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ABSTRACT

Background

Globally, cervical cancer is one of the most common cancers, yet it is largely preventable. Switching methods for primary screening from cytology testing, via Pap test, to human papillomavirus (HPV) testing is a component of that prevention. OncoSim-Cervix, a Canadian cervical cancer microsimulation model, assesses the long-term effects of HPV vaccination and screening interventions. This study projects the impact of differing roll-out strategies for HPV primary testing for cervical cancer screening in Canada.

Data and methods

OncoSim-Cervix simulates the progression from HPV infection to cervical cancer, incorporating Canadian data on incidence, mortality, HPV vaccination, screening, and costs. This analysis compared the effect of different roll-out strategies for switching from current practice to HPV primary screening every five years. Using OncoSim-Cervix, the study simulated one status quo scenario (cytology primary screening every three years) and three quinquennial HPV primary screening scenarios: (1) one-time roll-out, (2) population-based roll-out over two years, and (3) age-based roll-out over three years.

Results

All HPV screening roll-out strategies were found to improve clinical outcomes, with reductions of approximately 20% in cervical cancer cases and 18% in deaths, while screening less frequently, compared with cytology screening. The one-time roll-out scenario initially spiked colposcopy referrals by 60%, while phased implementation produced smaller peaks (35% to 40%) followed by declining referrals, compared with cytology screening.

Interpretation

Switching from three-year cytology to five-year HPV testing improves outcomes, with phased strategies mitigating the initial colposcopy surge. Modelling can help programs anticipate and manage colposcopy demand during the transition.

Keywords

cervical cancer, cervical cancer deaths, screening, human papillomavirus, colposcopy

AUTHORS

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What is already known on this subject?

- Cervical screening using the Pap test has been demonstrated to be effective.
- Testing for the presence of high-risk human papillomavirus (HPV) infection of the cervix or vagina has been shown to be a more sensitive screening test than the Pap test.
- Canadian cervical screening recommendations are to replace Pap tests with HPV-based screening.

What does this study add?

- This study projects that implementing HPV primary screening will result in superior clinical outcomes and lower long-term resource requirements than current Pap-based practice.
- This study projects that short-term increases in the demand for diagnostic services associated with a change to HPV can be mitigated by phased implementation with little loss in overall clinical efficacy.

Cervical cancer remains one of the most common cancers affecting women worldwide, yet it is largely preventable.[1] Many countries, including Canada, have recognized the possibility of eliminating cervical cancer, defined as a reduction in the age-standardized incidence rate to less than 4 per 100,000, and are committed to achieving this goal by 2040.[2] A key step in this journey is improving cervical cancer screening. Screening reduces cervical cancer incidence by facilitating the early detection of precancerous changes, which allows for timely intervention and treatment to prevent progression to invasive cancer.

Practically all cases of cervical cancer are caused by persistent infection with high-risk types of human papillomavirus (HPV), which emphasizes the critical role of HPV in cervical cancer prevention and control.[3] For cervical cancer screening in Canada, the current practice across most provinces involves primary cytology-based testing (i.e., Pap testing) every three years.[4] However, recent Canadian and international studies support a transition from Pap testing to HPV testing for cervical cancer screening.[5,6] HPV testing, in particular, provides significant advantages over Pap tests by detecting cervical pre-cancer earlier and with greater sensitivity, facilitating less frequent testing—five years is a recommended screening interval for HPV primary testing.[5] Additionally, HPV testing permits self-testing. HPV self-testing has the potential to increase access to, and participation in, cervical cancer screening across Canada, thereby reaching more individuals and supporting the national goal of the elimination of cervical cancer.[7] However, as seen in Australia—an early adopter of HPV testing—the initial implementation can lead to a surge in colposcopy demand due to the higher positivity rate of HPV testing, which increases referrals for follow-up procedures.[8] This highlights the need for careful planning of the roll-out of HPV testing in Canada to manage such demands effectively.

