Research Article

Cancer Epidemiology, Biomarkers & Prevention

Sociodemographic Inequalities in Sexual Activity and Cervical Cancer Screening: Implications for the Success of Human Papillomavirus Vaccination

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Abstract

Background: Papanicolaou smear screening has significantly reduced cervical cancer morbidity and mortality. However, inequalities still persist across different socioeconomic status (SES) groups. These inequalities have been associated with differential participation in screening. However, even with equal participation to screening, some women may still have greater risk of cervical cancer because of sexual behavior. We aim to identify the sociodemographic characteristics of women who reported greater sexual activity and/or screening underuse.

Methods: We used data from (i) the Canadian Community Health Survey—2005, a population-based survey of 130,000 Canadians, and (ii) a multicenter study including 952 women screened for cervical cancer.

Results: Aboriginals and women with lower SES reported greater sexual activity and lower screening participation, which may produce synergetic effects toward higher cervical cancer risk. Women who did not complete high school and aboriginals were, respectively, 3.6 and 2.5 times more likely to report sexual debut before 15 years old compared with women with university degree and Caucasians. Women who did not complete high school were 2.2 times more likely to have never been screened compared with women with university degree. East and South Asian women were, respectively, 4.3 and 3.1 times more likely to have never been screened than Canadian-born women but reported lower levels of sexual activity and were adherent to screening guidelines when screened at least once.

Conclusions: The success of human papillomavirus vaccination at reducing cervical cancer and inequalities will depend on achieving high coverage among high-risk subpopulations.

Impact: These groups must be monitored closely, and if need be, targeted for additional interventions. *Cancer Epidemiol Biomarkers Prev; 22(4); 641–52. ©2013 AACR.*

Introduction

Over the past 50 years, Papanicolaou (Pap) smear screening has significantly reduced cervical cancer morbidity and mortality in industrialized countries (1–3). However, inequalities in cervical cancer incidence and mortality persist across sociodemographic groups and geographic regions (4–6). Lower socioeconomic status (SES), living in a rural area, and being Black, Hispanic, or Asian have been independently associated with higher cervical cancer incidence or mortality (7–9). For example, the incidence of cervical cancer in areas within the United States where more than 20% of residents live under the poverty line is 18% to 39% higher than areas where less than 10% of residents live below the poverty line (10).

These inequalities in the incidence of cervical cancer have been associated with differential participation in screening and treatment due to factors such as access to health care and health seeking behavior (refs. 11–15; Fig. 1). In North America, more than 55% of cervical cancers are among women who were not screened in the previous 5 years (16, 17) and underuse of screening is disproportionately high among women with lower SES and among immigrants (18–23). Previous studies have focused on identifying the sociodemographic determinants of cervical screening underuse without distinguishing between the characteristics of women who were never screened and those who have been screened but less often than

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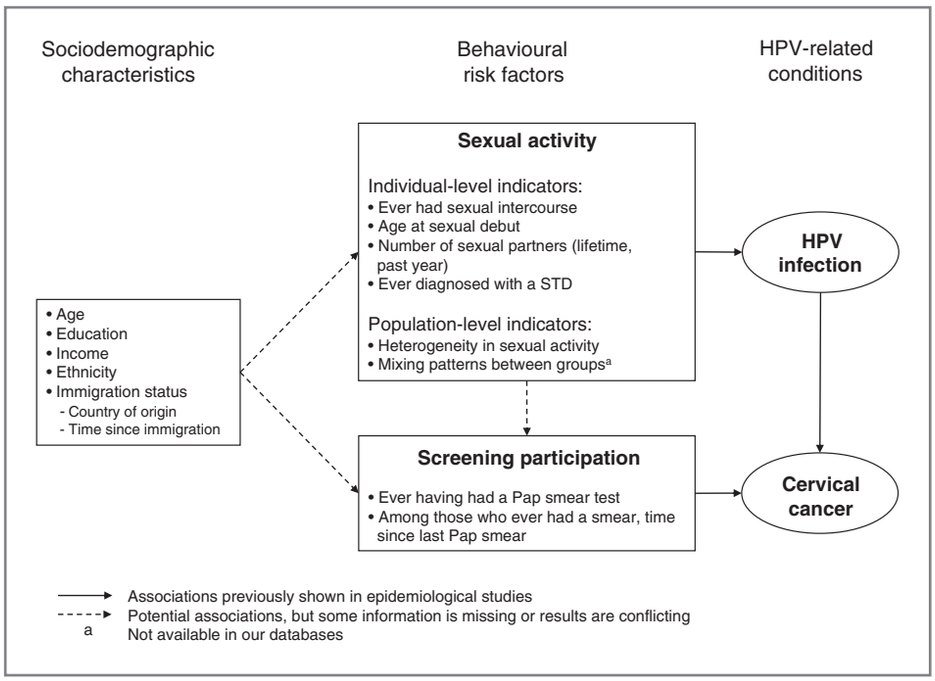

Figure 1. Conceptual framework of the different pathways linking sociodemographic characteristics and HPV-related conditions.

recommended. This distinction is important because these 2 measures of screening underuse may have a differential impact on the risk of cervical cancer. Moreover, they may be explained by different phenomenon (e.g., barriers to access to health care system, cultural differences, lack of awareness of the benefits of screening, low adherence to health recommendations, etc.) and consequently have different interventions.

Even with equal access to health care or adherence to screening guidelines, subgroups of women may still have greater risk of cervical cancer than others. Cervical cancer is caused by the human papillomavirus (HPV; refs. 24, 25), one of the most common sexually transmitted infections (STI) worldwide (refs. 26, 27; Fig. 1). As with any STI, the main risk-factors for HPV infection are related to sexual behavior. The indicators of sexual activity that have been shown to impact other STIs and that are likely to be important for HPV infection can be classified into individual-level and population-level risk factors (28–32; Fig. 1). Individual-level risk factors include younger age at sexual debut and greater number of lifetime sexual partners. Population-level risk factors include heterogeneity in sexual behavior (e.g., presence of small groups of highly sexually active individuals—core groups) and mixing patterns between risk groups. Although studies have consistently reported associations between higher levels of sexual activity and the risk of HPV infection (33–36), data remain scarce on the association between sociodemographic characteristics and different measures of sexual activity. Studies from the United States and Canada suggest that non-Caucasian individuals and/or individuals with lower SES may have higher levels of sexual activity (37–39), but results are conflicting and largely depend upon the indicator used.

