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Understanding mortality differentials of Black adults in Canada



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ABSTRACT

Background

It is not clear whether the increased mortality pattern observed in a prior analysis of the Canadian Census Health and Environment Cohorts for HIV/AIDS, diabetes, prostate cancer, and uterine cancer among Black adults is reflected in incident hospitalization (a marker of severity) or the diagnosis of these diseases, nor is it clear whether disparities exist regarding early screening and survivability.

Methods

To understand the paths that contribute to differential mortality patterns, standard Cox proportional hazard models were used to assess the incidence risk of diagnosis (uterine and prostate cancer) and incident hospitalization (HIV and diabetes) among 161,520 Black adults, compared with 6,866,070 White adults. Competing risk regression was used to evaluate the cumulative risk of death for the four disease outcomes since diagnosis or hospitalization. For the observed differential cancer mortality, mediation analysis was conducted to investigate the role of cancer diagnosis at follow-up (a proxy for delayed diagnosis that is not entirely indicative of late-stage cancer).

Results

Across all examined outcomes, except for uterine cancer, Black adults had elevated incident diagnoses or hospitalizations compared with White adults. Notably, Black males demonstrated a risk of incident prostate cancer and hospitalizations from HIV and diabetes twice as high relative to White males. For Black females, the risk of incident HIV hospitalization was 12 times as high. However, Black females were 15% less likely to be diagnosed with uterine cancer, compared with White females. Cumulative mortality risk analysis showed significantly lower survivability (two times lower) among Black females diagnosed with uterine cancer, relative to White females. Delayed diagnosis mediated a marginally higher proportion of the total differential uterine cancer mortality among Black females (14.9%; 95% confidence interval [CI]: 10.5% to 23.1%), compared with White females (8.9%; 95% CI: 6.3% to 13.9%).

Interpretation

This study unveils substantial parallels between heightened incidence risk and relative mortality for most of the four explored outcomes between Black and White adults in Canada. Notably, the study highlights a lower incident diagnosis of uterine cancer among Black females, despite a relatively higher uterine cancer mortality. Three in every 20 uterine cancer deaths were mediated through the time of uterine cancer diagnosis (relatively delayed in Black females), underscoring the need for targeted interventions and early detection strategies to address health disparities in this population.

Keywords

Mortality, cancer, health equity, longitudinal studies

AUTHORS

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What is already known on this subject?

- Prior analyses using national population-based cohorts such as the Canadian Census Health and Environment Cohorts identified elevated mortality risks among Black adults, compared with White adults in Canada.
- These mortality risks, such as those from HIV/AIDS, prostate cancer, diabetes, cerebrovascular diseases, and various cancers, were differentially higher among Black adults despite accounting for social determinants of health.

What does this study add?

- This study explored various paths either via diagnosis (for prostate and uterine cancer) or morbidity severity (as assessed by hospitalization for HIV and diabetes) prior to death among Black adults, compared with White adults.
- The increased mortality risk for prostate cancer, HIV, and diabetes among Black adults was also observed for incident diagnosis (prostate cancer) or incident hospitalizations for HIV and diabetes.
- This was not the case for Black females, who had a lower likelihood of uterine cancer diagnosis, compared with White females, contrary to the relatively higher uterine mortality reported previously.

A prior analysis using the Canadian Census Health and Environment Cohorts (CanCHECs) highlighted elevated risks of mortality from certain causes among Black adults, compared with White adults.¹ Notably, Black males had an increased relative mortality risk from HIV/AIDS, prostate cancer, diabetes, and cerebrovascular diseases compared with White males. Similarly, relative to White females, Black females were observed to have higher mortality risks from HIV/AIDS, diabetes, stomach cancer, corpus uteri cancer, lymphomas, and multiple myeloma.¹ These differential mortality risks were observed after accounting for known social determinants of health variables available on the CanCHEC. This also echoes the disproportional increased risk of self-reported diabetes and cardiovascular diseases reported among Black participants in a study that combined nine cycles (2001 to 2012) of the Canadian Community Health Survey.² This study found no association or impact of socioeconomic status in the reported differential risks.²

Furthermore, it is not clear whether this increased mortality pattern among Black adults is reflected in incident hospitalization or diagnosis of these diseases, nor is it clear whether disparities exist regarding early screening and survivability. Despite accounting for known determinants of health, these discrepancies persist and are thus indicative of other factors that may not be explained by these social determinants of health. Additionally, the methodology employed in prior studies using standard Cox proportional hazard models might introduce survival bias, particularly in scenarios with competing risks such as cardiovascular diseases that are prevalent among individuals of African ancestry.² Methodologically, these competing risks impede the event of interest, and a standard Cox regression is able to produce incidence-rate curves that are appropriate only for a hypothetical universe where competing events do not occur. Based on the method of Fine and Gray,³ competing risk

regression provides a useful alternative to Cox regression⁴ for survival data in the presence of competing risks.

Recognizing these limitations, the current study seeks to delve deeper in understanding the paths that contribute to the differential mortality patterns observed in the previous study, particularly for the outcomes that showed substantial increased risk for both Black males and females. These outcomes include HIV, diabetes, prostate cancer (males), and uterine cancer (females). This study employs competing risk regression analysis as an alternative to a standard Cox regression, offering a more nuanced assessment of mortality risks while considering competing causes of death.