Modelling plays a significant role in informing cancer screening strategies[9] because population-based screening is not merely a test, but a pathway integrated into broader health systems. The effectiveness of cancer screening policies hinges on various factors, including test sensitivity, follow-up procedures and treatment options. These components often vary across jurisdictions and over time, meaning that outcomes may differ from those observed in traditional screening trials. To address these complexities, computer simulation models like OncoSim[10] and those that are part of the Cancer Intervention and Surveillance Modeling Network (CISNET),[9] that are developed using empirical data, allow for the customization of scenarios that reflect local context and the exploration of "what-if" scenarios.[11] These models have been instrumental in shaping cancer screening clinical guidelines across North America, enabling researchers and policy makers to simulate real-world scenarios, project long-term outcomes, and compare various strategies without implementing them in reality. In this study, the OncoSim-Cervix microsimulation model was used to project the system impact of transitioning to HPV primary testing for cervical cancer screening in Canada, with the objective of assessing the clinical and health system impacts of several roll-out strategies to mitigate the immediate burden on the health care system.

Data and methods

Overview of models

The OncoSim-Cervix microsimulation model simulates the natural history of cervical cancer in the Canadian population.[10,12] It integrates Canadian demographic data, HPV infection history, disease progression, screening protocols, screening and treatment costs, and quality of life. OncoSim simulates the Canadian population based on Statistics Canada demographics, both historic (back to 1874) and projected (up to 2050). Each simulated individual possesses attributes like sex, province or territory of residence, education, immigration history, and cervical cancer-risk factors (e.g., sexual interactions, vaccination status). HPV infection and cervical

cancer progression are modelled in two steps. First, the interactive agent HPV Microsimulation Model (HPVMM) simulates HPV transmission through sexual interactions.[13] The HPVMM-generated HPV infection rates are subsequently ingested by OncoSim-Cervix, which traces the pathway from HPV infection to the onset of cervical cancer using phase-specific disease progression and remission rates calibrated to Canadian Cancer Registry data (Figure 1). Outcomes include cervical cancer incidence and mortality rates, precancerous lesions, screening counts, quality-adjusted life years, and costs. The OncoSim program is led and supported by the Canadian Partnership Against Cancer, with model development by Statistics Canada, and funding by Health Canada.[10]

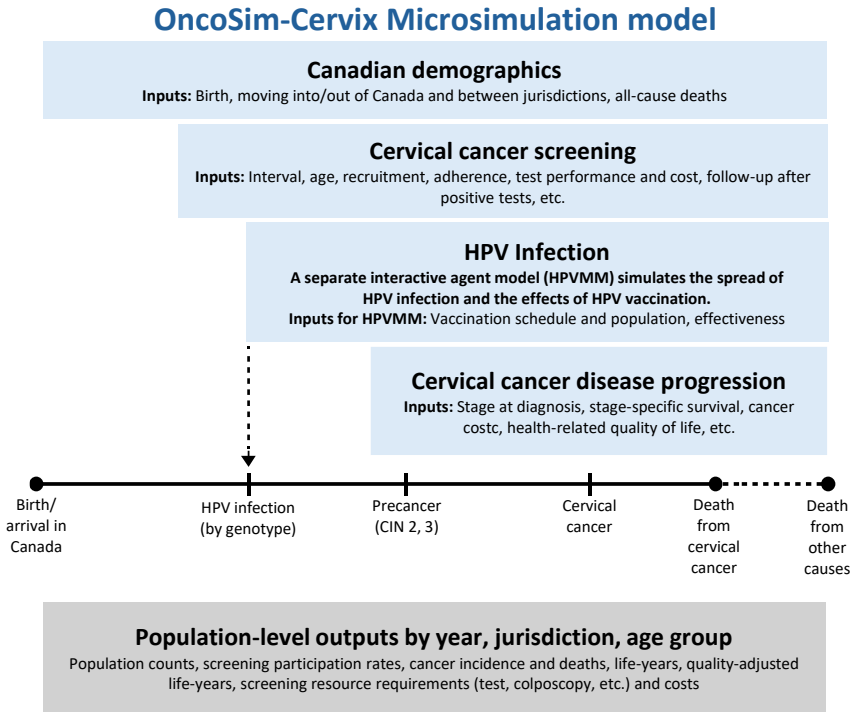
HPV vaccination and cervical cancer screening