With the advent of HPV vaccines, there is tremendous potential to reduce inequalities in the burden of cervical cancer. Prophylactic HPV vaccines are currently licensed for use in women in many countries across the world. Given evidence that HPV vaccines are highly efficacious against persistent infections and cervical lesions (vaccine efficacy = 98%–100%; refs. 40, 41) and cost-effective in preadolescent females (42), most developed countries have introduced routine vaccination of girls through school-based programs. Between 2007 and 2009, school-based HPV vaccination programs for preadolescent girls were introduced across Canada, with vaccination coverage varying from 60% to 80% (43–46). The success of HPV vaccination programs to reduce inequalities in the burden of cervical cancer will depend on overall vaccination coverage, and whether the subpopulations with the greatest need (i.e., those at highest risk of cervical cancer) avail themselves of this technology.

The main objective of this study is to identify the key sociodemographic characteristics of adult women more likely to report greater sexual activity and/or underuse of cervical cancer screening, and thus who are at higher risk of cervical cancer. More specifically, we examine the associations between education, income, immigration status, and ethnicity and (i) individual and population-level indicators of sexual activity, and (ii) never having been screened, as well as longer screening intervals as indicators of screening underuse. Results will allow clinicians, public health officials, and epidemiologists to: (i) understand current sociodemographic inequalities in the burden of cervical cancer, and (ii) identify the most at risk

subpopulations that must be monitored for high HPV vaccination coverage and cervical screening participation, and if need be, targeted for additional prevention interventions.

Materials and Methods

Data sources

We used data from the Canadian Community Health Survey (CCHS Cycle 3.1, 2005; ref. 47) and the Psychosocial impact of abnormal Smear pap and Condylomas in Canada, an epidemiological study (PISCES; ref. 48). Figure 1 illustrates the data available for the purposes of our analyses.

Canadian Community Health Survey cycle 3.1. We used data from the CCHS 3.1, a national, cross-sectional, population-based survey conducted by Statistics Canada to provide information about the health status, health care utilization, and health determinants of Canadians. A detailed description of the CCHS methodology is available at Statistics Canada (47). Briefly, the CCHS 3.1 was conducted between January, 2005 and December, 2005. The target population includes household residents 12 years or older of all provinces and territories. A response was obtained for 143,076 of 168,464 households selected (84.9%). Among these responding households, 143,076 individuals (1 per household) were selected to participate in the survey and 132,947 individuals completed the interview (92.9%), for a combined response rate of 78.9% (84.9% $\times$ 92.9%). The survey used 2 main sampling frames: (i) 49% of household were selected from an area frame and individuals were interviewed in person, and (ii) 50% of households were selected from a list of telephone numbers and interviews were done by phone. The remaining households were selected using Random Digit Dialling. Data are weighted to represent the 2005 Canadian population defined at the region-level for 10 age-sex groups and to take into account the sampling design and nonresponse (49). Information available in the CCHS includes the sociodemographic characteristics of respondents (age, education, personal income, ethnicity, immigration status, country of origin, and delay since immigration (Fig. 1). The CCHS also documents 4 indicators of individual-level sexual activity: (i) ever having had sexual intercourse (yes or no), (ii) age at sexual debut, (iii) number of sexual partners in the past 12 months (0, 1, 2, 3, and $\geq$4), and (iv) ever been diagnosed with a sexually transmitted disease (STD; yes or no). Finally, the CCHS contains information about 2 indicators of cervical screening participation: (i) ever having had a Pap smear (yes or no), and (ii) time since last Pap smear (<6 months, 6 months–<1 year, 1–<3 years, 3–<5 years, and $\geq$5 years ago; Fig. 1).

Psychosocial impact of abnormal smear Pap and Condylomas in Canada: an epidemiological study (PISCES). PISCES is a Canadian multicenter, clinic-based, prospective study undertaken to describe the psychosocial burden of HPV-related diseases. Details of PISCES have been previously published (48). Briefly, between August, 2006 and August, 2008, 61 physicians across Canada recruited 492 women with an abnormal smear result and a comparison group of 460 women with a normal smear. Women completed 3 self-administered questionnaires at recruitment, 4 and 12 weeks later. Information available in PISCES includes the sociodemographic characteristics of women (age, education, personal income, and ethnicity; Fig. 1) and 4 indicators of sexual activity: (i) age at sexual debut, (ii) number of new partners in past year (0, 1–2, 3–4, 5–10, exact number if >10), (iii) lifetime number of sexual partners (0, 1–2, 3–4, 5–10, exact number if >10), and (iv) ever been diagnosed with a STD (Fig. 1).

Statistical analysis

We restricted our analyses to women of ages 25 to 44 years old as the education level, and percentages of women sexually active and ever screened were relatively constant across this age group, following steep increases in the younger ages. In addition, women of ages 45 years or older were excluded to avoid cohort effects attributable to the important societal changes that occurred in Canada during the 1960s, which led to greater access to education, particularly for women, liberalization of sexual mores and an opening of the Canadian society to other cultures and immigration (50–52), and to changes in the overall participation and organization of cervical cancer screening in developed countries (1–3, 53). To further avoid confounding by age, we adjusted all our multivariate models by age.

Associations between sociodemographic characteristics and individual-level sexual activity (CCHS 3.1 and PISCES). We examined the association between the sociodemographic characteristics and the 4 indicators of sexual activity using logistic regression. To dichotomize the age at sexual debut and the number of sexual partners, we examined the distributions of each variable and opted for a dichotomization that produced a limited group of individuals exposed to higher levels of sexual activity while maintaining a number sufficient to stratify the group according to SES. We first examined the bivariate association between the sociodemographic characteristics and each indicator. We then included age and all other sociodemographic variables in multivariate models (1 model for each of the 4 indicators). Because immigration status, country of origin, and time since immigration were highly correlated, it was impossible to simultaneously include all these variables in the same multivariate model. Hence, our main multivariate model included only immigration status. We built 2 additional models for each of the 4 indicators of sexual activity by replacing immigration status by either (i) country of origin or (ii) time since immigration. We obtained bootstrap 95% confidence intervals (CI) using the method developed by Statistics Canada [Bootvar macro (54)] that takes into account the complex design of surveys. We also estimated P_{trends} for education, income, and time since immigration using logistic regression. We replicated these analyses for the indicators available in PISCES to corroborate the results

obtained in the CCHS (results available in the Supplementary Data).

