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Income and education inequalities in cervical cancer incidence in Canada, 1992–2010

Carol Morriscey[1], Mohammad Hajizadeh[2]

[1]Faculty of Medicine, Dalhousie University, Halifax, B3H 4R2, Canada
[2]School of Health Administration, Dalhousie University, Halifax, B3H 4R2, Canada
Address correspondence to Mohammad Hajizadeh, E-mail: m.hajizadeh@dal.ca

ABSTRACT

Background There is evidence of socioeconomic inequalities in cancer incidence in Canada and other countries globally, yet there is no study investigating socioeconomic inequalities in national cervical cancer incidence in Canada. Thus, the current study investigated income and education inequalities in the incidence of cervical cancer in Canada from 1992 to 2010.

Methods Data were derived from a linked dataset that combined cervical cancer incidence from the Canadian Cancer Registry and demographic and socioeconomic information from the Canadian Census of Population and the National Household Survey. The Concentration index approach was used to measure income and education inequalities in the incidence of cervical cancer over time.

Results National incidence of cervical cancer decreased significantly from 1992 to 2010. The age-standardized C was negative for the majority of years for both income and education inequalities, but the preponderance were not significant. Trend analyses of socioeconomic inequalities suggested an increasing concentration of cervical cancer incidence among less-educated females over the study period.

Conclusions Over almost two decades, there were no pervasive socioeconomic inequalities in the incidence of cervical cancer in Canada. As such, policies aimed at reducing the incidence of cervical cancer should focus on the general population, irrespective of socioeconomic status.

Keywords Canada, cervical cancer, incidence, inequalities, socioeconomic status, trend

Introduction

As the second leading cause of death worldwide, cancer plays a large role in mortality on a global scale.[1] One in two Canadians will be diagnosed with cancer in their lifetime, and one quarter of Canadians will die from cancer.[2,3] Approximately one in 150 Canadian women will develop cervical cancer in their lifetime, making it the 13th most common cancer among Canadian females.[3]

Cervical cancer incidence and related mortality had been steadily decreasing for several decades in Canada,[3] a decline largely attributed to screening with Papanicolaou (Pap) tests.[4] However, rates have remained relatively stable since 2005.[3] The majority of cervical cancer is diagnosed at an early stage in Canada, another posited benefit of screening programmes.[3] Yet, stage at diagnosis increases with age and there is significant geographic variation in stage at diagnosis throughout Canada.[3]

The most influential risk factor for cervical cancer, described as necessary but not sufficient for its development, is infection with human papillomavirus (HPV).[5,6] However, not all HPV infections progress to cervical cancer; some infections are transient and self-resolve, whereas others are not carcinogenic. HPV infections are associated with over 90% of all cervical cancer, with HPV types 16 and 18 being considered high-risk subtypes which are associated with 70% of cervical cancer cases.[7,8] Other risk factors which contribute to the development of cervical cancer include smoking, younger age at first intercourse, parity, long-term use of oral contraceptives and a weakened immune system.[5,6,9] There are currently three vaccines available in Canada, all of which protect against infection with the most carcinogenic strains of HPV, 16 and 18, as well as a complement of other

Carol Morriscey, MD student
Mohammad Hajizadeh, Associate Professor

high-risk HPV subtypes.[5] Overall uptake for the HPV vaccine in Canada is around 55%, but varies substantially based on age group and socioeconomic status (SES), with higher vaccination uptake among high SES women.[10–12] Further, HPV associated cancers, including cervical, penile and anal, have a higher incidence in lower SES populations.[12,13]

SES, a measure of social standing determined by measures such as income, education and occupation, is intimately linked to health, with lower SES being associated with poorer overall health.[14] Specifically, SES has been found to mediate prognosis and mortality of cancer.[15,16] Within Canadian populations lower SES continues to be associated with a greater incidence of cancer, later stage of cancer at time of diagnosis and poorer survival.[17,18]