Addressing the shortcomings of prior research, this study poses several research questions:

1. **Assessment of mortality proportions and potential competing events:** What proportions of individuals diagnosed with prostate or uterine cancer or those with incident hospitalizations from HIV or diabetes died from the same cause, compared with those who died from other causes? Are these proportions different between Black and White adults in Canada?
2. **Differential hazard risks:** Are Black adults at higher hazard risk for incident prostate or uterine cancer and incident hospitalizations from HIV or diabetes during the follow-up period, compared with White adults?
3. **Cumulative risks of death (survivability):** Is there a differential cumulative risk of death resulting from prostate or uterine cancer and hospitalizations from HIV or diabetes during the follow-up period among Black adults, compared with White adults?
4. **Mediating role of late cancer diagnosis:** What role does delayed cancer diagnosis play in the observed differential mortality among Black adults in the study?

Methods

Study population

The study population is based on the 2001, 2006, and 2011 CanCHECs, which linked the long-form census questionnaire and the 2011 National Household Survey to the Canadian Cancer Registry (CCR) (to flag cancer diagnosis), the Discharge Abstract Database (DAD) (for hospitalization), and the vital statistics database. Details of the CanCHECs have been previously published elsewhere.⁵ Briefly, CanCHECs are a collection of probabilistically linked population-based datasets that integrate data from respondents of the Canadian long-form census questionnaire with administrative health data (e.g., mortality records) and annual residential postal code histories through the Statistics Canada Social Data Linkage Environment.⁵ In this study, multiple CanCHEC datasets (census years 2001, 2006, and 2011) were used to create a study population that included noninstitutionalized respondents at the time of cohort entry. The study population was followed from the respective census dates to December 31, 2016, for the 2001 CanCHEC, and December 31, 2019, for the 2006 and 2011 CanCHECs.

Mortality, hospitalization, and cancer outcomes

Mortality outcomes of interest were HIV/AIDS (International Classification of Diseases, 10th revision [ICD-10] codes B20 to B24), diabetes mellitus (ICD-10 codes E10 to E14), prostate cancer for males (ICD-10 code C61), and uteri cancer for females (ICD-10 codes C54 to C55). These were extracted from vital statistics records from the start of follow-up (i.e., the respective census date) to December 31, 2016, for the 2001 CanCHEC, and December 31, 2019, for the 2006 and 2011 CanCHECs. For cancer diagnosis, the CCR was used to flag diagnosis of prostate cancer (males) and uteri cancer (females) from 1992 to December 31, 2015. This is the scope of the period for which the CCR is currently linked to the CanCHECs. Similarly, the Canadian Institute for Health Information DAD was used as the health administrative database to obtain data on first-time hospitalizations for HIV/AIDS and diabetes mellitus that occurred from the baseline (i.e., the respective census date) to the end of follow-up on December 31, 2016, except for the 2011 CanCHEC, which was followed until December 31, 2019. The first-time hospitalization for HIV/AIDS or diabetes in the follow-up is used as a proxy for the severity of the disease that could have led to this hospitalization. Thus, it is not an indicator of the diagnosis of the disease. As done in previous studies that have used the DAD to operationalize and flag incident hospitalization,⁶ a seven-year wash-out period preceding the census date was used to account for prevalence cases of these outcomes. Furthermore, the DAD is available only from 1994 (for administrative reasons), so a seven-year pre-start of follow-up is the maximum wash-out available for the earliest cohort used in this study (i.e., the 2001 CanCHEC). It should be noted that residents of Quebec were excluded from all analyses that

used the CCR and DAD because of the unavailability of data from this province.

Statistical analysis

Descriptive statistics were used to describe the characteristics of the cohort and to delineate the proportion of participants whose death was attributed to the same cause as their initial diagnosis, allowing for a comprehensive understanding of mortality proportions attributable to other causes. This served as a critical rationale for accounting for competing risk events in the analyses. Competing risk regression, following the methodology of Fine and Gray,³ was employed to evaluate the cumulative incidence risk from the point of diagnosis (pertaining to cancer outcomes) or incident hospitalization to mortality. This analytical approach accommodates competing risks of mortality from other causes, in contrast to standard Cox proportional hazard models that do not account for these competing events.

The incidence risk of cancer diagnosis and incident hospitalization among Black adults throughout the follow-up period were also assessed using standard Cox proportional hazard models. The proportional hazards assumption was assessed and met for all models. As in the previous analysis, the reference population group was White, and estimated parameters accounted for all other population groups in the cohort, thus providing a comprehensive reflection of the true and complete reality, rather than parameters for only specific population groups. More concisely, the model estimates for Black adults accounted for the parameters from all other population groups (e.g., Arab, Chinese, Japanese, Korean, South Asian, Southeast Asian, Filipino, Latin American, and Indigenous) in the cohort, with the White group as the reference. This enabled the inference of the model estimates for Black adults compared with White adults, in the presence of all other population groups.