The carcinogenicity of HPV has been recognized for many years[14] and the cervical carcinogenic risk varies by HPV type,[15] with HPV types 16 and 18 having very high risk and high prevalence. HPVMM (version 1.9.2.0) models HPV strains that are classified into six groups, three of which are carcinogenic—16, 18, and other carcinogenic (including strains 31, 33, 45, 52, and 58)—and three that are non-carcinogenic—6, 11, and other non-carcinogenic. HPVMM can also model the impacts of three types of vaccine: bivalent (targeting HPV strains 16 and 18), quadrivalent (additionally targeting HPV strains 6 and 11) and nonavalent (additionally targeting HPV strains 31, 33, 45, 52, and 58). Users can customize the vaccination program by defining the target age, sex, implementation years, participation rate, vaccine type, efficacy, protection duration, prior vaccination status in the target population, and vaccination expenses. In this analysis, vaccination was offered at age 12, with 70% of age-eligible youth receiving vaccination. The quadrivalent vaccine was offered to girls from 2007 to 2017 and to boys in 2016 and 2017; both girls and boys were offered the nonavalent vaccine from 2018 onward.[16] All vaccinated subjects were assumed to receive 100% life-long protection against the HPV strains targeted by the respective vaccine.

OncoSim-Cervix also features a customizable screening program, whereby users can select a primary testing modality (e.g., Pap, HPV test or colposcopy) as well as different follow-up pathways for abnormal results. This analysis focuses on two screening modalities. The first uses primary cytology testing (i.e., Pap test) for cervical cancer screening, where abnormal results are triaged by cytologic grade (Figure 2-A). Any classification above atypical squamous cells of undetermined significance (ASCUS) prompts immediate referral to

Figure 1

Conceptual framework of the Human Papillomavirus Microsimulation Model (HPVMM) and OncoSim-Cervix



Note: HPV - human pappilloma virus, CIN - cervical intraepithlial neoplasia.

Source: Miller et al, J Cancer policy 2015;5:7-13 : https://doi.org/10.1016/j.jcpo.2015.05.001

colposcopy. The second modality uses HPV primary testing with genotyping for cervical cancer screening. Individuals who test positive for HPV undergo reflex cytology, with follow-up triage based on their HPV genotype and cytology results. Those that are positive for HPV strains 16 or 18 are referred directly to colposcopy (Figure 2-B).

Analysis: Rolling out HPV primary testing for cervical cancer screening

Using OncoSim-Cervix version 3.6.3.9, four scenarios were simulated to evaluate the clinical and resource impacts of changing from Pap primary testing to HPV primary testing for cervical cancer screening in Canada.

1. Cytology primary screening every three years in women aged 25 to 69, serving as a representation of the current cervical cancer screening practice in Canada (i.e., status quo scenario).

The other three scenarios evaluated HPV primary testing every five years in the same people with different roll-out strategies:

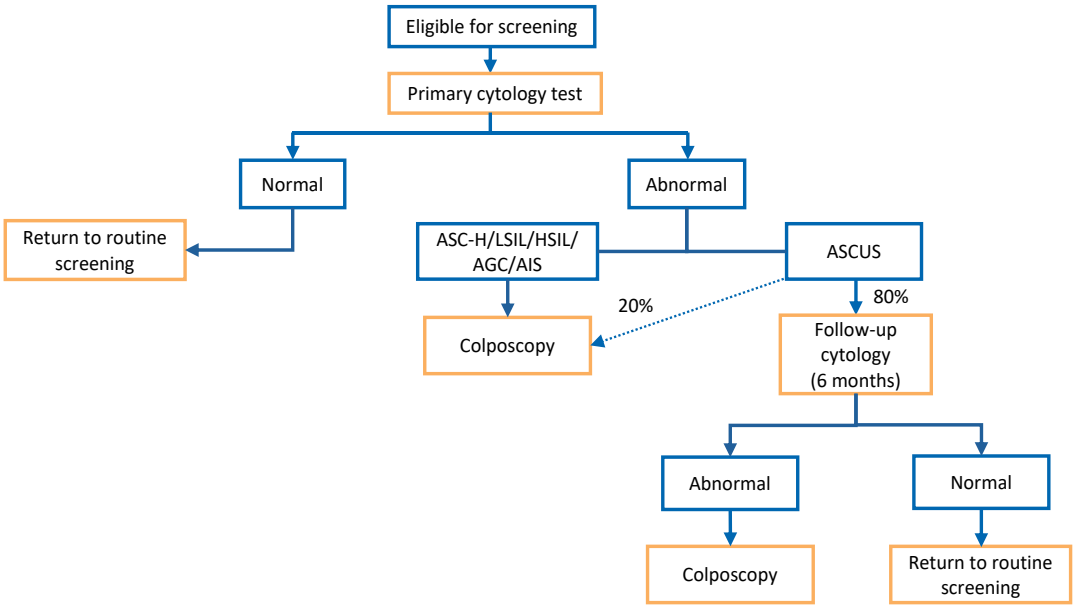
2. A one-time population roll-out of HPV primary screening to all age-eligible people (ages 25 to 69) beginning in 2024.
3. A population-based roll-out over two years (2024 to 2025) to HPV primary screening every five years, with 50% of the age-eligible population attending receiving HPV screening and the other 50% receiving a Pap test in 2024, and all attendees receiving HPV screening in 2025 and thereafter.
4. An age-based roll-out over a three-year (2024 to 2026) timeframe. HPV primary screening is given to individuals aged 50 to 69 in 2024, and to those aged 40 to 69 years in 2025, and finally to all aged 25 to 69 in 2026 and thereafter. During the roll-out timeframe, Pap testing is done for those not offered HPV testing until it is fully implemented. The choice of age groups is based on the risk of cervical cancer and prevalence of HPV infection.[13]

All scenarios were run with 32 million cases. The scenarios simulated the Canadian population over a 26-year period (2024 to 2050), with new individuals added (through birth or immigration) throughout this timeframe, followed by an additional 60-year follow-up of the 2050 population cohort through 2110, for a total 86-year observation period. After 2050, no new individuals were added to the simulated population, and the existing population aged without replacement. Screening interventions were assumed to continue when implemented for those aged 25 to 69, with individuals aging out of screening eligibility at age 70 but continuing to be followed for cancer outcomes throughout the simulation period. Because of this population structure, results after 2050 represent outcomes for the 2050 population cohort only, with progressively older age distributions in later years of the simulation.

Key assumptions in the scenarios are as follows:

- HPV vaccination rate of 70% in Canadians females born after 1995 and over age 12 and in Canadian males born after 2004 and over age 12[16]