The relationship between SES and outcomes persists in cervical cancer, with greater incidence, a more advanced stage at the time of diagnosis, and possibly more malignant phenotypes being associated with lower SES.[18–24] Furthermore, lower SES is associated with diminished rates of cervical cancer survival.[22,25] Nonetheless, there are significant variations in the impact of SES on incidence and survival within and between countries.[26–28]

Decreased rates of Pap testing, an effective screening test for cervical cancer, among lower SES populations[29,30] points to a possible explanation for the discrepancies in incidence and mortality of cervical cancer. Another possible explanation may be similar socioeconomic inequalities in HPV infection, yet such inequalities are still debated.[26–28]

Although there is evidence of socioeconomic inequalities in cancer incidence in Canada and some other countries, as well as evidence of cervical cancer inequalities in subsets of the Canadian population,[31] to our knowledge there is no study investigating socioeconomic inequalities in national cervical cancer incidence in Canada as a whole. Thus, using data from the Canadian Cancer Registry and the Canadian Census of Population and the National Household Survey and the Concentration index approach, we measured the income and education inequalities in cervical cancer incidence in Canada for the period between 1992 and 2010. This is the period in which the Canadian Cancer Registry data became available for all Canadian provinces. Identifying socioeconomic inequalities is an important step in informing policy to address such inequalities in health.

Methods

Data and variables

The Canadian Cancer Registry is a population-based cancer registry dataset, containing incidence of each new primary cancer among Canadian residents since 1992. The year of diagnosis, sex of the patient, an International Classification of Diseases for Oncology (ICD-O-3) code identifying the type of cancer, and the six-digit postal code indicating area of residence are included in the Canadian Cancer Registry. As the Canadian Cancer Registry does not contain SES information of patients, the Canadian Census of Population, (1992, 1996, 2001 and 2006), and the National Household Survey (2011) were used to obtain SES information required for the analyses. The 2011 National Household Survey was used to derive SES variables for the years 2009 and 2010, as per Statistics Canada's suggestion, as 2011 Canadian Census of Population did not collect information on SES.

Based on information available in the Canadian Cancer Registry, the Canadian Census of Population, and the National Household Survey, we constructed a dataset containing cervical cancer incidence, socioeconomic and demographic (average age) information at the Census Division (~300) level. The Census Division is defined as 'intermediate geographic areas between the province/territory level and the municipality'.[32] Specifically, we used the ICD-O-3 code number C53 to identify cases of cervical cancer in the Canadian Cancer Registry data. The six-digit postal code associated with each case of cervical cancer in the Canadian Cancer Registry was used to determine the Census Division coordinates of each case, using the Postal Code Conversion File plus (PCCF +) version D software.

Socioeconomic and sociodemographic information for each Census Division were obtained from the Canadian Census of Population, and the National Household Survey. The Canadian Census of Population was only administered every 5 years, therefore Canadian Census of Population data were linked with Canadian Cancer Registry data from the 2 years preceding and 2 years following Canadian Census of Population administration, National Household Survey data were linked with the Canadian Cancer Registry data from the 2 years preceding (Table 1). Average/median equivalized household income and proportion of individuals with a bachelor's degree and above in the Census Division were used as SES measures in the analyses. Household annual income was equivalized by dividing total household income by the square root of household size, according to the Organisation for Economic Co-operation and Development.[33]

Aggregated demographic and socioeconomic information (i.e. average/median equivalized household income and education level) were then linked to the number of cervical cancer cases diagnosed for each Census Division to calculate cervical cancer incidence and socioeconomic inequalities in the incidence of cervical cancer.

Table 1 Source of socioeconomic and demographic information linked with the Canadian Cancer Registry data

Source of socioeconomic and demographic information (year)	*Years of the Canadian Cancer Registry Linked*
Canadian Census of the Population (1991)	1992–1993
Canadian Census of the Population (1996)	1994–1998
Canadian Census of the Population (2001)	1998–2003
Canadian Census of the Population (2006)	2004–2008
National Household Survey (2011)	2009–2010