The final model incorporated adjustments for well-established and available social determinants of health, including census family structure, labour force status, income, educational attainment, marital status, household size, generation status, urban residency, and birth region. The base model includes strata in the Cox model defined for age (in 10-year groups) and cohort cycle (i.e., 2001, 2006, and 2011 CanCHECs). For the fully adjusted models, immigrant status was included in the strata, in addition to adjusted social determinants of health. Furthermore, covariates guided by a directed acyclic graph (DAG) were used. The DAG, illustrated in Supplemental Figure S1, outlined the presumed relationships between the primary independent variable (population groups) and mortality (or incident cancer or hospitalization), while also encompassing pertinent social determinants of health as potential confounding variables. Adjustment for marital status, residence in a census metropolitan area or census agglomeration (i.e., urban or rural), and income quintile, in addition to the base model, was

identified as the minimal covariate requirement based on the DAG. The results presented in this study were based on the DAG model, and the fully adjusted model was included for comparison with previous analysis of this cohort.

As a sensitivity analysis for the two cancer outcomes, mortality from any type of cancer was flagged as the outcome of interest, owing to the likelihood of cancer metastasis, in the analysis assessing the cumulative risk of death. In addition, an attempt

Table 1
Descriptive statistics and characteristics of the analytical cohort

	Black		White	
	Females	Males	Females	Males
	number		number	
Cohort participants¹	86,700	74,820	3,525,100	3,340,970
	%		%	
Age group (years)				
19 to 24	16.5	17.5	11.9	12.7
25 to 34	22.2	20.8	15.1	15.3
35 to 44	23.8	24.4	18.7	19.0
45 to 54	16.9	18.1	19.8	20.3
55 to 64	11.2	11.3	15.1	15.6
65 to 74	6.2	5.8	10.3	10.2
75 to 84	2.5	1.8	6.9	5.6
85 and older	0.7	0.4	2.2	1.3
Place of residence				
In a CMA or CA	98.3	97.5	79.1	78.2
Outside a CMA or CA	1.7	2.5	20.9	21.8
Marital status				
Never married (single)	38.7	35.3	18.8	23.8
Married or common-law	40.2	54.2	62.8	67.4
Separated or divorced	16.7	9.5	9.3	6.6
Widowed	4.4	1.0	9.0	2.2
Census family structure				
Common-law or married with or without children	38.2	51.3	62.2	66.8
One-parent family	24.5	3.4	7.6	2.0
Single person (no partner or children)	37.3	45.2	30.2	31.3
Educational attainment				
No high school diploma	15.6	15.6	19.7	20.7
High school diploma or equivalency	35.6	40.8	35.2	41.3
Trades, college or university below bachelor's degree	32.1	24.3	26.4	19.8
Bachelor's degree or higher	16.7	19.4	18.8	18.2
Labour force status				
Employed	63.2	71.6	60.1	70.1
Unemployed	7.8	7.9	3.8	4.7
Not in the labour force	29.0	20.5	36.1	25.2
Income quintile				
1 (lowest)	32.2	25.1	18.7	14.8
2	21.9	21.4	19.3	18.2
3	18.5	20.4	19.8	20.2
4	16.2	19.0	20.5	22.2
5 (highest)	11.3	14.2	21.7	24.6
Immigrant status and period of immigration				
Non-immigrant	25.4	29.0	85.0	85.2
Immigrated within last 10 years before census	23.9	24.0	2.1	2.0
Immigrated more than 10 years before census	50.7	47.0	12.9	12.7
CanCHEC cycle				
2001	26.0	24.1	32.6	32.6
2006	36.6	37.9	35.5	35.5
2011	37.4	38.0	32.0	32.0

1. Excludes participants residing in Quebec because of unavailability on the Canadian Cancer Registry and Discharge Abstract Database.

Notes: Because of rounding, percentages may not add up to 100%.

CMA: census metropolitan area; CA: census agglomeration.

CanCHEC: Canadian Census Health and Environment Cohort.

Source: Statistics Canada, Canadian Census Health and Environment Cohort, 2001, 2006, and 2011.

was made to decompose the observed mortality differentials through an exploration of a health care access proxy. This entailed investigating scenarios where diagnoses from the CCR were observed and flagged after cohort entry (i.e., the respective Census Day). Note that this operational definition of late diagnosis by virtue of time of diagnosis at follow-up does not indicate the stage of diagnosis. However, by examining the mediating role of late cancer diagnoses in the observed differential mortality within the cohort, the goal was to decompose the total effect (i.e., average proportion of mortality experienced by Black adults, compared with White adults) into a natural indirect effect (reflecting mortality via the late diagnosis pathway) and a natural direct effect (representing mortality through all other pathways).⁸ The proportional hazard assumption was assessed using Schoenfeld residuals.

Data management steps were done in SAS version 9.4, while the data analysis—Cox proportional hazard regression models (“*stcox*” package),⁷ competing risk analysis (“*stcrreg*” package),⁷ and mediation analysis (“*medeff* mediation” package)⁸—was completed using Stata version 17.0.⁹

Results

As detailed in the previous analysis, the initial study cohort comprised 92,245 male and 106,640 female Black adults aged 19 years and older. However, for specific portions of the current analyses, where incidence or new hospitalization was of importance, a disease-free subcohort was used. Disease-free status was defined as the absence of prior cancer diagnoses or relevant hospitalizations within a seven-year pre-follow-up period from the baseline (i.e., the respective census date). Consequently, the analytical cohort included 74,820 male and 86,700 female Black adults. Notably, the smaller size of the analytical cohort was because data (CCR and DAD) from

Quebec were unavailable, and those excluded did not differ from the cohort in terms of their population characteristics (Table 1). The average length of follow-up for incident cancer was 10 years, while that for incident hospitalization was 12 years.

