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Can high overall human papillomavirus vaccination coverage hide sociodemographic inequalities? An ecological analysis in Canada

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ABSTRACT

Background: Human papillomavirus (HPV) vaccination programs have been implemented in more than 50 countries. These programs offer tremendous promise of reducing HPV-related disease burden. However, failure to achieve high coverage among high-risk groups may mitigate program success and increase inequalities. We examined sociodemographic inequalities in HPV vaccination coverage in 4 Canadian provinces (Quebec (QC), Ontario (ON), Manitoba (MB), British Columbia (BC)).
Methods: We obtained annual HPV vaccination coverage of pre-adolescent girls at provincial and regional levels, from the start of programs to 2012/2013. Regions refer to administrative areas responsible for vaccine implementation and monitoring (there are 18/36/10/16 regions in QC/ON/MB/BC). We obtained regions' sociodemographic characteristics from Statistics Canada Census. We used univariate weighted linear regression to examine the associations between regions' sociodemographic characteristics and HPV vaccination coverage.
Results: Provincial HPV vaccination coverage is generally high (QC:78%; ON:80%; MB:64%, BC:69%, 2012/13). QC had the highest provincial vaccination coverage since the program start, but had the greatest inequalities. In QC, regional HPV vaccination coverage was lower in regions with higher proportions of socially deprived individuals, immigrants, and/or native English speakers ($p < 0.0001$). These inequalities remained stable over time. Regional-level analysis did not reveal inequalities in ON, MB and BC.
Conclusion: School-based HPV vaccination programs have resulted in high vaccination coverage in four Canadian provinces. Nonetheless, high overall coverage did not necessarily translate into equality in coverage. Future work is needed to understand underlying causes of inequalities and how this could impact existing inequalities in HPV-related diseases and overall program success.

1. Introduction

Over the past five decades, cervical screening has greatly contributed to reductions in the incidence and mortality from cervical cancer in developed countries [1–3]. However, despite major investments and sustained efforts to increase regular participation in cervical screening programs, 5–10% of women have never been screened and another 10–15% of women do not undergo regular recommended screening [4,5]. Considering that about 60% of cervical cancers are diagnosed among these under-screened women [6–9] and that screening underuse has been observed among women with lower socioeconomic status, and immigrants, as well as aboriginal women [4,10–13], it is not surprising that the burden of cervical cancer remains disproportionately high among socioeconomically disadvantaged women [14–21].

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Since 2007, immunization programs against human papillomavirus (HPV), the major etiological agent for cervical cancer [22,23], have been implemented across the world, including Canada [24]. These immunization programs offer the benefit of primary prevention, and the promise of reducing the burden of cervical cancer and other HPV-related diseases. Encouraging results have already been published regarding the short-term population-level impact of these programs [25]. However, failure to achieve high vaccination coverage in subgroups of girls who will be at higher risk of cervical cancer, as a result of screening underuse and/or higher sexual activity, may mitigate the success of these vaccination programs and increase health inequalities [26]. Inequalities in HPV vaccination coverage have been documented and some data indicate that the sociodemographic determinants of HPV vaccination uptake are similar to those of cervical cancer screening participation. For example, different studies suggested that HPV vaccination series completion was lower among girls from ethnic minorities [20,27–29] and from deprived areas [20,27,28,30]. However, the overall picture of inequalities in HPV vaccination coverage remains unclear, as results vary between countries, regions, age groups and by vaccination delivery mode (i.e., clinic-based or school-based).

Given the major investments in HPV vaccination programs, it is crucial to determine whether subgroups of girls, who may be at greater risk of cervical cancer or other HPV-related diseases, are vaccinated. This assessment is important in all settings, including those with high vaccination coverage, as high overall coverage may conceal lower coverage of vulnerable subgroups of the population. Furthermore, inequalities in vaccination coverage should be examined both at the individual and population levels. Indeed, HPV is a sexually transmitted infection and, as all infections, the risk of acquiring HPV depends not only on individuals' risk factors (e.g., vaccination status, sexual activity) but also on their social and sexual network's risk factors (e.g., vaccination coverage). We aim to examine the associations between key population-level sociodemographic characteristics and HPV vaccination coverage of pre-adolescent girls in four Canadian provinces (Quebec (QC), Ontario (ON), Manitoba (MB) and British Columbia (BC)).