Statistical analysis

Measuring socioeconomic inequalities

The Concentration index approach[34] was employed to measure income and education inequalities in cervical cancer incidence in Canada, as it demonstrates the direction of the relation between the health measure and SES across the entire SES distribution.[35,36] The Concentration index is defined based on the Concentration curve,[37] which graphs the cumulative percentage of individuals (Census Divisions) ranked by SES on the x-axis and cumulative percentage of cervical cancer incidence on the y-axis. Twice the area between the Concentration curve and the 45° line, deemed the line of perfect equality, is defined as the Concentration index (C). The index ranges between −1 and +1, with 0 indicating perfect equality. Negative values of the C indicate a higher incidence of cancer among people with lower SES and *vice versa*. The crude C can be calculated using the 'convenient regression' formula[38]:

$$2\sigma_R^2\left(\frac{CCA_i}{\mu}\right) = \alpha + \delta Fr_i + \varepsilon_i$$

where CCA_i is Census Division i's cervical cancer incidence, μ is the mean incidence rate of cervical cancer for all Census Divisions, α is the intercept and Fr_i is the fractional rank for Census Division i's in the distribution ($i = 1$ for the lowest SES Census Division and $i = n$ for the highest SES Census Division). The fractional rank of Census Division i's was calculated as $Fr_i = i/n$. The term σ_R^2 shows for the variance of fractional rank. The ordinary least squares (OLS) estimate of δ and its standard error denote the value and standard error for the crude C, respectively.

As age characteristics vary across Census Divisions, age-standardized C was calculated using the following formula[39]:

$$2\sigma_R^2\left(\frac{CCA_i}{\mu}\right) = \alpha + \delta Fr_i + \beta_1 Age_{avi} + v_i$$

where Age_{avi} denotes the average age of Census Division i, β_1 is the corresponding coefficient, and δ is the OLS estimate denoting the age-standardized C.

Measuring trends in the incidence and socioeconomic inequalities

Trend analyses were performed to evaluate changes in the crude incidence of cervical cancer and socioeconomic inequalities in cervical cancer incidence from 1992 to 2010. We regressed incidence of cervical cancer or the age-standardized C on time (19 points corresponding to the years 1992–2010) to determine statistically significant linear trends in the values of the crude incidence of cervical cancer and socioeconomic inequality in cervical cancer incidences. A negative (positive) trend coefficient, calculated from the slope of the regression line, indicates that there is a decreasing (increasing) trend in the incidence rates of cervical cancer or the age-standardized C values. A trend coefficient of zero indicates no change in socioeconomic inequalities in cervical cancer incidence over time. A $P < 0.05$ was regarded as statistically significant.

Results

Cervical cancer incidence

The average crude incidence of cervical cancer in Canada from 1992 to 2010 is shown in Fig. 1. As shown in this figure, Nova Scotia had the highest average incidence of cervical cancer throughout the study period and Quebec and British Columbia had the lowest. Table 2 and Fig. 2 present national and provincial rates of cervical cancer incidence in Canada from 1992 to 2010. The national crude incidence has decreased significantly from 10.42 to 8.41 per 100 000 over the study period. Significant decreases in provincial incidences were seen in Nova Scotia, Quebec, Ontario, Manitoba and British Columbia. For the remaining provinces, there was no significant change in the incidence. At the beginning of the study period, in 1992, the highest and lowest incidence rates

