cmajOPEN

Research

Prostate cancer incidence among immigrant men in Ontario, Canada: a population-based retrospective cohort study

Aisha K. Lofters MD PhD, Jacqueline L. Bender PhD, Sarah Swayze MSc, Shabbir Alibhai MD MSc, Anthony Henry BA, Kenneth Noel BSc, Geetanjali D. Datta ScD

Abstract

Background: Prostate cancer incidence has been associated with various sociodemographic factors, such as race, income and age, but the association with immigrant status in Canada is unclear. In this population-based study in Ontario, Canada, we compared age-standardized incidence rates for immigrant males from various regions of origin with the rates of long-term residents.

Methods: In this retrospective cohort study, we linked several provincial-level databases available at ICES, an independent, nonprofit research institute. We included all males aged 20 years and older in the province of Ontario eligible for health care for each fiscal year (Apr. 1 to Mar. 31) in 2008–2016. We determined age-standardized prostate cancer incidence rates, stratifying by immigrant status (a binary variable) and region of origin. We used a log-binomial model to estimate adjusted incidence rate ratios, with long-term residents (Canadian-born Ontarians as well as those who immigrated before 1985, when available data on immigration starts) as the reference group. We included age, neighbourhood income and time since landing in the models. Additional models limited to immigrant males in the cohort included immigration admission category (economic class, family class, refugee, other) and time since landing in Canada.

Results: There were 74 594 incident cases of prostate cancer in the study period, 6742 of which were among immigrant males. Males who had immigrated from West Africa and the Caribbean had significantly higher incidence of prostate cancer than other immigrants and long-term residents: adjusted rate ratios of 2.71 (95% confidence interval [CI] 2.41–3.05) and 1.91 (95% CI 1.78–2.04), respectively. Immigrants from other regions, including East Africa and Middle-Southern Africa, had lower or similar incidence rates to long-term residents. Males from South Asia had the lowest adjusted rate ratio (0.47, 95% CI 0.45–0.50).

Interpretation: The age-standardized incidence rate of prostate cancer from 2008 to 2016 was consistently and significantly higher among immigrants from West African and Caribbean countries than among other immigrants and long-term residents of the province. Future research in Canada should focus on further understanding heterogeneity in prostate cancer risk and epidemiology, including stage of diagnosis and mortality, for immigrants.

Prostate cancer is the second most common cancer among men worldwide and the most common cancer among men in 112 countries including Canada.[1] In Canada, 1 in 9 men will be diagnosed with prostate cancer during their lifetime, and 1 in 29 will die from it.[2] The province of Ontario has the second highest age-standardized incidence rate of prostate cancer of all Canadian provinces, reported at 121.8 cases per 100 000.[2]

Ontario also has a sizable and diverse foreign-born population; 29% of the province's population are immigrants according to the 2016 Canadian Census, coming from more than 200 countries.[3] It is important to understand differences, if any, in prostate cancer risk among immigrants to ensure that we are best serving the health care needs of a very diverse population. However, very little is known about heterogeneity in prostate cancer risk among immigrants in the Ontario or Canadian context. Incidence of breast and colorectal cancers has previously been found to differ significantly for immigrants versus long-term residents of Ontario, and to vary by region of origin and time in Canada,[4] and it is reasonable to consider the same may hold true for prostate cancer. Although prostate cancer is pervasive worldwide, incidence rates vary widely from country to country[1,5] and may similarly vary widely among Ontario's immigrant men.

Prostate cancer incidence has also been associated with other demographic factors. The risk of prostate cancer increases with age, such that 40% of all cases of prostate cancer

Competing interests: Aisha Lofters declares an operating grant paid to her institution from the Canadian Institutes of Health Research (grant no. 162506) and a paid role as provincial primary care lead, cancer screening with Ontario Health (Cancer Care Ontario). Anthony Henry is first vice president of The Walnut Foundation. Ken Noel is president of The Walnut Foundation. No other competing interests were declared.

This article has been peer reviewed.

Correspondence to: Aisha Lofters, Aisha.lofters@wchospital.ca

***CMAJ Open* 2022 November 1. DOI:10.9778/cmajo.20220069**

occur in men aged 60–69 years.[2] Higher socioeconomic status has been associated with increased incidence.[6,7] As well, Black men are commonly considered to be at higher risk for prostate cancer.[5] Therefore, in this population-based study, we aimed to compare age-standardized incidence rates for immigrants from various regions of origin with those of long-term residents of Ontario, and to better understand the role of sociodemographic and health factors in prostate cancer incidence, specifically age, neighbourhood income quintile, immigration admission category and years in Canada.

Methods

This was a population-based retrospective cohort study in Ontario using administrative data from 2008 to 2016, reported using the Strengthening the Reporting of Observational Studies in Epidemiology checklist.[8] Ontario is Canada's most populous province, with about 13 million people, and has a publicly funded health plan called the Ontario Health Insurance Plan (OHIP).[9,10] All Canadian citizens, permanent residents or landed immigrants, and refugees who live in Ontario are eligible for OHIP.[10]

Data sources

We used several databases available at ICES, an independent, nonprofit research institute. ICES houses a secure array of Ontario's health-related administrative provincial-level data. Data include population demographic characteristics and health service use information on all Ontario residents who are eligible for OHIP. All data sets are linked using unique encoded identifiers and analyzed at ICES.