Upon initial assessment, throughout the follow-up period for the cancer analysis (i.e., from the respective census date to December 31, 2015), Black females had lower uterine cancer diagnosis rates (0.29%) compared with White females (0.44%), without age or social determinant of health adjustments (Table 2A). However, across all explored outcomes, except for uterine cancer, Black adults showed increased incident diagnoses or hospitalizations, compared with White adults (Table 2A). These observations were confirmed in adjusted Cox models evaluating the incidence risk of cancer diagnoses and hospitalizations (Table 3). For instance, Black males had a risk of incident prostate cancer and hospitalizations from HIV and diabetes two times higher compared with White males (Table 3). By contrast, Black females had a risk of incident HIV hospitalization that was about 12 times as high, compared with White females (Table 3). Conversely, Black females were about 15% less likely to be diagnosed with uterine cancer, compared with White females (hazard ratio: 0.85; 95% confidence interval [CI]: 0.75 to 0.97). There were no violations of the proportional hazards assumption in the Cox regression models.

Assessing the impact of competing mortality events, Table 2B shows that Black females were more prone to dying from the same cause as their diagnosis, notably for uterine cancer (22.9% vs. 10.0%) and HIV (33.3% vs. 26.3%), compared with White females. This trend was not consistent for diabetes in both Black males and females, or for prostate cancer in Black males. A substantial proportion of deaths across all groups were attributed to causes other than the initial diagnosis, emphasizing

Table 2A

Incident cancer (prostate and uterine) and incident hospitalization (HIV and diabetes) in the analytical cohort

	Black				White			
	Females		Males		Females		Males	
	n	%	n	%	n	%	n	%
Cancer incidence (2001 to 2015)^{1,2}	86,600	100.00	73,605	100	3,514,360	100.00	3,285,970	100.00
Corpus uteri (females)	250	0.29	...	...	15,360	0.44	...	...
Prostate (males)	...	...	1,890	2.57	...	...	69,320	2.11
Hospitalization incidence¹ (2001 to 2016 or 2019³)	86,700	100.00	74,820	100	3,525,100	100.00	3,340,970	100.00
HIV	60	0.07	70	0.09	90	0.00	780	0.02
Diabetes	680	0.78	830	1.11	20,790	0.59	30,300	0.91

... not applicable

1. Excludes participants residing in Quebec because of unavailability on the CCR and Discharge Abstract Database (DAD).

2. The denominator is based on those who were alive to experience the incidence.

3. The 2001 and 2006 CanCHECs were followed for incident hospitalization in the DAD to 2016, while the 2011 CanCHEC was followed to 2019.

Notes: Because of rounding, percentages may not add up to 100%.

The 2001, 2006, and 2011 Canadian Census Health and Environment Cohorts (CanCHECs) were followed for incident cancer in the Canadian Cancer Registry (CCR) from Census Day to December 31, 2015, among those free of cancer.

Source: Statistics Canada, Canadian Census Health and Environment Cohort, 2001, 2006, and 2011.

Table 2B

Participants who died from the same cause as their diagnosis in the analytical cohort

	Black				White			
	Females		Males		Females		Males	
	n	%	n	%	n	%	n	%
Ever diagnosed with cancer¹ (1992 to 2015)								
Corpus uteri (females)								
Total incidence	350	100	...	...	25,940	100	...	...
Death from same cause	80	22.9	...	...	2,590	10.0	...	...
Death from other causes	45	12.9	...	...	5,080	19.6	...	...
Prostate (males)								
Total incidence	...	...	3,090	100	...	...	123,825	100
Death from same cause	...	...	190	6.1	...	...	13,390	10.8
Death from other causes	...	...	425	13.8	...	...	34,800	28.1
Hospitalization incidence² (2001 to 2016 or 2019²)								
HIV								
Total incidence	60	100	70	100	95	100	780	100
Death from same cause	20	33.3	20	28.6	25	26.3	180	23.1
Death from other causes	10	16.7	10	14.3	10	10.5	125	16.0
Diabetes								
Total incidence	680	100	830	100	20,790	100	30,300	100
Death from same cause	45	6.6	60	7.2	2,040	9.8	2,900	9.6
Death from other causes	210	30.9	200	24.1	8,130	39.1	11,965	39.5

... not applicable

1. Excludes participants residing in Quebec because of unavailability on the CCR and Discharge Abstract Database (DAD).

2. The 2001 and 2006 CanCHECs were followed for incident hospitalization in the DAD that occurred from the start of follow-up (Census Day) to 2016, while the 2011 CanCHEC was followed to 2019.

Notes: Because of rounding, percentages may not add up to 100%.

The 2001, 2006, and 2011 Canadian Census Health and Environment Cohorts (CanCHECs) were linked to the Canadian Cancer Registry (CCR) to flag cases in which prostate or uterine cancer was ever diagnosed from 1992 to 2015, excluding Quebec residents because of incomplete data.