Associations between sociodemographic characteristics and population-level sexual activity (PISCES). Given that PISCES contains the exact number of sexual partners for those with more than 10 partners, it was possible to explore the heterogeneity in sexual behavior using Lorenz curves and Gini coefficients (55). Lorenz curves illustrate the cumulative percentage of sexual partners accounted for by a given percentage of the population, whereas Gini coefficients quantify inequalities in the distribution of sexual partners (55). To obtain Lorenz curves, we ranked participants in an ascending order based on the number of sexual partners reported. We then plotted the cumulative percentage of sexual partners accounted for by the cumulative percentage of the population. If the number of sexual partners is distributed equally, then each participant accounts for the same proportion of sexual partners and the plot is diagonal. Deviation of the Lorenz curve from the diagonal line illustrates inequality in the distribution of the number of sexual partners. The Gini coefficient quantifies this deviation from the diagonal and is equal to twice the total area between the equality diagonal and the Lorenz curve (55). Thus, a higher Gini coefficient and a more skewed Lorenz curve represent greater inequality in the distribution of the number of sexual partners among study participants. We estimated the mean and median numbers of partners, Gini coefficients, the Lorenz curve, and the percentage of partners accounted for by the top 5%, 20%, and 50% of women for the total group of women and stratified for the different sociodemographic characteristics. For each measure, we estimated bootstrap 95% CIs according to the bias corrected accelerated method (56, 57). We initially conducted all analyses separately for women who received a normal or an abnormal smear result but given that results were identical, they were combined for all women.

Associations between sociodemographic characteristics and participation in cervical cancer screening (CCHS). We used logistic regression, as previously described for individual-level sexual activity indicators, to assess the associations between sociodemographic characteristics and the 2 indicators of screening underuse: (i) never had a Pap smear, and (ii) had a Pap smear more than 3 years ago (among women with at least 1 lifetime Pap smear).

Results

Sociodemographic characteristics of study populations

Table 1 presents the sociodemographic characteristics of women of ages 25 to 44 years who participated in the CCHS and PISCES. In both studies, a minority of women did not complete high school (<5%), more than 30% had completed a university degree, about a third of women earned less than $20,000 per year, and over three-quarters were Caucasian and Canadian-born.

Sociodemographic characteristics and individual-level sexual activity

In the CCHS, only 3% of women of ages 25 to 44 years reported never having had sexual intercourse (Table 2). This proportion was significantly higher among Asian women [East Asian: OR, 5.4 (95% CI, 3.2–8.9) and South Asian: OR, 3.6 (95% CI, 1.8–7.1)]. Among sexually active women, younger age at sexual debut was the indicator showing the greatest associations with lower SES, ethnicity, and immigration status. Women who did not complete high school were 3.6 (95% CI, 2.5–5.0) times more likely to report sexual debut before the age of 15 years compared with women with a university degree. In addition, there was a clear gradient between education and sexual debut ($P_{trend} < 0.0001$). Similarly, aboriginal women were 2.5 (95% CI, 1.9–3.4) times more likely to report sexual intercourse before 15 years of age compared with Caucasian women. Conversely, East Asian women were less likely to report this outcome [OR, 0.2 (95% CI, 0.1–1.0)] compared with Canadian-born women. SES and sexual activity were not significantly associated with the number of partners in last year and self-reported history of an STD diagnosis. However, compared with Caucasian women, aboriginal women were more likely to report a previous STD diagnosis [OR, 2.3 (95% CI, 1.7–3.0)], whereas East Asian women were less likely to report such a diagnosis [OR, 0.5 (95% CI, 0.3–0.9)]. Significant trends were observed for time since immigration and sexual activity outcomes ($P_{trend} < 0.0001$). Although nonsignificant, the above associations were similar in PISCES (Supplementary Table S1A).

Sociodemographic characteristics and population-level sexual activity

In PISCES, the number of sexual partners was concentrated within a small fraction of the most sexually most active women (Fig. 2). The top 5% of women accounted for a larger proportion of all lifetime sexual partners than the last 50% of less sexually active (25% vs. 17% of all lifetime partners, respectively; Supplementary Table S2A). Similarly, the top 5% of women accounted for 30% of all new partnerships in a year compared with the last 50% of women who reported no new partners. This heterogeneity in the distribution of partnerships is represented by Gini coefficients of 0.50 and 0.64 for the lifetime number of sexual partners and the number of new partners in the previous year, respectively, representing considerable inequality in the distribution of sexual activity [Gini coefficients vary from 0 (equal distribution) to 1 (highest concentration)]. However, there was no significant difference in the level of heterogeneity of the number of new or lifetime sexual partners in PISCES between SES and ethnical subgroups (Supplementary Table S2A).

Sociodemographic characteristics and cervical cancer screening underuse

In the CCHS, 9% of women of ages 25 to 44 years reported that they never had a Pap smear. The proportion

Table 1. Sociodemographic characteristics of women of ages 25 to 44 years old in the CCHS 3.1 and PISCES

	CCHS	PISCES	
	n = 4,945,611	Normal Pap test *n* = 240	Abnormal Pap test *n* = 256
Characteristics	**Weighted%[a]**	**%**	**%**
Age			
25–29	21.7	33.3	38.3
30–34	21.6	25.0	22.7
35–39	23.2	16.7	16.4
40–44	33.6	25.0	22.7
Education			
Primary[b]	4.7	0.8	2.7
High school	23.7	17.7	22.3
College	38.5	48.7	37.5
University	33.1	32.8	37.5
Personal income (Can$)			
<$20,000	31.4	22.1	28.5
$20,000–$39,999	30.8	45.4	42.2
$40,000–$59,999	17.0	20.4	19.9
≥$60,000	10.1	2.5	2.3
Missing	10.6	9.6	7.0
Province			
Maritime	7.1	7.1	8.2
Quebec	23.0	49.6	51.5
Ontario	40.1	32.5	29.7
West provinces	29.4	10.8	10.6
Territories	0.3	0.0	0.0
Ethnicity			
Aboriginal	2.5		
Black	2.0		
East Asian[f]	7.8		
South Asian[g]	4.4		
Latino	1.5		
Other[c]	2.7	7.6	9.4
Caucasian	79.0	92.4	90.6
Immigration status			
Canadian-born	77.2	NA	NA
Foreign-born	22.8		
Time since immigration[d]			
<3 y	11.2	NA	NA
3–10 y	34.4		
>10 y	54.4		
Region of origin[d,e]			
East Asia[f]	22.5	NA	NA
South Asia[g]	10.6		
High income Europe[h]	15.5		
United States	4.0		
Other	47.5		