We used the Immigration, Refugee and Citizenship Canada Permanent Resident (IRCC-PR) database, which includes demographic information on Ontario's immigrants and refugees who landed from 1985 onward, including country of origin, date of landing and immigration admission category.[11] The database does not capture those who immigrated before 1985 or immigrants who live in Ontario but originally landed in another province. Probabilistic linkage is used to link individuals in IRCC-PR data to ICES data. Overall linkage rates are about 86%.[11,12] We also used the Ontario Cancer Registry (OCR), which includes all Ontario residents who have been newly diagnosed with cancer (except nonmelanoma skin cancers), including the primary cancer site and diagnosis date.[13] Records in the OCR are created using data collected for purposes other than cancer registration. The data sources used to generate case records in the OCR are as follows: provincial pathology reports from hospital and private laboratories with any mention of cancer, records of patients referred to institutions treating cancer patients in the province, hospital admission and discharge information and day surgery summaries that include a cancer diagnosis, and cause-of-death data from the Office of the Registrar General where cancer is recorded.[12] Other ICES databases that we used included the Primary Care Population data set, which is a biannual cohort of OHIP-eligible Ontario residents with a date of last contact with the health care system within 7–9 years of index; the Registered Persons Database, which includes date of birth, sex, postal code and dates of contact with the health care system; and the OHIP Database, which contains procedural and diagnostic codes claimed by physicians in the province.[12]

Study population

We used the Primary Care Population data set to identify all males (we use the term "males" as the data set provides sex, not gender) aged 20 years and older in the province of Ontario eligible for health care for each fiscal year in 2008–2016. We identified incident prostate cancer cases for each year by linking annual cohorts to the Ontario Cancer Registry. We defined males in the IRCC-PR database as immigrants, and those not in the IRCC-PR database as long-term residents (as this group would include people who immigrated before 1985). We categorized immigrant males by region of origin (i.e., Caribbean, Latin America, Western Europe, Eastern Europe and Central Asia, Middle East and North Africa, East Asia and the Pacific, West Africa, East Africa, Middle-Southern Africa, and Australia, New Zealand and the United States) based on country of birth. These regions reflect classifications by the World Bank,[14] with subclassifications of Sub-Saharan Africa reflecting the United Nations geoscheme.[15]

Study outcome and study variables

We determined age-standardized incidence rates (annual and for 2008–2016 overall) of prostate cancer, age-standardized against the 2016 Canadian Census[9] population standard. We examined other variables that reflected factors potentially relevant to differences in prostate cancer incidence as described above: age (determined from the Registered Persons Database);[2] neighbourhood income quintile — a proxy for socioeconomic status determined from linking the postal code of the individual's home address from the Registered Persons Database to 2016 Census data on mean household income;[6,7] and, for immigrant males only, immigration admission category, which may also reflect socioeconomic status, categorized as economic (i.e., skilled workers, business class), family class (family reunification and sponsorship), and refugees or asylum seekers, and time since landing[4] based on IRCC-PR data.

Statistical analysis

First, we conducted descriptive analyses and calculated χ^2 statistics to describe the study cohort, for each year and overall. We calculated age-standardized incidence rates for each year and overall, stratifying by immigrant status and region of origin. We then used a log-binomial model to estimate adjusted incidence rate ratios, with long-term residents as the reference group. We included age, neighbourhood income and time since landing in the models. Then models were repeated and limited to immigrants in the cohort; these models included immigration admission category and time since landing in Canada as covariates. All analyses were performed using SAS version 9.4 (SAS Institute, Inc.).

Ethics approval

This study was approved by the Unity Health Toronto Research Ethics Board.

Results

Descriptive characteristics of the overall cohort (2008 to 2016) are shown in Table 1. Immigrants tended to be younger than long-term residents, with males from Middle-Southern Africa having a median age of 41 years and long-term residents having a median age of 48 years. The proportion of males in each immigration admission category varied widely by region; 59.5% of Western European immigrants were economic class versus 22.6% for Caribbean immigrants. More than half (57.1%) of East African immigrants came as refugees. Income quintile also varied widely. Caribbean, East African and West African males

Table 1: Descriptive characteristics of overall study cohort, Ontario, Canada (2008–2016)*

Variable	Caribbean *n* = 529 651	East Africa *n* = 289 254	East Asia and Pacific *n* = 1 969 550	Eastern Europe and Central Asia *n* = 1 065 676	Latin America *n* = 634 289	Middle East and North Africa *n* = 846 259
Age, yr						
Mean ± SD	42.9 ± 13.4	42.9 ± 13.6	46.0 ± 15.5	45.0 ± 14.2	43.9 ± 13.7	43.2 ± 14.6
Median (IQR)	42 (32–51)	42 (32–52)	45 (34–55)	45 (34–55)	43 (33–53)	43 (31–52)
Economic class	119 936 (22.6)	67 747 (23.4)	1 137 941 (57.8)	508 464 (47.7)	181 875 (28.7)	471 661 (55.7)
Family class	376 427 (71.1)	51 471 (17.8)	632 136 (32.1)	213 367 (20.0)	269 545 (42.5)	136 677 (16.2)
Refugee	23 024 (4.3)	165 062 (57.1)	158 333 (8.0)	331 121 (31.1)	167 899 (26.5)	228 069 (27.0)
Other	10 264 (1.9)	4974 (1.7)	41 140 (2.1)	12 724 (1.2)	14 970 (2.4)	9852 (1.2)
Income quintile						
1 (lowest)	173 267 (32.7)	131 476 (45.5)	486 560 (24.7)	233 729 (21.9)	185 944 (29.3)	211 773 (25.0)
2	128 653 (24.3)	55 738 (19.3)	479 606 (24.4)	196 724 (18.5)	157 504 (24.8)	159 145 (18.8)
3	116 933 (22.1)	43 783 (15.1)	392 267 (19.9)	209 583 (19.7)	131 328 (20.7)	161 064 (19.0)
4	72 929 (13.8)	36 727 (12.7)	362 229 (18.4)	245 483 (23.0)	97 800 (15.4)	178 241 (21.1)
5 (highest)	37 869 (7.1)	21 530 (7.4)	248 888 (12.6)	180 157 (16.9)	61 713 (9.7)	136 036 (16.1)
Time since landing, yr						
Mean ± SD	15.4 ± 8.0	14.3 ± 7.9	13.5 ± 7.5	15.4 ± 7.1	15.3 ± 8.4	12.7 ± 7.6
Median (IQR)	17 (9–22)	15 (8–21)	13 (7–19)	16 (10–21)	16 (8–22)	12 (6–19)