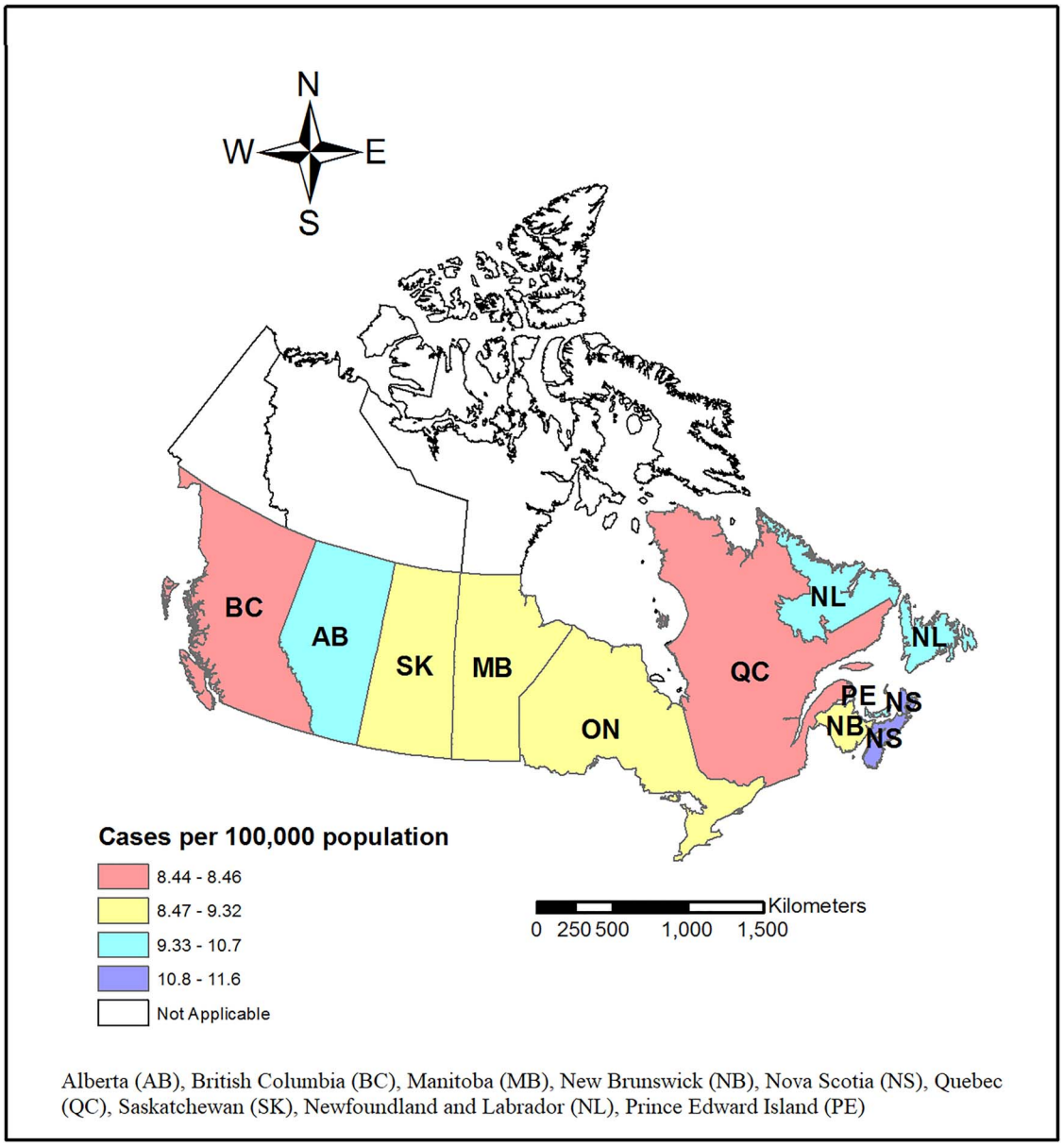

Fig. 1 Average incidence of cervical cancer in Canada per 100 000 from 1992 to 2010.

were found in Nova Scotia and Saskatchewan, respectively. At the end of the study period, 2010, the highest and lowest incidence rates were found in Newfoundland and Prince Edward Island, and New Brunswick, respectively.

Socioeconomic inequalities in cervical cancer incidence

The values of the age-standardized C for education-related inequalities were generally negative for most years, indicating a higher concentration of the incidence of cervical cancer among less-educated females. The education inequalities in cervical cancer incidence were not statistically significant, with the exception of years 2000, 2003 and 2010 (Table 3 and Fig. 3). This suggests no significant relationship between education and incidence of cervical cancer. The trend coefficient for this time period was -0.0015 ($P = 0.02$), suggesting a widening gap in education inequality in Canada over time (i.e. an increase in the concentration of cervical cancer incidence in females with a lower level of education).