Figure 2-A
Schematic diagram of primary cytology testing



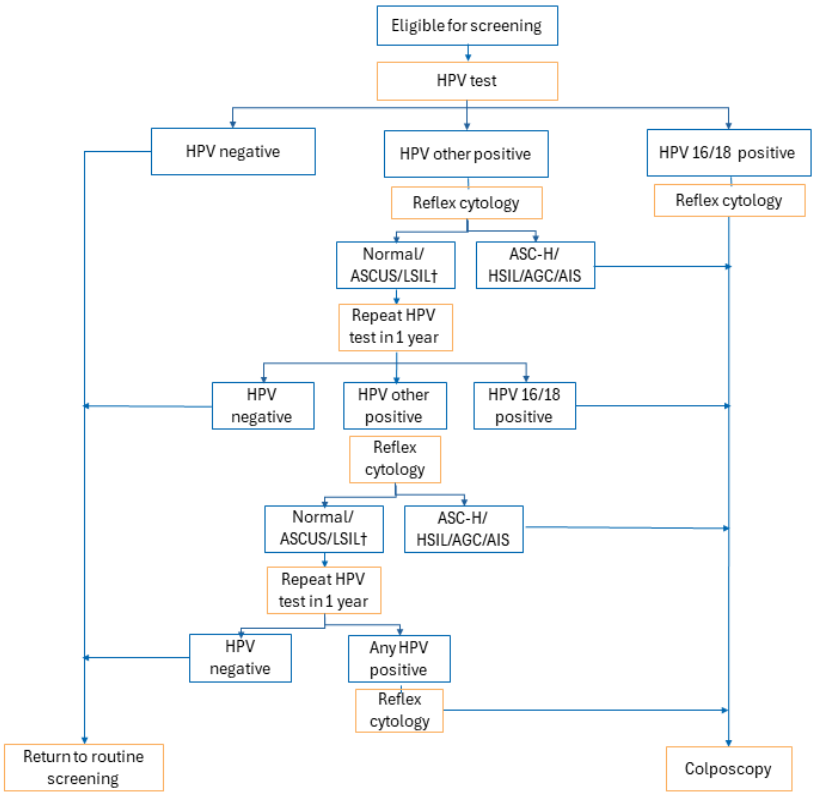
Notes: ASCUS = Atypical squamous cells of undetermined significance; ASC-H = Atypical squamous cells, maybe high-grade lesion; LSIL = Low grade squamous intra-epithelial lesion; HSIL = High grade squamous intra-epithelial lesion; ACG = Atypical glandular cells; AIS = Adenocarcinoma in situ.
Source: Cervical screening in Canada, 2023-24. https://www.partnershipagainstcancer.ca/topics/cervical-screening-canada-2023-2024

- Screening participation rate (the proportion of those who are age-eligible attending screening in a window of length equal to the screening interval) of 70% (assumed unchanged for three- and five-year screening intervals) to match Canadian screening data[17]
- a cytology test sensitivity of 40% with a base colposcopy rate of 3%[17,18]
- an HPV positivity rate of 8% (2% HPV 16/18+; 6% HPV other) in the screening age population prior to the use of vaccination.[19]

Table 1 contains values of screening parameters used in the simulations.

The system impact and resource use of implementing HPV primary testing using different roll-out strategies were compared to status quo Pap testing. For workload indicators, analyses focused on primary and follow-up screen counts, and colposcopy referrals over a 10-year projection period (i.e., 2024 to 2033) because this timeframe is more relevant for the planning of service provision. For clinical outcomes and effectiveness, analyses examined lesion detection, cervical cancer incidence and deaths. Regarding lesions, this study focused on CIN2+ detection (i.e., Cervical intraepithelial neoplasia grade 2 or higher). For clinical outcomes, a longer projection period is required because of the lag between intervention and outcomes: a 20-year projection period (i.e., 2024 to 2043) was chosen for CIN2+, and an 85-year projection period (i.e., 2024 to 2110) for cervical cancer incidence and death from cervical cancer.

Figure 2-B
Schematic diagram of HPV primary testing



† Individuals who are under screened or never screened may be at high risk for immediate CIN2+ and therefore may warrant immediate referral to colposcopy.

Notes: HPV=human papillomavirus; ASCUS = Atypical squamous cells of undetermined significance; LSIL = Low grade squamous intra-epithelial lesion; ASC-H = Atypical squamous cells, maybe high-grade lesion; HSIL = High grade squamous intra-epithelial lesion; ACG = Atypical glandular cells; AIS = Adenocarcinoma in situ; CIN2+ = cervical intraepithelial neoplasia grade 2 or higher.