Variable	Middle-Southern Africa *n* = 78 052	South Asia *n* = 2 151 654	Western Africa *n* = 146 040	Western Europe *n* = 544 498	US, Australia and New Zealand *n* = 153 710	Long-term residents *n* = 36 754 786	Total *n* = 45 163 419
Age, yr							
Mean ± SD	42.3 ± 14.1	44.1 ± 14.6	42.5 ± 12.0	44.5 ± 13.7	43.3 ± 14.4	48.7 ± 17.6	47.9 ± 17.2
Median (IQR)	41 (31–51)	42 (33–53)	43 (33–52)	44 (34–53)	42 (32–53)	48 (34–62)	47 (34–60)
Economic class	41 446 (53.1)	1 048 987 (48.8)	45 357 (31.1)	323 774 (59.5)	55 450 (36.1)	NA	4 002 638 (8.9)
Family class	12 393 (15.9)	693 638 (32.2)	58 951 (40.4)	188 731 (34.7)	92 755 (60.3)	NA	2 726 091 (6.0)
Refugee	21 959 (28.1)	381 704 (17.7)	36 406 (24.9)	26 697 (4.9)	3851 (2.5)	NA	1 544 125 (3.4)
Other	2254 (2.9)	27 325 (1.3)	5326 (3.6)	5296 (1.0)	1654 (1.1)	NA	135 779 (0.3)
Income quintile							
1 (lowest)	20 401 (26.1)	591 574 (27.5)	57 843 (39.6)	90 107 (16.5)	23 085 (15.0)	6 535 312 (17.8)	8 741 071 (19.4)
2	11 884 (15.2)	524 889 (24.4)	33 274 (22.8)	113 249 (20.8)	26 812 (17.4)	7 117 317 (19.4)	9 004 795 (19.9)
3	12 532 (16.1)	510 422 (23.7)	28 004 (19.2)	108 795 (20.0)	28 433 (18.5)	7 312 052 (19.9)	9 055 196 (20.0)
4	14 900 (19.1)	351 117 (16.3)	17 577 (12.0)	113 792 (20.9)	31 586 (20.5)	7 688 061 (20.9)	9 210 442 (20.4)
5 (highest)	18 335 (23.5)	173 652 (8.1)	9342 (6.4)	118 555 (21.8)	43 794 (28.5)	8 102 044 (22.0)	9 151 915 (20.3)
Time since landing, yr							
Mean ± SD	13.1 ± 8.3	11.8± 7.0	12.0 ± 7.5	15.8 ± 8.9	11.4 ± 8.4	NA	13.6 ± 7.7
Median (IQR)	12 (6–20)	11 (6–17)	12 (6–18)	17 (8–23)	10 (4–18)	NA	13 (7–20)

Note: IQR = interquartile range, NA = not applicable, SD = standard deviation.
**n* represents person-years.

were the least likely to live in the highest income quintiles (7.1%, 7.4% and 6.4%, respectively). Conversely, 28.5% of males from the US, Australia and New Zealand lived in the highest income quintile. Those from the US, Australia and New Zealand and those from South Asia had the least number of years since landing on average (mean 11.4 yr and 11.8 yr, respectively v. mean 13.6 yr for immigrants overall).

There were 74 594 incident cases of prostate cancer in the study period, 6742 of which were among immigrants. Figure 1 displays the age-standardized incidence rates for each fiscal year from 2008 to 2016 for long-term residents and for immigrant males stratified by region of origin. Males who had immigrated from West Africa and from the Caribbean consistently had higher incidence rates than other immigrant groups and long-term residents; in every fiscal year, West African males had the highest rates and those from the Caribbean had the second highest rates. Males from South Asia and East Asia consistently had the lowest incidence rates. Table 2 and Figure 2 display age-standardized incidence rates for all fiscal years combined. Overall, immigrants had a lower incidence rate than long-term residents (134.9, 95% confidence interval [CI] 131.6–138.3 v. 184.4, 95% CI 183.0–185.8), but the highest rates were seen among those from West Africa (475.3, 95% CI 385.7–579.4) and the Caribbean (313.1, 95% CI 289.7–337.8). Males from South Asia and East Asia had the lowest incidence rates (88.6, 95% CI 83.3–94.1 and 104.0, 95% CI 98.4–109.8, respectively).