Although the age-standardized C for income inequalities was predominantly negative from 1992 to 2010, it was not significant for the majority of years. There was a significant income inequality in 1998, 2000 and 2001 when average or median equivalized household income was used to calculate

Table 2 Incidence of cervical cancer per 100 000 in Canada and across its provinces from 1992 to 2010

Year	*NL&PE*	*NS*	*NB*	*QC*	*ON*	*MB*	*SK*	*AB*	*BC*	*Canada*
1992	11.56	13.29	9.68	9.28	10.89	10.10	9.21	11.61	9.99	10.42
1993	13.01	12.18	8.29	9.58	10.99	12.85	9.21	10.41	10.32	10.53
1994	8.72	13.01	6.75	9.41	9.95	10.75	7.10	11.26	9.37	9.82
1995	10.18	11.93	9.45	9.13	10.78	7.17	8.12	8.25	9.92	9.82
1996	13.09	13.01	10.80	8.85	10.51	12.54	9.13	9.75	8.54	9.96
1997	11.63	9.76	10.80	8.57	10.51	8.96	12.18	8.25	7.99	9.51
1998	11.63	10.84	13.49	8.00	8.48	10.75	10.15	11.63	10.19	9.26
1999	7.64	12.97	9.53	8.18	9.38	8.92	11.27	8.51	8.87	9.06
2000	9.17	17.30	10.89	8.59	8.69	8.92	9.22	12.26	6.78	9.09
2001	10.69	12.97	8.17	9.84	8.43	10.70	9.22	10.55	7.30	9.16
2002	10.69	10.81	8.17	8.32	8.86	7.13	6.15	12.26	8.87	8.99
2003	10.69	12.97	10.89	7.90	8.86	8.02	10.24	10.55	7.83	8.89
2004	12.28	12.83	10.85	7.65	8.21	8.67	9.29	8.92	6.91	8.35
2005	4.60	9.63	8.14	7.78	8.21	9.54	7.22	8.61	7.66	8.13
2006	10.74	10.69	8.14	8.58	7.97	7.80	7.22	9.54	6.91	8.25
2007	12.28	9.63	8.14	7.92	9.02	8.67	9.29	9.84	7.90	8.76
2008	10.74	9.63	9.50	7.92	8.62	9.54	11.35	8.92	8.15	8.60
2009	10.60	8.57	6.64	7.40	9.04	9.25	7.88	9.58	8.19	8.51
2010	13.63	7.50	6.64	7.78	8.65	6.73	8.87	8.45	8.64	8.41
Trend coefficients	−0.0074	−0.2300	−0.1071	−0.0965	−0.1390	−0.1576	−0.0246	−1.3698	−0.1213	−0.1165
P values	0.9360	0.0090	0.1600	0.0000	0.0000	0.0200	0.7180	0.1660	0.0060	0.0000

Note: Alberta (AB), British Columbia (BC), Manitoba (MB), New Brunswick (NB), Nova Scotia (NS), Quebec (QC), Saskatchewan (SK), Newfoundland and Labrador & Prince Edward Island (NL&PE).
Data for NL and PE were combined due to a low number of cases, to adhere to Statistics Canada's Research Data Centre data disclosure protocols, and the territories were excluded from the analysis for the same reason.