[a]All frequencies obtained from CCHS data are weighted frequencies, that is, a survey weight is given to each respondent according to his/her characteristics to be representative of the targeted Canadian population.
[b]Primary school: did not complete high school.
[c]In PISCES, given their small number, all non-Caucasian participants were classified as other.
[d]Percentage calculated among immigrants.
[e]Regions of origin available in the CCHS have been classified according to the 2006 World Bank Classification of countries (77).
[f]East Asia: China, Philippines, and Vietnam.
[g]South Asia: India, and Sri Lanka.
[h]High income Europe: France, Germany, Greece, Hungary, Italy, the Netherlands, Poland, and United Kingdom.

who reported never having a Pap test was significantly higher among women with lower education, lower income, non-Caucasians, foreign-born, and among women from Québec (Table 3). Women who did not complete high school were 2.4 (95% CI, 1.7–3.4) times more likely to report never having been screened for cervical cancer compared with women with a university degree. Similarly, women with a personal income less than $20,000 were 2.4 (95% CI, 1.6–3.4) times more likely to have never been screened compared with women earning $60,000 or more. Foreign-born women were significantly more likely to have never been screened [OR, 2.4 (95% CI, 1.8–3.1)], compared with Canadian-born women, with women from Asia having the highest proportion never screened (30%; Table 3). The proportion of foreign-born women never screened significantly decreased as years since immigration increased ($P_{trend} < 0.0001$; Table 3). Only lower education [OR, 2.9 (95% CI, 2.1–4.0)] and being aboriginal [OR, 1.5 (95% CI, 1.1–2.0] were associated with having the last Pap more than 3 years ago. Importantly, the proportions of non-Caucasians and foreign-born women who reported not having been screened within the past 3 years were similar to Caucasian and Canadian-born women, respectively.

Discussion

We examined the association between key sociodemographic characteristics and 2 main risk factors for cervical cancer: sexual activity and screening underuse (see Table 4 for a summary of key findings). Our results indicate that, in Canada, aboriginals and women with lower SES are more likely to report higher level of sexual activity and lower screening participation, which may potentially produce synergetic effects toward higher risk of cervical cancer. Conversely, although Asian women are more likely to report screening underuse in terms of ever being screened, they reported lower levels of sexual activity and were adherent to screening guidelines when screened at least once.

Table 2. Sociodemographic characteristics of Canadian women of ages 25 to 44 years old associated with sexual activity in the CCHS