2. Methods

2.1. Data sources

2.1.1. HPV vaccination coverage

In Canada, although all provinces vaccinate pre-adolescent girls with quadrivalent HPV vaccine through schools, vaccination programs (i.e., age at vaccination, dose regimens, catch-up campaigns) and monitoring of vaccination coverage differ between provinces (Table 1). In QC and BC, HPV vaccination coverage is monitored by regional public health authorities, whereas in MB, monitoring is centralized through the population-based Manitoba Immunization Monitoring System. In ON, there is monitoring for school-aged children at both the regional and provincial levels. We obtained data on the annual HPV vaccination coverage of pre-adolescent girls at the provincial and regional levels, from the start of the programs to 2012/2013. Regions (also known as Health Regions (QC, $n = 18$), Public Health Units (ON, $n = 36$), Regional Health Authorities (MB, $n = 10$), or Health Service Delivery Area (BC, $n = 16$)) refer to administrative areas responsible for vaccine implementation and monitoring [31,32]. We assessed HPV vaccine series completion, and the number of doses in a series differed by province. We restricted our analysis to vaccination coverage of the youngest age cohorts of girls (i.e., 3 doses for ON (Grade 8: 13/14 years old) and

Table 1
Description of HPV vaccination programs and methods used to estimate vaccination coverage in the four provinces.

	Quebec	Ontario	Manitoba	British Columbia
Start of publicly-funded program	2008/2009	2007/2008	2008/2009	2008/2009
Last year of coverage data available for analysis	2012/2013	2012/2013	2012/2013	2012/2013
Dose regimen	2 doses in Grade 4 and 3rd dose in Grade 9[a]	3 doses in Grade 8	3 doses in Grade 6	3 doses in Grade 6 (2008/09–2009/10) 2 doses in Grade 6 (since 2010/11)
Catch-up campaigns	3 doses in Grade 9 until 2012/13	None, however females are eligible for vaccine until the end of high school.	None, however females who missed the vaccine in Grade 6 and were born between 1997 and 2003 remain eligible.	3 doses in Grade 9 until 2010/11
Number of Regions	16[b] (103 local areas)	36	10[d]	16
Coverage data source	Data from the 16 regions summarized by the Bureau de surveillance et de vigie (Direction protection santé publique du MSSS). Data also available at the local level.	Data from the 36 regions summarized by the Immunization Record Information System (IRIS)	Population-based Manitoba Immunization Monitoring System (MIMS)	Data from the 16 regions summarized by the BC Center for Disease Control
Coverage numerator	Number of girls vaccinated with at least 2 doses in Grade 4	Number of girls considered complete for age[c]	Number of girls who received 3 doses between the ages of 10 and 13 years old[e]	Number of girls up-to-date for age by June 30
Coverage denominator	Number of girls enrolled in Grade 4 grade at the second dose (class lists)	Number of girls enrolled in grade 8 (class lists)	Number of girls aged 11 years old in Manitoba (population-based registry)	Number of girls enrolled in Grade 6 as of June 30 (class lists)

[a] In 2015 QC switched from a 3-dose regimen to a 2-dose regimen. Hence the third dose in Grade 9 has been withdrawn.
[b] Vaccination coverage was not available for 2 regions in QC (Nunavik and Terres-Cries-de-la-Baie-James) given the different methodology used to estimate coverage. These regions were also excluded from official governmental reports.
[c] A girl is considered complete-for-age if the required number of doses for a given age has been received with the appropriate interval between doses. Under this logic, some girls who have an incomplete series but are not yet overdue are considered complete-for-age[45]. This method might lead to overestimations of vaccination coverage.
[d] In 2012, the 10 health units in Manitoba were merged into 5 Regional Health Authorities. However, to be consistent throughout the duration of follow-up, we performed our analysis with the initial 10 health units.
[e] In Manitoba, the target age for vaccination is 11 (Grade 6), however the MIMS indicates that about 27% of girls were vaccinated at ages 10, 12 or 13 because of varying ages while being in Grade 6. The denominator only includes girls aged 11 whereas the numerator also includes girls who completed the vaccination series at the age of 10, 12 or 13. This method leads to overestimations of vaccination coverage