Source: Statistics Canada, Canadian Census Health and Environment Cohort, 2001, 2006, and 2011.

the importance of considering competing risk events (Table 2B). The analysis of cumulative mortality risk since diagnosis (Table 4) revealed significantly lower survivability among Black females diagnosed with uterine cancer, compared with White females (DAG-informed model—subhazard ratio [sHR]: 2.32; 95% CI: 1.83 to 2.93), after accounting for competing events and social determinants of health. Conversely, Black males diagnosed with prostate cancer had significantly better relative survivability, compared with White males (sHR: 0.76; 95% CI: 0.66 to 0.88). The observed cumulative mortality risk was unchanged without accounting for a competing risk event. This was also true when death from any cancer was explored in a sensitivity analysis to assess potential metastasis of either uterine or prostate cancer (Table A1). There was no observed differential survivability for mortality from HIV or diabetes between Black and White adults, among those diagnosed with these conditions (Table 4).

Further exploration aimed at understanding the relatively high uterine cancer mortality risk among Black females led to a sensitivity analysis. This involved evaluating scenarios where cancer diagnoses from the CCR were flagged after cohort entry as a proxy for potential delayed diagnosis (Table 5). The analysis revealed a higher proportion of the total differential uterine cancer mortality mediated by late diagnosis among Black females (14.9%; 95% CI: 10.5% to 23.1%), compared with White females (8.9%; 95% CI: 6.3% to 13.9%).

Conversely, no difference in the proportion of total differential prostate cancer mortality mediated by late diagnosis was observed for Black males, compared with White males (Table 5).

Discussion

This population-based cohort study delves into understanding probable paths that contribute to differential mortality outcomes among Black adults in Canada, using data from the 2001, 2006, and 2011 CanCHECs. The analysis aims to elucidate the observed mortality differentials, with a focus on outcomes such as HIV, diabetes, prostate cancer (among men), and uterine cancer (among women), building upon prior analyses of this cohort.¹

This study uncovered significant disparities across various health outcomes between Black and White adults in Canada. In contrast to White males, Black males had increased incident diagnoses or hospitalizations across all three explored outcomes, underscoring substantial disparities in disease burdens. Specifically, Black males had a risk of incident prostate cancer and hospitalizations from HIV or diabetes about twice as high, compared with White males, aligning with previous mortality analyses.¹ This parallel of heightened incidence risk and relative mortality risk may be attributed to

differential disease severity, susceptibility, or comorbidities, which were not accounted for in the current analysis.

A large body of literature documenting the existence of health disparities between Black and White populations in Canada and elsewhere has attributed these differential health outcomes to unequal health care access, screening, diagnosis, or treatments.^{10–14} To investigate the hypothesis of differential health care access or treatments in the current study, survivability from diagnosis to death was assessed among those who were diagnosed. Although the events preceding diagnosis were not ascertainable, no evidence of reduced survivability was found for Black males diagnosed with prostate cancer, HIV, or diabetes, compared with White males. In fact, the DAG-informed model indicated a 24% relative higher survivability for Black males diagnosed with prostate cancer, compared with diagnosed White males, by the end of the

follow-up period. In addition, no impact of the time of prostate cancer diagnosis on the mortality disparity between Black and White males was found. These sensitivity analyses highlight that health care access or treatments of diseases such as prostate cancer, HIV, or diabetes, do not explain the observed differential mortality outcomes from the previous analysis of Black males in this cohort.

Conversely, Black females had a lower likelihood of uterine cancer diagnosis, compared with White females, contrary to the relatively higher uterine mortality reported previously.¹ Further analysis uncovered significant disparities in survivability among Black females diagnosed with uterine cancer, with a likelihood of survival that was two times lower, compared with White females, by the end of the follow-up period. Late diagnosis emerged as a mediating factor that contributed to the differential mortality observed in the previous analysis. For

Table 3
Risk of incident cancer and hospitalizations among Black adults during the follow-up period

	Black females			Black males		
	Hazard ratio	95% confidence interval		Hazard ratio	95% confidence interval	
		from	to		from	to
Cancer incidence ¹ (2001 to 2015)						
Corpus uteri (females)						
Base model	0.91	0.80	1.03	...	...	...
Fully adjusted model	0.83 [‡]	0.70	0.99	...	...	...
DAG-informed model	0.85 [‡]	0.75	0.97	...	...	...
Prostate (males)						
Base model	...	...	...	2.13 [‡]	2.03	2.23
Fully adjusted model	...	...	...	1.68 [‡]	1.56	1.81
DAG-informed model	...	...	...	2.20 [‡]	2.10	2.31
Hospitalization incidence ¹ (2001 to 2016 or 2019 ²)						
HIV						
Base model	20.36 [‡]	13.52	30.66	3.83 [‡]	2.92	5.01
Fully adjusted model	8.22 [‡]	4.32	15.65	1.78 [‡]	1.20	2.66
DAG-informed model	11.97 [‡]	7.86	18.22	2.54 [‡]	1.94	3.33
Diabetes						
Base model	2.48 [‡]	2.29	2.69	2.22 [‡]	2.06	2.38
Fully adjusted model	1.80 [‡]	1.60	2.02	1.69 [‡]	1.53	1.86
DAG-informed model	2.31 [‡]	2.13	2.51	2.10 [‡]	1.96	2.26

... not applicable

[‡] significantly different from reference category (White adults) ($p < 0.05$)

1. Excludes participants residing in Quebec because of unavailability on the CCR and Discharge Abstract Database (DAD).

2. The 2001 and 2006 CanCHECs were followed for incident hospitalization in the DAD that occurred from the start of follow-up (Census Day) to 2016, while the 2011 CanCHEC was followed to 2019.

