Oncology, 3rd edition (ICD-O-3); International Statistical Classification of Diseases and Related Health Problems, 10th edition (ICD-10).

Appendix Table 3
Characteristics of the 2006 Canadian Census Health and Environment Cohort

Characteristic	Ethnicity							
	European	Non-Indigenous North American	East Asian	South Asian	West Central Asian and Middle Eastern	African	Caribbean	Latin, Central and South American
Number	3,644,025	1,909,073	367,966	226,429	106,059	95,518	90,574	72,289
Age, mean (SD)	39.9 (52.2)	35.7 (50.9)	34.7 (49.6)	32.2 (48.9)	30.9 (47.9)	28.5 (45.4)	31.1 (49.0)	29.0 (44.9)
	percent							
Age group (years)								
0 to 39	47.9	55.0	58.1	64.6	66.2	71.2	65.9	70.2
40 to 54	24.4	23.8	24.6	19.9	20.8	19.4	18.5	19.8
55 to 64	12.7	10.8	8.5	8.5	6.9	5.6	8.9	6.3
65 to 74	8.1	5.9	5.3	4.8	3.8	2.6	4.5	2.4
75 and older	6.9	4.4	3.5	2.2	2.3	1.3	2.2	1.3
Sex								
Male	49.0	49.0	47.3	50.3	51.6	50.8	46.2	48.2
Female	51.0	51.0	52.7	49.7	48.4	49.2	53.8	51.8
Number of reported ethnicity								
1	71.6	56.6	87.4	89.3	77.2	63.9	60.7	55.4
2 or more	28.4	43.4	12.6	10.7	22.8	36.1	39.3	44.6
Immigrant status								
Non-immigrant	85.1	98.6	29.8	29.9	34.0	38.0	48.7	37.5
Immigrant	14.6	1.4	67.5	68.4	63.7	58.4	50.1	58.6

Note: SD = standard deviation.

Source: 2006 Canadian Census Health and Environment Cohort.

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