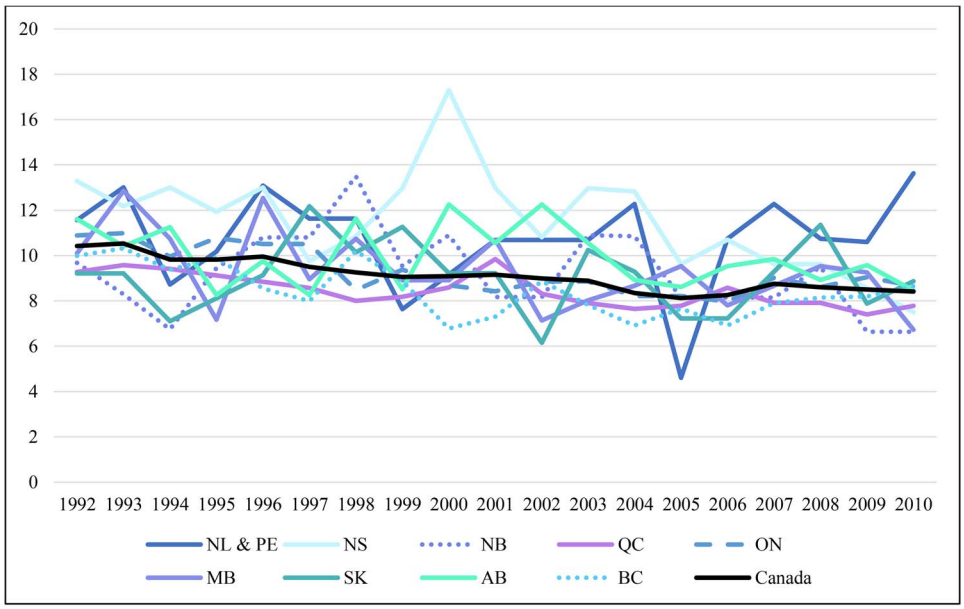

Fig. 2 Trends in national and provincial cervical cancer incidence rates per 100 000 in Canada from 1992 to 2010. *Note*: Alberta (AB), British Columbia (BC), Manitoba (MB), New Brunswick (NB), Nova Scotia (NS), Quebec (QC), Saskatchewan (SK), Newfoundland and Labrador & Prince Edward Island (NL&PE).

Table 3 Income and education inequalities in cervical cancer incidence in Canada from 1992 to 2010

Year	*Age-standardized C (95% confidence interval)*		
	Education (Bachelor's degree or higher)	*Average household equivalized income*	*Median household equivalized income*
1992	−0.005 (−0.051 to 0.04)	−0.005 (−0.045 to 0.036)	−0.006 (−0.047 to 0.035)
1993	−0.02 (−0.058 to 0.018)	−0.018 (−0.056 to 0.021)	−0.021 (−0.06 to 0.017)
1994	0.014 (−0.016 to 0.043)	0.011 (−0.018 to 0.04)	0.004 (−0.03 to 0.038)
1995	−0.032 (−0.067 to 0.002)	0.005 (−0.026 to 0.035)	0.014 (−0.02 to 0.049)
1996	0.001 (−0.027 to 0.029)	−0.004 (−0.034 to 0.026)	−0.011 (−0.042 to 0.02)
1997	0.001 (−0.047 to 0.049)	0.002 (−0.043 to 0.048)	−0.009 (−0.047 to 0.03)
1998	−0.032 (−0.066 to 0.002)	−0.038 (−0.08 to 0.004)	−0.045 (−0.087 to −0.002)
1999	−0.015 (−0.051 to 0.021)	−0.01 (−0.046 to 0.026)	−0.014 (−0.051 to 0.022)
2000	−0.044 (−0.084 to −0.004)	−0.059 (−0.097 to −0.021)	−0.068 (−0.111 to −0.024)
2001	−0.029 (−0.06 to 0.001)	−0.05 (−0.087 to −0.013)	−0.057 (−0.094 to −0.019)
2002	−0.018 (−0.066 to 0.029)	−0.008 (−0.058 to 0.043)	−0.009 (−0.059 to 0.042)
2003	−0.035 (−0.068 to −0.001)	−0.033 (−0.07 to 0.004)	−0.024 (−0.061 to 0.012)
2004	−0.02 (−0.051 to 0.011)	−0.019 (−0.052 to 0.015)	−0.028 (−0.061 to 0.006)
2005	−0.028 (−0.061 to 0.005)	−0.015 (−0.053 to 0.024)	−0.006 (−0.047 to 0.035)
2006	−0.04 (−0.072 to −0.007)	−0.018 (−0.061 to 0.025)	0.022 (−0.021 to 0.066)
2007	−0.017 (−0.059 to 0.024)	0.001 (−0.041 to 0.042)	−0.004 (−0.047 to 0.038)
2008	−0.032 (−0.064 to 0)	−0.027 (−0.062 to 0.008)	−0.024 (−0.061 to 0.014)
2009	−0.015 (−0.063 to 0.033)	0.03 (−0.016 to 0.076)	0.007 (−0.044 to 0.059)
2010	−0.038 (−0.069 to −0.006)	0.009 (−0.031 to 0.048)	0.021 (−0.019 to 0.06)
Trend coefficient	−0.0015	−0.0001	0.0005
P value	0.0200	0.9520	0.5450