In adjusted analyses for the overall population (Table 3), significantly higher incidence rate ratios were seen for immigrants from West Africa (adjusted rate ratio 2.71, 95% CI 2.41–3.05) and the Caribbean (adjusted rate ratio 1.91, 95% CI 1.78–2.04) than for long-term residents. Significantly lower incidence rate ratios were seen for males from East Africa (adjusted rate ratio 0.76, 95% CI 0.66–0.88), East Asia and the Pacific (adjusted rate ratio 0.55, 95% CI 0.52–0.58), Eastern Europe and Central Asia (adjusted rate ratio 0.84, 95% CI 0.79–0.89), the Middle East and North Africa (adjusted rate ratio 0.72, 95% CI 0.66–0.78) and South Asia (adjusted rate ratio 0.47, 95% CI 0.45–0.50). Neighbourhood income quintile and age group were also associated with incidence in adjusted analyses (Table 3). As income quintile increased, incidence rate ratios increased (adjusted rate ratio for the highest income quintile 1.22, 95% CI 1.20–1.25). Compared with males aged 60–69 years, males

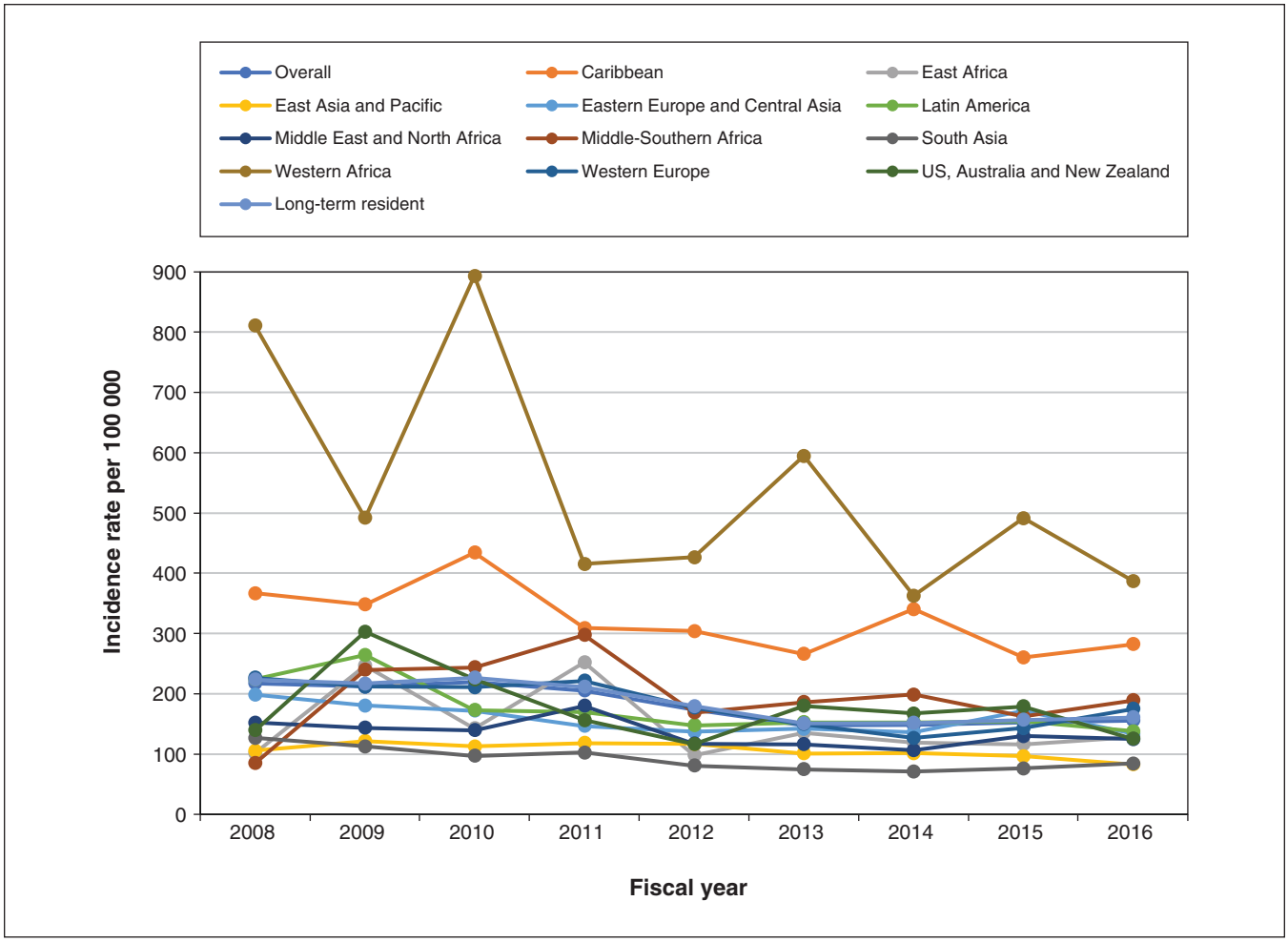

Figure 1: Age-standardized incidence rates per 100 000 for prostate cancer in Ontario for fiscal years 2008–2016, stratified by region of origin.

Table 2: Age-standardized incidence rates per 100 000 for prostate cancer for the overall cohort and stratified by region of origin, Ontario, Canada (2008–2016)

Region	Age-standardized incidence rate per 100 000 (95% CI)
Overall cohort	178.8 (177.6–180.1)
Caribbean	313.1 (289.7–337.8)
East Africa	144.0 (122.2–168.4)
East Asia and Pacific	104.0 (98.4–109.8)
Eastern Europe and Central Asia	154.1 (143.8–165.0)
Latin America	167.7 (153.1–183.3)
Middle East and North Africa	131.5 (120.7–143.0)
Middle-Southern Africa	194.0 (149.8–247.1)
South Asia	88.6 (83.3–94.1)
Western Africa	475.3 (385.7–579.4)
Western Europe	176.7 (160.7–193.9)
US, Australia and New Zealand	173.0 (143.1–207.4)
All immigrants	134.9 (131.6–138.3)
Long-term residents	184.4 (183.0–185.8)

Note: CI = confidence interval.

aged 70 years and older had higher rate ratios (with the highest value seen for men aged 70–79 yr: adjusted rate ratio 1.37, 95% CI 1.35–1.39), and those younger than 60 years had lower rate ratios.