Notes:

Base model: Only has the stratified Cox model by 10-year age group and cohort.

Fully adjusted model: Includes the base model strata, with the addition of immigrant status, and further adjusted for generation, region of birth, marital status, census family structure, household size, educational attainment, labour force status, income quintile, and residence in a census metropolitan area or census agglomeration.

Direct acyclic graph (DAG) informed model: Includes the base model strata, with the addition of immigrant status, and only adjusted for marital status, income quintile, and residence in a census metropolitan area or census agglomeration.

The 2001, 2006, and 2011 Canadian Census Health and Environment Cohorts (CanCHECs) were linked to the Canadian Cancer Registry (CCR) to flag cases in which prostate or uterine cancer was ever diagnosed from 1992 to 2015, excluding Quebec residents because of incomplete data.

Source: Statistics Canada, Canadian Census Health and Environment Cohort, 2001, 2006, and 2011.

Table 4
Cumulative mortality risk (survivability) since diagnosis to death, accounting for competing risk of dying from other causes

	Black females						Black males					
	Competing risk			Without competing risk			Competing risk			Without competing risk		
	Subhazard ratio	95% confidence interval		Hazard ratio	95% confidence interval		Subhazard ratio	95% confidence interval		Hazard ratio	95% confidence interval	
		from	to		from	to		from	to		from	to
Ever diagnosed with cancer ¹ (1992 to 2015)												
Corpus uteri (females)												
Base model	2.44 [‡]	1.93	3.09	2.76 [‡]	2.20	3.45	...	...	...	...	...	...
Fully adjusted model	1.68 [‡]	1.18	2.40	1.73 [‡]	1.22	2.45	...	...	...	...	...	...
DAG-informed model	2.32 [‡]	1.83	2.93	2.37 [‡]	1.87	2.99	...	...	...	...	...	...
Prostate (males)												
Base model	...	...	...	...	...	...	0.77	0.67	0.89	0.72 [‡]	0.62	0.83
Fully adjusted model	...	...	...	...	...	...	0.82	0.67	1.01	0.78	0.63	0.97
DAG-informed model	...	...	...	...	...	...	0.76	0.66	0.88	0.73 [‡]	0.63	0.85
Hospitalization incidence ¹ (2001 to 2016 or 2019 ²)												
HIV												
Base model	1.28	0.38	4.40	1.58	0.84	2.95	1.55	0.84	2.87	1.57	0.97	2.55
Fully adjusted model	4.12	0.98	17.36	8.22 [‡]	1.32	51.14	2.23	0.87	5.71	2.10	0.85	5.14
DAG-informed model	1.28	0.35	4.66	2.07	0.63	6.78	1.44	0.77	2.69	1.40	0.76	2.57
Diabetes												
Base model	0.83	0.61	1.13	0.73	0.54	0.98	0.96	0.73	1.25	0.80	0.61	1.04
Fully adjusted model	0.93	0.56	1.53	0.88	0.56	1.39	0.96	0.69	1.33	0.86	0.60	1.22
DAG-informed model	0.78	0.57	1.07	0.77	0.56	1.05	0.94	0.72	1.23	0.84	0.64	1.11

... not applicable

‡ significantly different from reference category (White adults) ($p < 0.05$)

1. Excludes participants residing in Quebec because of unavailability on the CCR and Discharge Abstract Database (DAD).

2. The 2001 and 2006 CanCHECs were followed for incident hospitalization in the DAD that occurred from the start of follow-up (Census Day) to 2016, while the 2011 CanCHEC was followed to 2019.

Notes: Subhazard ratios are reported from the competing risk analysis.

Base model: Only has the stratified Cox model by 10-year age group and cohort.

Fully adjusted model: Includes the base model strata, with the addition of immigrant status, and further adjusted for generation, region of birth, marital status, census family structure, household size, educational attainment, labour force status, income quintile, and residence in a census metropolitan area or census agglomeration.

Direct acyclic graph (DAG) informed model: Includes the base model strata with the addition of immigrant status, and only adjusted for marital status, income quintile, and residence in a census metropolitan area or census agglomeration.

The 2001, 2006, and 2011 Canadian Census Health and Environment Cohorts (CanCHECs) were linked to the Canadian Cancer Registry (CCR) to flag cases in which prostate or uterine cancer was ever diagnosed from 1992 to 2015, excluding Quebec residents because of incomplete data.