Note: The inverse of the standard errors of the age-standardized C were applied as weights in the trend analyses.

the age-standardized C, illustrating a greater concentration of cervical cancer incidence in populations with a lower income in these years. The age-standardized C for income inequalities for the remainder of the years were not statistically different from 0 (Table 3). Although the age-standardized C for income inequalities were positive for some years, none of these indices were statistically significant. The trend coefficients for income inequalities were not significant, indicating no change in income inequalities in cervical cancer from 1992 to 2010.

Discussion

Main finding of this study

The aim of the current study was to quantify socioeconomic inequalities in the incidence of cervical cancer throughout Canada from 1992 to 2010. Results suggested a decline in the overall crude incidence of cervical cancer during this time period. There were no persistent income and education inequalities in the incidence of cervical cancer in Canada. Education inequalities appear to be widening over time, with an increasing concentration of cervical cancer incidence in individuals with a lower level of education. The current study did not reveal socioeconomic inequalities in cervical cancer incidence for the period analyzed, with the exception of some years.

What is already known on this topic

Several existing studies suggested socioeconomic inequalities in the incidence of cervical cancer worldwide, both within and between countries, with a higher incidence in populations of a lower SES.[17,21,29] Some explanations given for such disparities include greater incidence of carcinogenic HPV infection and lower levels of Pap screening in lower SES groups.[11,13,29]

What this study adds

Although previous studies have found socioeconomic inequalities in the incidence of cervical cancer in small portions of the Canadian population,[29] the results of this

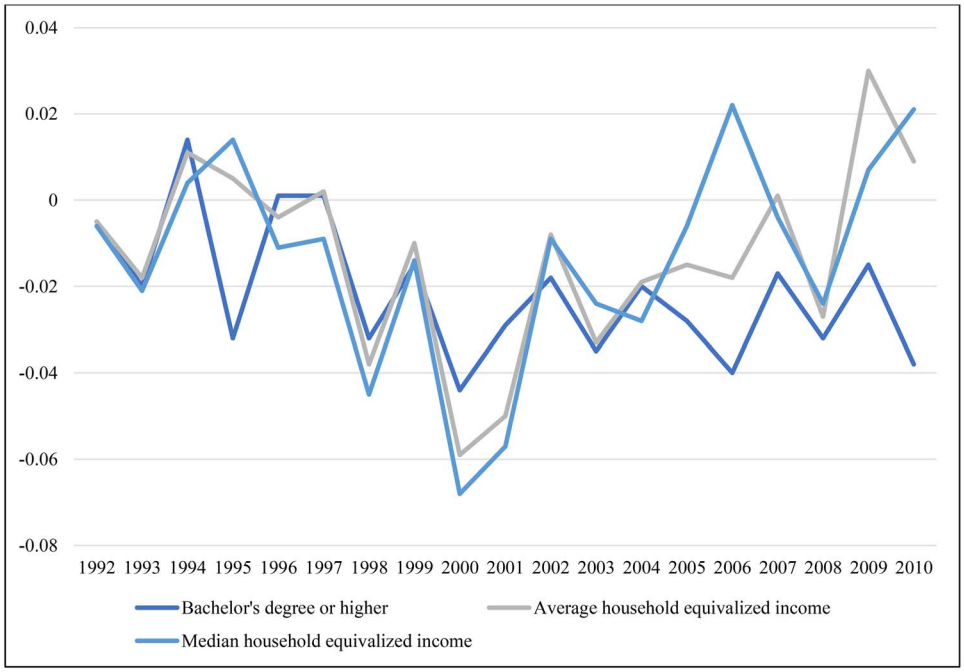

Fig. 3 Trends in income and education inequalities in cervical cancer incidence in Canada 1992 to 2010.