In adjusted analyses for immigrants only (Table 3), similar patterns were seen, although the income gradient was less pronounced (adjusted rate ratio for the highest income quintile 1.11, 95% CI 1.02–1.20). Males who had been in Canada longer than 5 years had lower adjusted rate ratios than men who had been in Canada 5 years or less, peaking at adjusted rate ratio 0.92 (95% CI 0.84–1.00) for males in Canada for 16–20 years. Immigration admission category was not associated with prostate cancer incidence.

Interpretation

In this population-based study, we found that males who have immigrated from West Africa and from the Caribbean have significantly and persistently higher incidence of prostate cancer than other immigrants and long-term residents of Ontario (age-standardized incidence rates of 2.71, 95% CI 2.41–3.05, and 1.91, 95% CI 1.78–2.04, respectively), representing a 171% and 91% higher incidence rate than that of long-term residents. Immigrants from other major regions of the world either had lower or similar incidence rates to those of long-term residents, with males from South Asia having the lowest adjusted rate

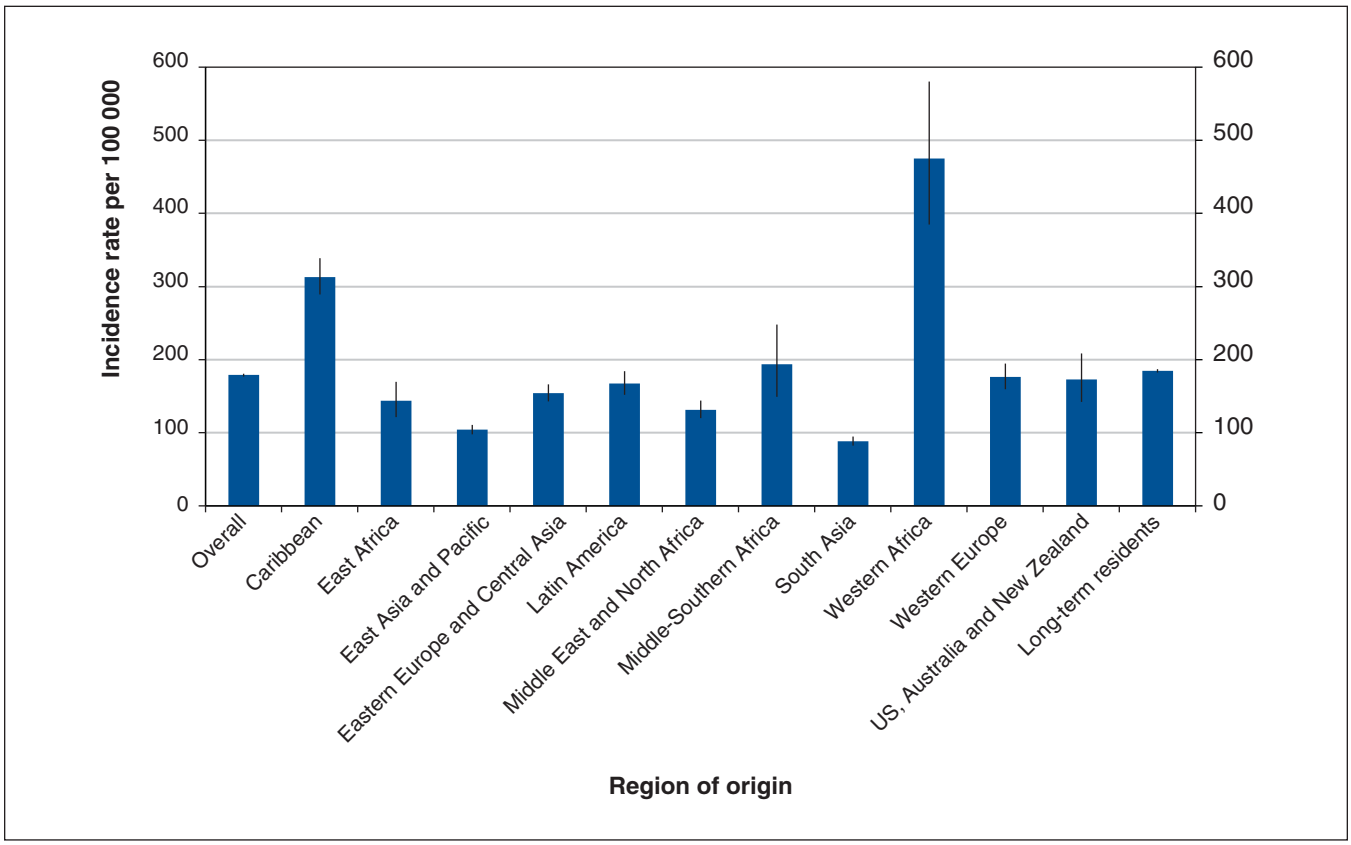

Figure 2: Age-standardized incidence rates per 100 000 for prostate cancer for the overall cohort and stratified by region of origin, Ontario, Canada (2008–2016). Error bars represent 95% confidence intervals.