Source: Statistics Canada, Canadian Census Health and Environment Cohort, 2001, 2006, and 2011.

instance, a higher proportion of the total differential uterine cancer mortality was mediated by late diagnosis among Black females (14.9%), compared with White females (8.9%). This underscores the critical role of timely cancer diagnoses in mitigating health disparities among Black females.^{11,15,16}

Additionally, Black females had a risk of incident HIV hospitalizations about 12 times higher compared with White females, mirroring patterns observed in the United States.^{13,14,17} The previous analysis on this current cohort found the risk of dying from HIV among Black females to be six times as high, compared with White females. While lower uptake of antiretroviral therapy use has been documented to be associated with higher mortality risk among Black females,^{13,14,17} an attempt was made to explore survivability among the subcohort

with an HIV diagnosis. No differential survivability was observed when competing risks (i.e., dying from other causes) were accounted for, or in the DAG-informed model. However, without accounting for competing risk, Black females infected with HIV were approximately eight times less likely to survive by the end of the follow-up period, compared with HIV-infected White females in the fully adjusted model. The specific reasons for these differential incidence and mortality are complex and multifaceted and warrant further research to fully unravel and address these disparities.

To the best of the authors' knowledge, this is the only national population-based study in Canada exploring paths via diagnosis to understand the mortality burden of HIV, diabetes, prostate cancer, and uterine cancer among the Black adult population.

Table 5
Mediating role of time of cancer diagnosis of interest in the observed differential mortality between Black and White adult Canadians

	Total effect (Black vs. White)			Proportion of total effect mediated					
				Black			White		
	Mean	95% confidence interval		%	95% confidence interval		%	95% confidence interval	
		from	to		from	to		from	to
Mortality mediated by late diagnosis (i.e., diagnosis after start of follow-up)									
Corpus uteri (females)									
Base model	0.141 [‡]	0.099	0.186	13.7 [§]	10.4	19.6	7.7 [§]	5.8	11.0
Fully adjusted model	0.065 [‡]	0.017	0.120	19.0 [§]	9.4	63.9	13.9 [§]	6.9	46.8
DAG-informed model	0.118 [‡]	0.075	0.166	14.9 [§]	10.5	23.1	8.9 [§]	6.3	13.9
Prostate (males)									
Base model	-0.026 [‡]	-0.037	-0.015	1.5 [§]	1.1	2.7	1.9 [§]	1.3	3.3
Fully adjusted model	-0.018	-0.036	0.002	-0.9	-6.8	2.9	-1.1	-7.7	3.3
DAG-informed model	-0.021 [‡]	-0.033	-0.008	2.7 [§]	1.7	7.1	3.1 [§]	2.0	8.2

[‡] significantly different from reference category (White adults) ($p < 0.05$)

[§] significant mediation effect within each population group at $p < 0.05$ (no comparisons between Black and White adults)

Notes: The mean is the coefficient.

Base model: Only has the stratified Cox model by 10-year age group and cohort.

Fully adjusted model: Includes the base model strata, with the addition of immigrant status, and further adjusted for generation, region of birth, marital status, census family structure, household size, educational attainment, labour force status, income quintile, and residence in a census metropolitan area or census agglomeration.

Direct acyclic graph (DAG) informed model: Includes the base model strata, with the addition of immigrant status, and only adjusted for marital status, income quintile, and residence in a census metropolitan area or census agglomeration.

The 2001, 2006, and 2011 Canadian Census Health and Environment Cohorts were linked to the Canadian Cancer Registry to flag cases in which prostate or uterine cancer was ever diagnosed from 1992 to 2015, excluding Quebec residents because of incomplete data.

Source: Statistics Canada, Canadian Census Health and Environment Cohort, 2001, 2006, and 2011.

The large sample size of the CanCHECs facilitated a comprehensive analysis across population groups, strengthened analytically by accounting for other competing events that may impede the outcome of interest. An essential observation is the substantial proportion of deaths attributed to causes other than the initial diagnosis across all population groups. This underscores the critical importance of considering competing risk events in understanding mortality patterns among Black adults from the point of diagnosis. Methodologically, these findings emphasize the complexities in attributing mortality solely to the diagnosed condition and highlight the need for a nuanced approach when evaluating mortality outcomes in a longitudinal cohort.

However, there are some limitations to the study worth noting. The lack of information on behaviours (e.g., smoking, alcohol, physical activity, sexual behaviour) and other comorbidities in the CanCHECs may impact the susceptibility of certain disease burdens within the explored population groups. Additionally, the absence of information on health care access or unmet health needs and the use of proxies may introduce potential outcome and mediator misclassification. For example, the incident hospitalization flag from the DAD was used to identify new cases of HIV or diabetes, following the application of a seven-year wash-out period in ascertaining a disease-free cohort. This approach might have introduced potential outcome