	Never had sexual intercourse			Sexual debut < 15 years old			≥3 partners in past year			Ever diagnosed with a STD		
		Crude	Multivariate[a]		Crude	Multivariate[a]		Crude	Multivariate[a]		Crude	Multivariate[a]
Characteristics	**%**	**OR (95% CI)**	**OR (95% CI)**	**%**	**OR (95% CI)**	**OR (95% CI)**	**%**	**OR (95% CI)**	**OR (95% CI)**	**%**	**OR (95% CI)**	**OR (95% CI)**
Total	2.8			7.7			2.3			8.7		
Age	—	0.9 (0.8–0.9)	0.9 (0.8–0.9)	—	1.0 (0.9–1.0)	0.9 (0.9–1.0)	—	0.9 (0.9–0.9)	0.9 (0.9–0.9)	—	1.0 (0.9–1.0)	1.0 (0.9–1.0)
Education												
Primary[b]	3.9	1.1 (0.6–2.1)	1.6 (0.8–3.4)	14.9	4.1 (3.0–5.6)	3.6 (2.5–5.0)[f]	1.3	0.6 (0.3–0.9)	0.7 (0.4–1.3)	8.2	0.9 (0.6–1.3)	0.8 (0.5–1.2)
High school	2.5	0.7 (0.5–1.0)	0.9 (0.6–1.3)	10.4	2.7 (2.2–3.4)	2.3 (1.8–3.0)	2.2	0.9 (0.7–1.3)	1.1 (0.8–1.6)	8.4	0.9 (0.8–1.0)	0.8 (0.7–1.0)
College	2.2	0.6 (0.4–0.8)	0.8 (0.6–1.1)	8.4	2.2 (1.8–2.7)	1.8 (1.5–2.3)	2.3	1.0 (0.7–1.4)	1.0 (0.8–1.4)	8.5	0.9 (0.8–1.1)	0.8 (0.7–1.0)
University	3.6	Ref.	Ref.	4.1	Ref.	Ref.	2.3	Ref.	Ref.	9.2	Ref.	Ref.
Personal income (Can$)												
Missing	5.8	2.8 (1.4–5.2)	2.1 (1.1–4.2)	5.7	1.4 (0.9–2.2)	1.0 (0.6–1.6)	1.4	0.8 (0.4–1.7)	0.7 (0.3–1.6)	7.1	0.7 (0.5–1.0)	0.8 (0.5–1.1)
<20,000	2.7	1.3 (0.8–2.2)	1.0 (0.6–1.7)	9.5	2.5 (1.8–3.4)	1.4 (1.0–2.0)[f]	1.9	1.1 (0.7–1.7)	0.8 (0.5–1.3)	8.7	0.9 (0.7–1.1)	0.9 (0.7–1.1)
20,000–39,999	2.7	1.3 (0.8–2.1)	1.1 (0.7–1.9)	8.5	2.2 (1.6–2.9)	1.3 (1.0–1.8)	2.7	1.5 (0.9–2.4)	1.0 (0.6–1.7)	8.7	0.9 (0.7–1.1)	0.9 (0.7–1.1)
40,000–59,999	2.5	1.2 (0.7–2.0)	1.1 (0.7–1.8)	6.0	1.5 (1.0–2.1)	1.2 (0.8–1.7)	2.7	1.6 (0.9–2.5)	1.2 (0.7–1.9)	8.7	0.9 (0.7–1.2)	0.9 (0.7–1.1)
≥60,000	2.1	Ref.	Ref.	4.1	Ref.	Ref.	1.8	Ref.	Ref.	9.7	Ref.	Ref.
Province												
Quebec	1.3	0.3 (0.2–0.5)	0.4 (0.2–0.6)	10.3	2.1 (1.7–2.5)	1.8 (1.4–2.1)	3.4	1.9 (1.3–2.6)	1.7 (1.2–2.3)	11.6	2.0 (1.6–2.3)	1.8 (1.5–2.1)
West	2.9	0.7 (0.5–0.9)	0.8 (0.6–1.0)	8.7	1.7 (1.4–2.1)	1.4 (1.2–1.7)	1.9	1.0 (0.8–1.4)	1.0 (0.7–1.3)	9.8	1.6 (1.4–1.9)	1.5 (1.3–1.8)
Maritime	1.8	0.4 (0.3–0.7)	0.6 (0.4–1.0)	7.9	1.6 (1.2–1.9)	1.1 (0.9–1.4)	1.7	0.9 (0.6–1.4)	0.8 (0.5–1.3)	7.6	1.2 (1.0–1.5)	1.1 (0.9–1.4)
Territories	1.7	0.4 (0.2–0.9)	0.5 (0.2–1.1)	15.2	3.2 (2.2–4.8)	1.4 (0.9–2.2)	3.2	1.8 (1.0–3.0)	1.4 (0.8–2.6)	21.8	4.2 (2.9–5.9)	2.6 (1.8–3.7)
Ontario	3.9	Ref.	Ref.	5.3	Ref.	Ref.	1.9	Ref.	Ref.	6.3	Ref.	Ref.
Ethnicity												
Aboriginal	2.4	1.3 (0.6–2.9)	1.1 (0.5–2.4)	21.8	3.1 (2.4–4.1)	2.5 (1.9–3.4)	2.6	1.0 (0.7–1.7)	1.1 (0.7–1.9)	19.3	2.4 (1.8–3.0)	2.3 (1.7–3.0)
Black	4.7	2.5 (1.3–5.0)	2.6 (1.2–5.8)	10.7	1.3 (0.6–2.9)	2.1 (0.9–5.0)	2.7	1.1 (0.5–2.3)	1.3 (0.5–3.4)	10.5	1.2 (0.7–1.8)	1.6 (0.9–2.7)
East Asian	8.4	4.8 (3.3–6.8)	5.4 (3.2–8.9)	1.5	0.2 (0.1–0.4)	0.4 (0.1–1.0)	0.3	0.1 (0.0–0.4)	0.2 (0.1–0.7)	3.2	0.3 (0.2–0.6)	0.5 (0.3–0.9)
South Asian	*NA*	4.1 (2.4–7.1)	3.6 (1.8–7.1)	*NA*	0.2 (0.0–2.7)	0.4 (0.0–5.9)	*NA*	0.4 (0.0–4.3)	0.6 (0.1–7.3)	*NA*	0.1 (0.1–0.8)	0.2 (0.0–1.3)
Latino	*NA*	0.3 (0.0–26.5)	0.3 (0.0–32.0)	*NA*	0.1 (0.0–17.9)	0.1 (0.0–36.0)	*NA*	1.2 (0.4–3.2)	1.5 (0.5–4.9)	*NA*	0.5 (0.2–1.3)	0.6 (0.3–1.8)
Other	7.0	6.1 (3.0–12.3)	6.2 (2.7–14.0)	2.1	0.3 (0.1–0.9)	0.7 (0.3–1.9)	1.3	0.3 (0.3–2.5)	0.4 (0.0–3.8)	3.9	0.8 (0.5–1.4)	1.1 (0.6–2.0)
Caucasian	1.9	Ref.	Ref.	8.2	Ref.	Ref.	2.5	Ref.	Ref.	9.2	Ref.	Ref.
Immigration status												
Foreign-born	4.8	2.2 (1.6–3.0)	1.9 (0.2–13.8)	2.6	0.3 (0.2–0.4)	0.5 (0.3–0.7)	1.1	0.4 (0.2–0.7)	0.7 (0.3–1.3)	4.6	0.5 (0.4–0.6)	0.7 (0.5–0.9)
Canadian-born	2.3	Ref.	Ref.	9.0	Ref.	Ref.	2.6	Ref.	Ref.	9.8	Ref.	Ref.
Delay since immigration[c]												
<3 years	6.8	3.2 (1.7–6.0)	1.9 (0.9–3.9)[d]	0.4	0.0 (0.0–0.1)	0.1 (0.0–36.6)[f]	0.7	0.3 (0.0–1.0)	0.3 (0.0–29.8)	2.5	0.2 (0.1–0.5)	0.3 (0.1–0.7)[f]
3–10 years	4.2	1.9 (1.2–2.9)	1.4 (0.9–2.3)	0.8	0.1 (0.0–0.2)	0.1 (0.1–0.3)	0.7	0.3 (0.1–0.5)	0.4 (0.2–0.9)	1.7	0.2 (0.1–0.3)	0.2 (0.1–0.4)
>10 years	4.8	2.2 (1.5–3.2)	2.1 (1.4–3.1)	4.2	0.4 (0.3–0.7)	0.7 (0.4–1.0)	1.3	0.5 (0.3–1.0)	0.9 (0.4–1.9)	6.7	0.7 (0.5–0.9)	1.0 (0.7–1.3)
Canadian-born	2.3	Ref.	Ref.	9.0	Ref.	Ref.	2.6	Ref.	Ref.	9.8	Ref.	Ref.
Region of origin[c,e]												
Asia	7.9	3.8 (2.6–5.6)	2.9 (1.9–4.5)[d]	0.9	0.1 (0.0–4.7)	0.2 (0.0–10.3)	0.2	0.1 (0.0–1.5)	0.2 (0.0–9.0)	1.2	0.1 (0.1–0.3)	0.2 (0.1–0.6)
Europe	2.5	1.1 (0.3–3.9)	1.1 (0.3–3.9)	4.9	0.5 (0.3–1.0)	0.7 (0.3–1.3)	1.4	0.5 (0.3–1.0)	0.7 (0.3–1.3)	8.7	0.9 (0.6–1.4)	1.0 (0.7–1.7)
Other	3.6	1.6 (1.1–2.4)	1.4 (0.9–2.1)	2.9	0.3 (0.2–0.5)	0.4 (0.3–0.7)	1.5	0.6 (0.3–1.1)	0.7 (0.2–1.8)	5.2	0.5 (0.4–0.7)	0.6 (0.4–0.8)
Canada	2.3	Ref.	Ref.	9.0	Ref.	Ref.	2.6	Ref.	Ref.	9.8	Ref.	Ref.