Table 3: Adjusted incidence rate ratios for overall study population (*n* = 45 163 419 person-years) and for immigrants (*n* = 8 408 633 person-years) in the cohort only, adjusted for variables listed in the table

	Adjusted rate ratio (95% CI)	
Variable	Overall study cohort	Immigrants in the study cohort
Region of origin		
Caribbean	1.91 (1.78–2.04)	2.06 (1.72–2.45)
East Africa	0.76 (0.66–0.88)	0.85 (0.68–1.06)
East Asia and Pacific	0.55 (0.52–0.58)	0.60 (0.50–0.71)
Eastern Europe and Central Asia	0.84 (0.79–0.89)	0.94 (0.79–1.12)
Latin America	0.95 (0.87–1.02)	1.04 (0.87–1.25)
Middle East and North Africa	0.72 (0.66–0.78)	0.80 (0.66–0.95)
Middle-Southern Africa	1.14 (0.91–1.41)	1.27 (0.97–1.67)
South Asia	0.47 (0.45–0.50)	0.52 (0.44–0.62)
Western Africa	2.71 (2.41–3.05)	3.01 (2.46–3.68)
Western Europe	0.95 (0.87–1.04)	0.95 (0.87–1.04)
US, Australia and New Zealand	0.91 (0.78–1.07)	1 (Ref.)
Long-term residents	1 (Ref.)	–
Income quintile		
1 (lowest)	1 (Ref.)	1 (Ref.)
2	1.08 (1.06–1.11)	1.03 (0.96–1.10)
3	1.13 (1.10–1.16)	1.06 (0.99–1.14)
4	1.17 (1.14–1.19)	1.13 (1.05–1.21)
5 (highest)	1.22 (1.20–1.25)	1.11 (1.02–1.20)
Age group, yr		
< 50	0.01 (0.01–0.01)	0.01 (0.01–0.01)
50–59	0.31 (0.30–0.32)	0.30 (0.28–0.31)
60–69	1 (Ref.)	1 (Ref.)
70–79	1.37 (1.35–1.39)	1.43 (1.34–1.52)
≥ 80	1.04 (1.02–1.07)	0.96 (0.87–1.06)
Immigrant admission category		
Economic class	–	1 (Ref.)
Family class	–	1.01 (0.95–1.07)
Refugee	–	0.94 (0.87–1.01)
Other	–	0.93 (0.77–1.12)
Time since landing, yr		
0–5	–	1 (Ref.)
6–10	–	0.77 (0.70–0.84)
11–15	–	0.78 (0.71–0.85)
16–20	–	0.92 (0.84–1.00)
≥ 21	–	0.88 (0.81–0.95)

Note: CI = confidence interval, Ref. = reference category.

ratio (0.47, 95% CI 0.45–0.50). We also found that higher neighbourhood income quintile and advancing age were both associated with higher incidence of prostate cancer and that, among immigrants, being in Canada for 5 years or less was associated with higher incidence.

We found that immigrants from the Caribbean and West Africa had the highest incidence of prostate cancer. In the US context, African-American men have been found to have a higher incidence of prostate cancer, the cause of which is not well understood and has been speculated to be due to social,

economic and environmental disparities, as well as potential genetic differences.[1,5,16–19] If biology does play a role, and considering that race is a social construct, not a biological one,[20] our findings suggest that future research and current discourse in this field should focus on understanding if there are particular population genetic subgroups of West African origin that have a higher predisposition for developing prostate cancer, recognizing that both people of the Caribbean and African-Americans are largely descendants of West African victims of the transatlantic slave trade.[18,21,22] Our findings also suggest that efforts should be made in Ontario to raise awareness about prostate cancer among Caribbean and West African men, and to raise awareness about the higher incidence for these men among primary care providers.

Although the Canadian literature is limited, our results are in line with other studies. McDonald and colleagues used Canadian Census data and found that immigrant men overall had lower incidence of prostate cancer than Canadian-born men, and that immigrant men from the Americas (the Caribbean was not a separate group) had the highest odds ratio (OR) for prostate cancer (OR 1.588, $p < 0.01$) and that men from South Asia (OR 0.67, $p = 0.01$) and other Asian nations (OR 0.506, $p < 0.01$) had the lowest ORs when compared with immigrant men born in the US.[23] In the Canadian province of Alberta, Chinese immigrants have been found to have lower prostate cancer incidence than Canadian-born men.[24] Looking at international data, Sung and colleagues found that African-American men and men in the Caribbean have the highest incidence rates globally and suggested that West African ancestry modulates prostate cancer risk.[1] They found that men from South Central Asia had the lowest age-standardized incidence rates.[1] Culp and colleagues found the highest estimated incidence rates in Australia and New Zealand, Western and Northern Europe, and the Caribbean.[5] In Sweden, men from the Caribbean and from Middle Africa had increased incidence; immigrant men overall had decreased incidence.[25]

Our finding that incidence rates increased as income quintile increased is in line with the literature and may reflect increased screening for prostate cancer or lifestyle factors among men of higher socioeconomic status.[6,7,26–28] We also found that those who have been in Canada the shortest amount of time had higher incidence of prostate cancer, which is not in line with the concept of the healthy immigrant effect.[4,23] The healthy immigrant effect refers to the observation that immigrants are in relatively better health on arrival in Canada (or the country of immigration) than native-born Canadians, and that immigrant health eventually converges to that of native-born levels after years spent in Canada.[23] Our finding of shorter time in Canada being associated with higher prostate cancer incidence is also in contrast to the results of other studies. For example, in Sweden, immigrant men had higher risk of prostate cancer with longer time in the country.[25,29] McDonald and colleagues found that immigrant men overall exhibit convergence to Canadian-born levels for diagnosis of prostate cancer.[23] The reasons for our results cannot be elucidated from these data but warrant further study. One hypothesis worth exploration is that there may have been increased medical investigations, such as prostate-specific antigen testing, during the initial arrival and immigration period to Ontario in more recent years.