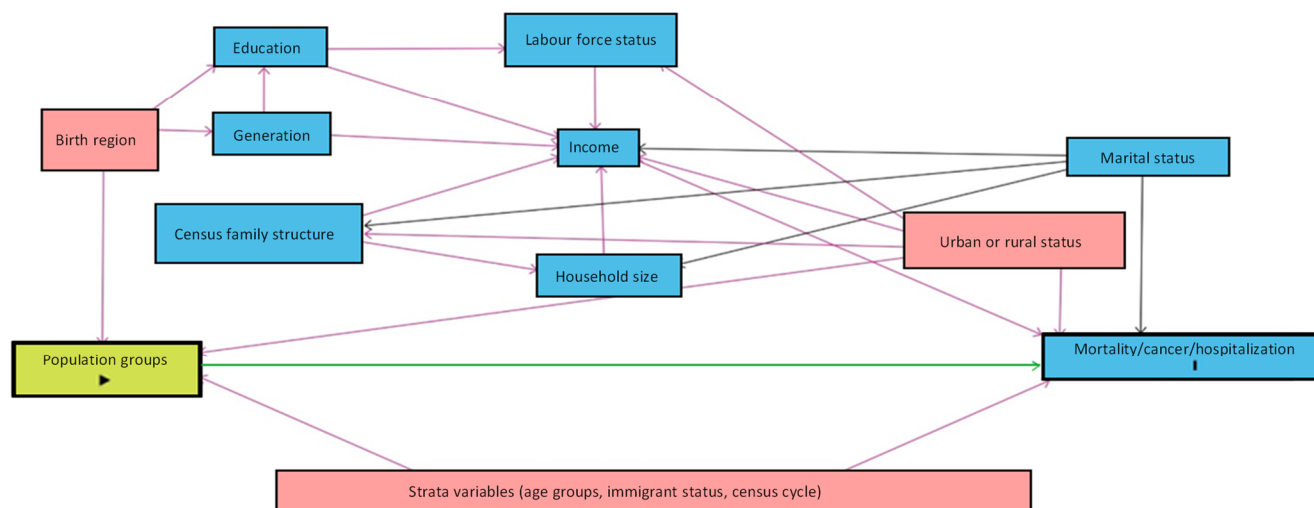
misclassification if certain population characteristics were associated with a differential likelihood of being hospitalized for the outcome of interest. Similarly, the definition of “late or delayed cancer diagnosis,” using diagnosis flagged at cohort entry and beyond as a proxy for differential health care access, may not adequately capture the severity or stage of the cancer. Lastly, survey weights could not be used because of the combination of the 2001, 2006, and 2011 CanCHECs, and findings reported are thus limited to the cohorts. However, it should be noted that the cohorts comprise respondents of the long-form census questionnaire and thus are nationally representative except for Quebec, where DAD and CCR data were incomplete and unavailable.

In conclusion, these findings underscore the imperative for targeted interventions addressing the multifaceted determinants of health disparities among Black adults in Canada. Strategies that emphasize equitable access to health care (as observed for differential diagnosis and survivability for uterine cancer), culturally competent interventions, early detection initiatives, and tailored treatment approaches are pivotal in mitigating these disparities. Future research could delve deeper into the complex interplay of sociocultural and behavioural factors, health care access, comorbidities, and biological determinants influencing differential health outcomes, paving the way for more targeted and effective interventions.

Appendix

Figure S1

Conceptual directed acyclic graph for population groups and outcomes such as mortality, cancer diagnosis, or incident hospitalization for HIV or diabetes



Source: The directed acyclic graph was developed using the DAGitty (an open source tool for creating, editing, and analyzing causal diagrams (DAGs) in epidemiology and other disciplines. The model can be found in this public repository - <https://dagitty.net/dags.html?id=ZSEuRnc3>

Table A1

Cumulative mortality risk (survivability) since diagnosis to any cancer death, accounting for competing risk of dying from other causes

	Black females						Black males					
	Competing risk			Without competing risk			Competing risk			Without competing risk		
	Subhazard ratio	95% confidence interval from	to	Hazard ratio	95% confidence interval from	to	Subhazard ratio	95% confidence interval from	to	Hazard ratio	95% confidence interval from	to
Ever diagnosed with cancer¹ (1992 to 2015)												
Corpus uteri (females)												
Base model	2.08 *	1.69	2.56	2.20 *	1.81	2.68	...	...	...	...	...	...
Fully adjusted model	1.70 *	1.27	2.29	1.69 *	1.26	2.26	...	...	...	...	...	...
DAG-informed model	1.99 *	1.61	2.45	2.01 *	1.64	2.46	...	...	...	...	...	...
Prostate (males)												
Base model	...	...	...	...	...	...	0.69 *	0.62	0.77	0.65 *	0.59	0.73
Fully adjusted model	...	...	...	...	...	...	0.80 *	0.67	0.95	0.79 *	0.67	0.93
DAG-informed model	...	...	...	...	...	...	0.68 *	0.61	0.76	0.67 *	0.60	0.75

... not applicable

* significantly different from reference category ($p < 0.05$)

1. Excludes participants residing in Quebec because of unavailability on the CCR.

Notes:

Reference category = White adults.

Subhazard ratios are reported from the competing risk analysis.

Base model: Only has the stratified Cox model by 10-year age group and cohort.

Fully adjusted model: Includes the base model strata, with the addition of immigrant status, and further adjusted for generation, region of birth, marital status, census family structure, household size, educational attainment, labour force status, income quintile, and residence in a census metropolitan area or census agglomeration.

Direct acyclic graph (DAG) informed model: Includes the base model strata, with the addition of immigrant status, and only adjusted for marital status, income quintile, and residence in a census metropolitan area or census agglomeration.

The 2001, 2006, and 2011 Canadian Census Health and Environment Cohorts were linked to the Canadian Cancer Registry (CCR) to flag cases in which prostate or uterine cancer was ever diagnosed from 1992 to 2015.

Source: Statistics Canada, Canadian Census Health and Environment Cohort, 2001, 2006, and 2011.

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