Abbreviations: STD: Sexually transmitted disease; OR: Odds ratio; CI: Confidence interval; NA, Nonavailable: when cell sizes are less than 30 individuals, frequency results are not released by Statistics Canada.

[a]The multivariate model was adjusted for age and included all sociodemographic variables.

[b]Primary school: did not complete high school.

[c]Two different multivariate models were built to estimate the association between sexual activity and the time since immigration, and the region of origin.

[d]Because of the small sample size and the important correlation between the variables related to the immigration status (immigration status, delay since immigration and region of origin) and to ethnicity, these multivariate models excluded the variable related to ethnicity.

[e]Because of the small sample size, immigrants from South and East Asia were combined as well as those from the United States and other countries.

[f]$P_{trend} < 0.002$.

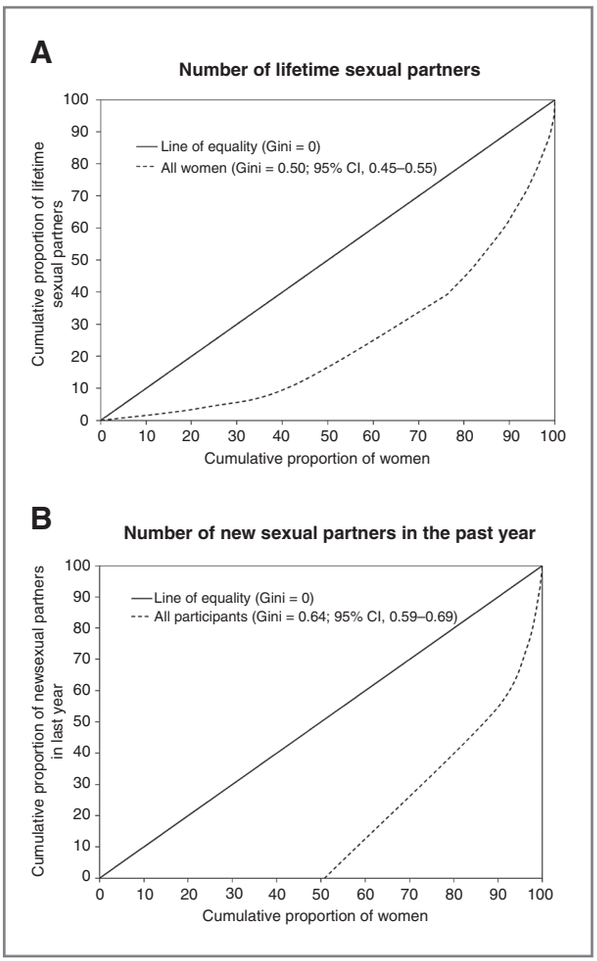

Figure 2. Heterogeneity in the distribution of sexual activity in PISCES: Lorenz curves for the distribution of the number of sexual partners.

Screening underuse and higher sexual activity both constitute intermediate factors in the association between SES and cervical cancer, and thus may act in synergy to further increase the risk of cervical cancer. Although it has been previously shown that the incidence of cervical cancer is disproportionately high among women with lower SES (5), the causal pathways underlying this association were unclear. Consistent with previous studies (18, 58), we found an association between SES (particularly lower level of education) and screening underuse. However, the association between SES and sexual activity is not consistent in the literature (37–39), and similarly to our study, depends on the indicator of sexual activity that is examined. Earlier sexual debut emerged as the most sensitive outcome to variations in SES. Interestingly, this outcome is widely recognized as a strong marker of riskier sexual behavior (59–62) and is strongly associated with increased risk of HPV infection (63, 64) and disease (65). On the other hand, the other indicators of sexual activity, at the individual-level (number of partners in the past year and a previous STD diagnosis) or population-level (heterogeneity in the number of lifetime or recent partners) were not associated with SES in our study. This may be due to several reasons. First, given that virtually all women (98%) reported 1 or 2 partners in the past year in the CCHS, the possible variations according to SES were very limited. Second, although PISCES contains more detailed data and greater variability in the number of sexual partners making it possible to examine the heterogeneity in sexual behavior, this study was not initially powered for this purpose. Hence, although some differences were observed according to the SES, they were not statistically significant. In addition, these results should be considered as exploratory, and given that sexual behavior is complex and involves not only the women but also her sexual contacts and network, more research is needed to better understand the role of these indicators of sexual activity as intermediate factors in the relation between SES and cervical cancer.

Our results also provide additional information about the reasons for previous observations of screening underuse among foreign-born women. Several barriers have been suggested to explain low cervical screening participation for these women: language barriers, limited knowledge of cancer prevention, cultural barriers, alternate health priorities, and structural barriers (66). Our results suggest that foreign-born women, particularly from Asia, are less likely to have ever been screened, but when screened at least once are as adherent to guidelines as Canadian-born women, which supports the hypothesis of barriers to access of health services. The observation that the proportion of foreign-born women never screened decreases as the number of years since immigration increases also supports this hypothesis. Hence, although foreign-born women, particularly from Asia, could represent a subgroup at higher risk of cervical cancer (8) as a result of screening underuse, our data suggest that this risk may partly be counterbalanced by their lower level of sexual activity and adherence with screening guidelines, when screened at least once.