Limitations

This population-based study has several limitations to note. First, the IRCC-PR database does not include immigrants who migrated to another province before Ontario or those who arrived before 1986. Both groups would have been misclassified as long-term residents of the province. However, this misclassification would bias our results toward the null. Second, we did not look at differences based on specific country of origin. There may still be sizeable differences in prostate cancer incidence within one world region. For example, although the top 2 countries in the world for prostate cancer incidence (Guadeloupe and Martinique) are in the Caribbean, the number 3 country is Ireland.[30] Future research in the Canadian context should explore this question. Third, it is possible that health care providers and men themselves may be more vigilant about screening for and identifying prostate cancer among certain ethnic groups considered to be at higher risk, leading to diagnostic suspicion bias.[1] As noted, this increased vigilance has been proposed as an explanation for the association between higher income and increased prostate cancer incidence.[31] Thus, future research should explore differences between immigrants and long-term residents in use of prostate cancer screening, stage of diagnosis, treatment differences and, importantly, mortality in the Canadian context. Fourth, we were not able to account for important variables such as family history, dietary exposures and environmental exposures that are not available in provincial databases. Future research to ascertain these details among immigrant men from these world regions may make a substantial contribution to advancing our understanding of why differences in risk exist. Fifth, we did not validate our definition of incident prostate cancer cases. Finally, we were not able to examine race or ethnicity in this study and considered only country of origin.

Conclusion

In this population-based study in Ontario, Canada, the age-standardized incidence rate of prostate cancer from 2008 to 2016 was consistently and significantly higher among immigrants from West African and Caribbean countries than among other immigrants and long-term residents of the province. Future research in Canada should recognize this difference and focus on further understanding prostate cancer risk and epidemiology, including screening, stage of diagnosis, treatment patterns and mortality.

References

1. Sung H, Ferlay J, Siegel RL, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin* 2021;71:209-49.
2. Canadian cancer statistics. Toronto: Canadian Cancer Society; 2018.
3. Learn about Ontario. Ottawa: Government of Canada; 2021. Available: https://www.canada.ca/en/immigration-refugees-citizenship/services/new-immigrants/prepare-life-canada/provinces-territories/ontario.html (accessed 2021 Sept. 29).
4. Shuldiner J, Liu Y, Lofters A. Incidence of breast and colorectal cancer among immigrants in Ontario, Canada: a retrospective cohort study from 2004–2014. *BMC Cancer* 2018;18:537.

5. Culp MB, Soerjomataram I, Efstathiou JA, et al. Recent global patterns in prostate cancer incidence and mortality rates. *Eur Urol* 2020;77:38-52.
6. Coughlin SS. A review of social determinants of prostate cancer risk, stage, and survival. *Prostate Int* 2020;8:49-54.
7. Cheng I, Witte JS, McClure LA, et al. Socioeconomic status and prostate cancer incidence and mortality rates among the diverse population of California. *Cancer Causes Control* 2009;20:1431-40.
8. von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Int J Surg* 2014;12:1495-9.
9. Data products, 2016 census. Ottawa: Statistics Canada. Available: https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/index-Eng.cfm (accessed 2022 June 6).
10. Apply for OHIP and get a health card. Kingston (ON): Ministry of Health; 2022. Available: https://www.ontario.ca/page/apply-ohip-and-get-health-card#section-2 (accessed 2022 June 7).
11. Chiu M, Lebenbaum M, Lam K, et al. Describing the linkages of the immigration, refugees and citizenship Canada permanent resident data and vital statistics death registry to Ontario's administrative health database. *BMC Med Inform Decis Mak* 2016;16:135.
12. ICES Data Dictionary Toronto. Toronto: ICES; 2022. Available: https://datadictionary.ices.on.ca/Applications/DataDictionary/Default.aspx (accessed 2022 June 7).
13. Ontario Cancer Registry Toronto. Toronto: Ontario Health (Cancer Care Ontario). Available: https://www.cancercareontario.ca/en/cancer-care-ontario/programs/data-research/ontario-cancer-registry (accessed 2022 June 6).
14. Data & statistics — country classification. Washington (D.C.): World Bank; 2008. Available: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups (accessed 2022 Oct. 5).
15. Methodology: Standard country or area codes for statistical use (M49). New York: United Nations Statistics Division. Available: https://unstats.un.org/unsd/methodology/m49/ (accessed 2021 Sept. 29).
16. Tsodikov A, Gulati R, de Carvalho TM, et al. Is prostate cancer different in black men? Answers from 3 natural history models. *Cancer* 2017;123:2312-9.
17. Powell IJ. Epidemiology and pathophysiology of prostate cancer in African-American men. *J Urol* 2007;177:444-9.
18. Kheirandish P, Chinegwundoh F. Ethnic differences in prostate cancer. *Br J Cancer* 2011;105:481-5.
19. Datta GD, Glymour MM, Kosheleva A, et al. Prostate cancer mortality and birth or adult residence in the southern United States. *Cancer Causes Control* 2012;23:1039-46.
20. Enea K, Barsky SH. Race and genetic ancestry in medicine. *N Engl J Med* 2021;384:2070.
21. Schroeder H, Ávila-Arcos MC, Malaspinas AS, et al. Genome-wide ancestry of 17th-century enslaved Africans from the Caribbean. *Proc Natl Acad Sci U S A* 2015;112:3669-73.
22. Fortes-Lima C, Gessain A, Ruiz-Linares A, et al. Genome-wide ancestry and demographic history of African-descendant Maroon communities from French Guiana and Suriname. *Am J Hum Genet* 2017;101:725-36.
23. McDonald JT, Farnworth M, Liu Z. Cancer and the healthy immigrant effect: a statistical analysis of cancer diagnosis using a linked Census-cancer registry administrative database. *BMC Public Health* 2017;17:296.
24. Luo W, Birkett NJ, Ugnat AM, et al. Cancer incidence patterns among Chinese immigrant populations in Alberta. *J Immigr Health* 2004;6:41-8.
25. Beiki O, Ekbom A, Allebeck P, et al. Risk of prostate cancer among Swedish-born and foreign-born men in Sweden, 1961–2004. *Int J Cancer* 2009;124:1941-53.
26. Clegg LX, Reichman ME, Miller BA, et al. Impact of socioeconomic status on cancer incidence and stage at diagnosis: selected findings from the surveillance, epidemiology, and end results: National Longitudinal Mortality Study. *Cancer Causes Control* 2009;20:417-35.
27. Spencer BA, Babey SH, Etzioni DA, et al. A population-based survey of prostate-specific antigen testing among California men at higher risk for prostate carcinoma. *Cancer* 2006;106:765-74.
28. Gilligan T, Wang PS, Levin R, et al. Racial differences in screening for prostate cancer in the elderly. *Arch Intern Med* 2004;164:1858-64.
29. Mousavi SM, Fallah M, Sundquist K, et al. Age- and time-dependent changes in cancer incidence among immigrants to Sweden: colorectal, lung, breast and prostate cancers. *Int J Cancer* 2012;131:E122-8.
30. Prostate cancer statistics. London (UK): World Cancer Research Fund International. Available: https://www.wcrf.org/dietandcancer/prostate-cancer-statistics/ (accessed 2021 Sept. 29).
31. Liu L, Cozen W, Bernstein L, et al. Changing relationship between socioeconomic status and prostate cancer incidence. *J Natl Cancer Inst* 2001;93:705-9.