study did not indicate persistent socioeconomic inequalities in the national incidence of cervical cancer in Canada. The difference in the study findings may be due to some important differences in the methodology used to measure socioeconomic inequalities between previous studies and the current study. Notably, the current study was nationwide, whereas previous Canadian studies looked only at a subset of the population.[29] Furthermore, we used the C approach which captures inequality in the incidence of cervical cancer across entire SES, whereas the majority of studies,[15,16,20,29,37,38] have divided the population into quintiles or discrete social classes to assess social inequality in cervical cancer incidence. This is an important consideration when comparing findings, because different measures of inequality can produce conflicting results even with the same data.[35] By focusing solely on comparisons between the extreme SES groups (lowest and highest SES groups), much of the variation within SES groups can be overlooked and extraneous conclusions can be drawn.[35] The C approach used in the current study addresses this shortcoming of other measures of health inequality, providing a measure of inequality that uses entire population health status.

It has been suggested that inequalities in cervical cancer incidence arising from socioeconomic inequities is lower in countries which have population based screening.[41] The majority of Canadian provinces and territories have implemented an organized screening program, thereby reducing socioeconomic inequalities in screening,[42] providing a potential explanation for the rather equal distribution of cervical cancer across SES groups.

A major strength of the current study is the quality of data used from the Canadian Cancer Registry. Each province is legislated to record incidence of cancer in the Canadian Cancer Registry, and as such the data used is considered to be relatively complete and of good quality.[43] In addition, the time period over which possible socioeconomic inequalities were measured allowed for trends in income and education inequalities to be analyzed. Finally, SES was well-defined and both income and education inequalities were analyzed separately to examine the presence of any inequalities.

Limitations of this study

The discrepancy between area-based SES and individual SES is a possible limitation of the current study. Given the possible inconsistencies in area-based and individual SES, the current findings may not be generalizable to individual socioeconomic inequalities. In addition, the Canadian Census of Population was not administered every year; thus, if there were significant changes in a Census Division's socioeconomic qualities over the 5 years between Canadian Census of Population administration, the SES information used may have become outdated. In order to mitigate this outcome, Canadian Census of Population data were only linked with Canadian Cancer Registry data that was collected within 2 years of Canadian Census of Population administration.

In addition, this study did not measure socioeconomic inequalities in subtypes of cervical cancer. The make-up of the histologic subtypes of cervical cancer has been changing over time in Canada. The incidence of squamous cell carcinoma has been decreasing whereas adenocarcinoma and adenosquamous carcinoma have been increasing, to make up a larger portion of the overall incidence of cervical cancer in Canada.[44,45] It has been suggested that adenocarcinoma has either a positive association with SES (i.e. a higher incidence in higher SES populations), or no association at all.[28,40,45,46] Therefore, due to the opposing direction of the relationships between SES and squamous cell carcinoma and adenocarcinoma, respectively, and an increased proportion of adenocarcinoma, when these histologic subtypes are measured together the significance of socioeconomic inequalities of overall cervical cancer incidence may be dampened, possibly explaining the lack of significant inequalities found in the current study. Given the changes in the incidence of histologic subtypes of cervical cancer and their varying relations with SES, future studies should investigate the income and education inequalities of each specific histologic subtype.

Conclusion

The current study addresses an important gap in the literature regarding socioeconomic inequalities in cervical cancer in Canada. The findings indicated a steady decline in the overall incidence nationally from 1992 to 2010, and no persistent income and education inequalities during the study period. Thus, programs which encourage population-wide screening will likely have the largest effect on overall cervical cancer incidence in Canada.

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Ethics statement

Data have been accessed through Canadian Research Data Centre Network (RDC) at Dalhousie University. Data accessed through the RDCN, which follows strict disclosure protocols according to the Statistics Canada Acts, is exempt from research ethics board review based on Tri-council policy statement: Ethical conduct for research involving humans (TCPS2) article 2.2 (a).

Conflict of interest

None declared.

Authors' contribution

Both authors contributed to the conception and design of the study. MH performed data analysis. CM wrote the first draft of the paper and MH critically reviewed and revised the draft of the paper. All authors read and approved the final version of the manuscript.

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