Women from minority ethnic backgrounds, particularly aboriginal and Black women, are generally recognized as subpopulations experiencing important health inequalities (30, 39, 67, 68). Our results confirm that aboriginal women represent a subgroup of women at particularly high risk of cervical cancer (69, 70) as they reported higher levels of sexual activity (younger age at sexual debut and greater proportion with a previous STD diagnosis) and screening underuse. The reasons underlying screening underuse among aboriginals are difficult to identify and are most likely a combination of cultural differences and barriers to access to health care (67). Our results also suggest potential greater level of sexual activity (younger age at sexual debut) and screening underuse (never having been screened) among Black women, though differences were not statistically significant due to small sample size. Previous studies in the United States, with larger sample size, have reported screening underuse (18). Importantly, recent studies have indicated that

Table 3. Sociodemographic characteristics of Canadian women of ages 25 to 44 years old associated with underuse of cervical cancer screening in the CCHS

	Never had a Pap smear			Previous smear more than 3 year ago (among women who ever had a smear)		
		Crude	Multivariate[a]		Crude	Multivariate[a]
Characteristics	**%**	**OR (95% CI)**	**OR (95% CI)**	**%**	**OR (95% CI)**	**OR (95% CI)**
Total	8.8			10.0		
Age	—	0.9 (0.9–1.0)	0.9 (0.9–1.0)	—	1.1 (1.0–1.1)	1.1 (1.1–1.1)
Education						
Primary[b]	19.7	2.2 (1.6–3.0)	2.4 (1.7–3.4)[d]	21.9	3.9 (2.8–5.2)	2.9 (2.1–4.0)[d]
High school	8.1	0.8 (0.6–1.0)	1.0 (0.8–1.3)	12.2	1.9 (1.6–2.3)	1.6 (1.3–2.0)
College	6.9	0.7 (0.5–0.8)	0.8 (0.7–1.0)	10.1	1.5 (1.3–1.9)	1.4 (1.1–1.7)
University	10.0	Ref.	Ref.	6.8	Ref.	Ref.
Personal income (Can$)						
Missing	17.3	5.1 (3.4–7.5)	3.7 (2.4–5.7)	9.8	1.0 (0.7–1.3)	0.9 (0.6–1.2)
<$20, 000	10.8	3.7 (2.6–5.3)	2.4 (1.6–3.4)[d]	11.9	1.2 (0.9–1.6)	1.1 (0.8–1.5)
$20,000–$39,999	8.8	3.0 (2.1–4.3)	2.3 (1.6–3.5)	9.8	0.9 (0.7–1.3)	1.0 (0.7–1.3)
$40,000–$59,999	5.5	1.8 (1.2–2.6)	1.6 (1.1–2.4)	7.3	0.7 (0.5–0.9)	0.8 (0.6–1.0)
≥$60,000	3.2	Ref.	Ref.	10.0	Ref.	Ref.
Province						
Quebec	12.9	1.4 (1.2–1.7)	2.6 (2.1–3.1)	11.9	1.3 (1.1–1.6)	1.3 (1.0–1.5)
West provinces	6.5	0.7 (0.6–0.8)	0.8 (0.6–0.9)	9.7	1.0 (0.9–1.2)	1.0 (0.9–1.2)
Maritime	3.4	0.3 (0.2–0.5)	0.7 (0.5–0.9)	9.7	1.0 (0.8–1.3)	0.9 (0.7–1.1)
Territories	4.7	0.5 (0.3–0.9)	0.7 (0.4–1.4)	5.7	0.6 (0.4–0.9)	0.4 (0.3–0.7)
Ontario	9.3	Ref.	Ref.	9.3	Ref.	Ref.
Ethnicity						
Aboriginal	5.2	0.9 (0.6–1.4)	1.2 (0.8–1.9)	14.2	1.5 (1.1–1.9)	1.5 (1.1–2.0)
Black	14.7	2.9 (1.8–4.8)	1.5 (0.8–2.8)	8.9	0.9 (0.5–1.6)	0.9 (0.5–1.9)
East Asian	25.4	5.1 (4.6–7.3)	4.1 (3.0–5.5)	6.3	0.6 (0.4–0.9)	0.6 (0.4–1.0)
South Asian	*NA*	6.5 (4.8–8.8)	3.6 (2.4–5.3)	*NA*	0.6 (0.3–1.0)	0.7 (0.4–1.3)
Latino	*NA*	2.1 (1.2–3.7)	0.9 (0.4–1.6)	*NA*	1.0 (0.4–2.3)	1.0 (0.4–2.9)
Other	27.3	6.4 (4.6–9.0)	3.4 (2.2–5.3)	*NA*	1.2 (0.6–2.5)	1.5 (0.7–3.1)
Caucasian	5.5	Ref.	Ref.	10.2	Ref.	Ref.
Immigration status						
Foreign-born	20.6	4.5 (3.8–5.4)	2.4 (1.8–3.1)	8.6	0.8 (0.7–1.0)	0.9 (0.7–1.2)
Canadian-born	5.4	Ref.	Ref.	10.3	Ref.	Ref.
Delay since immigration[c]						
<3 years	37.0	10.3 (7.5–14.1)	4.1 (2.6–6.5)[d]	8.2	0.8 (0.3–1.8)	1.1 (0.4–2.9)
3–10 years	25.2	5.9 (4.7–7.4)	2.7 (1.9–3.8)	9.1	0.9 (0.6–1.3)	1.2 (0.8–1.8)
>10 years	14.7	3.0 (2.4–3.8)	1.9 (1.4–2.6)	8.5	0.8 (0.6–1.0)	0.8 (0.6–1.1)
Canadian-born	5.4	Ref.	Ref.	10.3	Ref.	Ref.
Region of origin[c]						
East Asia	30.4	7.6 (5.7–10.1)	4.3 (2.5–7.3)	6.0	0.5 (0.3–0.9)	0.7 (0.2–2.0)
South Asia	30.9	7.8 (5.3–11.5)	3.1 (1.7–5.8)	*NA*	0.5 (0.2–1.2)	0.6 (0.2–1.9)
Europe	1.6	3.9 (0.9–2.5)	1.8 (1.0–3.0)	10.9	1.1 (0.7–1.5)	0.9 (0.6–1.3)
United States	*NA*	0.9 (0.3–2.6)	1.0 (0.3–3.0)	*NA*	1.3 (0.7–2.3)	1.3 (0.7–2.4)
Other	19.3	4.2 (3.4–5.2)	2.6 (1.7–3.8)	9.0	0.9 (0.6–1.2)	0.9 (0.6–1.3)
Canadian-born	5.4	Ref.	Ref.	10.3	Ref.	Ref.