Affiliations: Peter Gilgan Centre for Women's Cancers (Lofters), Women's College Hospital; Department of Family and Community Medicine (Lofters), University of Toronto; Cancer Rehabilitation and Survivorship (Bender), Department of Supportive Care, Princess Margaret Cancer Centre, University Health Network; ICES (Lofters, Swayze); Dalla Lana School of Public Health (Bender), University of Toronto; Department of Medicine and Institute of Health Policy, Management, and Evaluation (Alibhai), University of Toronto; Department of Medicine (Alibhai), University Health Network; Institute of Health Policy, Management and Evaluation (Bender), University of Toronto; ; Walnut Foundation (Henry, Noel), Toronto, Ont.; Department of Medicine (Datta), Cedar-Sinai Medical Center; Cancer Research Center for Health Equity (Datta), Samuel Oschin Comprehensive Cancer Institute, Los Angeles, Calif.

Contributors: Aisha Lofters, Jacqueline Bender and Geetanjali Datta conceived and designed the study. Aisha Lofters, Shabbir Alibhai and Geetanjali Datta provided oversight to the analysis plan. Sarah Swayze analyzed and all authors interpreted the data. Aisha Lofters drafted the manuscript, and all authors critically revised the manuscript for important intellectual content. Sarah Swayze had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. All authors gave final approval of the version to be published and agreed to be accountable for all aspects of the work.

Funding: This work was supported by the Canadian Institutes of Health Research (CIHR) (grant no. 162506). Aisha Lofters is supported as the provincial primary care lead, cancer screening at Ontario Health (Cancer Care Ontario). Aisha Lofters is supported by a CIHR New Investigator Award, as a clinician scientist by the University of Toronto Department of Family and Community Medicine, and as chair in implementation science at the Peter Gilgan Centre for Women's Cancers at Women's College Hospital, in partnership with the Canadian Cancer Society. The analyses, conclusions, opinions and statements expressed herein are those of the authors, and not necessarily those of CIHR, Canadian Institute for Health Information (CIHI), Cancer Care Ontario or Immigration, Refugee and Citizenship Canada; no endorsement is intended or should be inferred.

Data sharing: The data set from this study is held securely in coded form at ICES. While legal data-sharing agreements between ICES and data providers (e.g., health care organizations and government) prohibit ICES from making the data set publicly available, access may be granted to those who meet prespecified criteria for confidential access, available at https://www.ices.on.ca/DAS (email: das@ices.on.ca). The full data set creation plan and underlying analytic code are available from the authors on request, understanding that the computer programs may rely on coding templates or macros that are unique to ICES and are therefore either inaccessible or may require modification.

Acknowledgements: This study was supported by ICES, which is funded by an annual grant from the Ontario Ministry of Health (MOH) and the Ministry of Long-Term Care (MLTC). Parts or whole of this material are based on data and/or information compiled and provided by Immigration, Refugees and Citizenship Canada (IRCC). However, the analyses, conclusions, opinions and statements expressed in the material are those of the author(s) and not necessarily those of IRCC. Parts of this material are based on data and/or information compiled and provided by CIHI and Cancer Care Ontario. The analyses, conclusions, opinions and statements expressed herein are solely those of the authors and do not reflect those of the data sources; no endorsement is intended or should be inferred.

Supplemental information: For reviewer comments and the original submission of this manuscript, please see www.cmajopen.ca/content/10/4/E956/suppl/DC1.