Abbreviations: STD: Sexually transmitted disease; OR: Odds ratio; CI: Confidence interval; NA, Nonavailable: when cell sizes are less than 30 individuals, frequency results are not released by Statistics Canada.

[a]The multivariate model was adjusted for age and included all sociodemographic variables.

[b]Primary school: did not complete high school.

[c]Two different multivariate models were built to estimate the association between screening participation and the time since immigration and the region of origin.

[d]$P_{trend} < 0.0006$.

Table 4. Summary of the potential synergies in the sociodemographic characteristics influencing sexual activity and screening underuse

Sociodemographic characteristics	Sexual activity[a]	Screening underuse: Never had a Pap	Screening underuse: Previous Pap > 3 year ago	Relation between risk factors
Lower level of education	↑	↑	↑	Synergy
Lower income	↑	↑	—	Synergy
Province (compared with Ontario)				
Quebec	↑↑↑↑	↑	↑	Synergy
West provinces	↑↑	↓	—	Antagonist
Maritimes	—	↓	—	—
Territories	↑	—	↓	Antagonist
Ethnicity (compared with Caucasian)				
Aboriginal	↑↑	—	↑	Synergy
Black	—	—	—	—
East Asian	↓↓↓↓	↑	—	Antagonist
South Asian	↓	↑	—	Antagonist
Latino	—	—	—	—
Other	↓	↑	—	Antagonist
Foreign-born women (compared with Canadian-born)				
East Asia	↓↓	↑	—	Antagonist
South Asia	↓↓	↑	—	Antagonist
High income Europe	—	↑	—	—
Other	↓↓	↑	—	Antagonist
Longer delay since immigration	—	↓	—	—

[a]The number of arrows represents the number of sexual activity indicators (never had sexual intercourse, sexual debut < 15 years old, ≥3 partners in past year, ever diagnosed with a STD) showing a statistically significant association with the given sociodemographic characteristic in the multivariate model.

the disproportionately high rates of STI among Black women could largely depend upon population-level risk factors, such as sexual mixing and heterogeneity in sexual activity (30, 39).

Our results have several implications. First, our results indicate that women from lower SES and aboriginals are at increased risk of cervical cancer as a result of both, higher level of sexual activity and low screening participation. Failure to vaccinate these high-risk groups against HPV could increase current inequalities in the burden of cervical cancer. It is hoped that free school-based vaccination programs in Canada will reach these subpopulation. However, preliminary data suggest that there may still be an association between SES, ethnicity (particularly for aboriginals), and lower vaccination coverage in Canada (71, 72), though much weaker than previously observed with private vaccination (73). It will be important to closely monitor HPV vaccination coverage among all populations to ensure that high-risk subgroups are vaccinated. Second, inequalities may be produced among young women newly arrived in Canada who are too old to be vaccinated in school-based public programs (particularly after catch-up campaigns have subsided). Most of these women will likely immigrate to Canada unvaccinated against HPV, and as highlighted in this study, at increased risk of never being screened for cervical cancer. However, to our knowledge, Canada or the United States do not have specific vaccination programs for newly arrived immigrants. Given that immigrants represent an increasing proportion of the Canadian population, future research should examine the most efficient and cost-effective strategies of ensuring that these young women are vaccinated and screened for cervical cancer. Third, we show differences in the sociodemographic characteristics of (i) women who have never been screened, and (ii) those who have been screened but have longer intervals between tests than recommended by guidelines. Given their different associations with sociodemographic characteristics, future studies should analyse the determinants of these 2 measures of screening underuse separately.

This study has several strengths. It represents a first attempt to integrate, into a comprehensive conceptual framework, the 2 main behavioral risk factors for cervical cancer, their predictors, as well as potential synergies between them. This conceptual framework can be used in future research to help better understand how HPV vaccination can potentially increase or decrease inequalities in the burden of cervical cancer. Second, this is the first study to examine simultaneously the sociodemographic predictors of sexual behavior and screening

participation using a common source of data. Third, we used data from the CCHS collected by Statistics Canada, which are subject to high standards of quality assurance and are representative of the Canadian population.

The main limitation of this study is the potential for information bias, given that all data were self-reported. In particular, women from different ethnic backgrounds may respond differently to questions about sexual activity. Hence, although our results are similar to previous studies indicating earlier sexual debut in Quebec compared with the other Canadian provinces (74) and lower levels of sexual activity for Asian women [lower number of sexual partners in India and Pakistan (75); older age at sexual debut in Philippines and Indonesia (76)], it is unclear whether these differences are true or attributable to cultural differences or social desirability bias. In addition, our sample size was not sufficient to allow for more refined stratification of the country of origin of immigrant or the ethnic background. Finally, as one needs to be a resident of a household to participate in CCHS, participants may not be truly representative of the entire SES spectrum.

In conclusion, HPV vaccination programs offer tremendous promises of reducing the burden of HPV-related diseases, including cervical cancer. However, failure to achieve high vaccine coverage among high-risk subpopulations could mitigate population-level effectiveness and increase health inequalities. Our study indicate that women with lower SES, particularly women with low level of educational attainment, and aboriginal women cumulate both risk factors for cervical cancer and are consequently at high risk of cervical cancer. Foreign-born women, as a group, are also at increased risk of cervical cancer as a result of screening underuse. However, the risk for Asian women is possibly counterbalanced by their lower level of sexual activity. These results are important for clinicians, public health officials, and epidemiologist as they improve our understanding of current sociodemographic inequalities in the burden of cervical cancer and clearly identify subgroups of women that should be closely monitored, and if need be, targeted to achieve high vaccination coverage and screening participation.

Disclosure of Potential Conflicts of Interest

M. Brisson has consulted and received reimbursement for travel expenses from Merck Frosst and GlaxoSmithKline. No potential conflicts of interest were disclosed by the other authors. Although the research and analysis are based on data from Statistics Canada, the opinions expressed do not represent the views of Statistics Canada.

Authors' Contributions

Conception and design: M. Drolet, M. Brisson
Development of methodology: M. Drolet, M. Brisson
Acquisition of data (provided animals, acquired and managed patients, provided facilities, etc.): M. Drolet, M. Brisson
Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): M. Drolet, M.-C. Boily, C. Greenaway, S.L. Deeks, C. Blanchette, J.-F. Laprise, M. Brisson
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Study supervision: M. Drolet, M. Brisson

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