Source: Cervical screening in Canada, 2023-24. https://www.partnershipagainstcancer.ca/topics/cervical-screening-canada-2023-2024

Table 1
Screening parameters used in simulations by screening scenario

Scenario description[1]	Recruitment to screening	Rescreening among screeners	Compliance with follow-up Pap test	Compliance with follow-up HPV testing	Compliance with follow-up colposcopy
			percent		
Status quo: Women of eligible ages (25 to 69) receive a Pap test every 3 years					
Base participation	90	86	80	...	80
One-time roll-out: Starting in 2024, all women of eligible ages (25 to 69) receive screening with HPV test every 5 years					
Base participation	90	86	100	80	80
Increased participation	90	91	100	80	80
Population-based roll-out over two years: (1) In 2024, 50% of women of eligible ages (25 to 69) receive screening with HPV test (to be re-screened every 5 years), and the remaining 50% receive screening with Pap test (to be re-screened every 3 years); (2) In 2025 and moving forward, all women of eligible ages (25 to 69) receive screening with HPV test (to be re-screened every 5 years)					
Base participation	90	86	100	80	80
Increased participation	90	91	100	80	80
Age-based roll-out over three years: (1) In 2024, women aged 50 to 69 receive screening with HPV test (to be re-screened every 5 years); women aged 25 to 49 receive screening with Pap test (to be re-screened every 3 years); (2) In 2025, women aged 40 to 69 receive screening with HPV test (to be re-screened every 5 years); women aged 25 to 39 receive screening with Pap test (to be re-screened every 3 years); (3) In 2026 and moving forward, all women aged 25 to 69 receive screening with HPV test (to be re-screened every 5 years)					
Base participation	90	86	100	80	80
Increased participation	90	91	100	80	80

... not applicable

1. All scenarios share a common vaccination scenario: (a) starting in 2007, 12-year-old females were offered HPV vaccination (12-year-old males were offered vaccination starting in 2016); (b) the quadrivalent vaccine was offered from 2007 to 2017, and the nonavalent vaccine was offered starting in 2018; (c) 70% of age-eligible youth were vaccinated; (d) the vaccine is 100% effective against HPV strains it targets; and (e) the vaccine has no waning effect over time.

Notes: HPV = human papillomavirus.

Source: Base participation rate parameters for Pap testing were selected to replicate reported participation in Canada. Base participation parameters were assumed unchanged for HPV testing. Increased participation parameters assumed a 5% increase in rescreening over base.
https://www.partnershipagainstcancer.ca/topics/cervical-cancer-screening-in-canada-2021-2022/programs/guidelines/#:~:text=Cervical%20cancer%20screening%20in%20Canada%3A%202021%2F2022,-Summary&text=The%20Canadian%20Task%20Force%20on,25%20to%20reflect%20these%20guidelines

Results

Resource impact

Switching from cytology primary testing every three years to HPV primary testing every five years was projected to reduce the number of primary screens in the population, irrespective of how the transition is carried out (Chart 1). Over a 10-year period, Pap testing results in about 3 million primary screens, while HPV testing requires around 2 million, easing the demand on human and screening resources.

The analysis projects an initial surge in colposcopies in the years following the switch to HPV primary testing every five years (Chart 2), followed by a long-term decreasing trend. The magnitude of the surge hinges on the roll-out strategy. A one-time roll-out was found to lead to a 60% peak increase in annual colposcopy referrals within one year (in 2024), while a population-based approach phased in over two years was found to reduce the peak to a 40% rise (Chart 2). An age-based approach over three years was also found to reduce the peak to a 35% increase, relative to Pap testing every three years, and delays the peak until 2026 (Chart 2). Implementing a staged roll-out not only results in smaller peaks but also smaller troughs in colposcopy demand. The effects of different screening scenarios on colposcopy demand are superimposed on a declining trend associated with ongoing HPV vaccination and increasing population prevalence of vaccination.

Clinical outcomes

Transitioning from cytology testing every three years to HPV primary testing every five years is projected to improve clinical outcomes by detecting more precancerous lesions (e.g., CIN2+), thus reducing the incidence of cancer and related deaths (Chart 3). These improvements in clinical outcomes with HPV primary testing are of similar magnitude, regardless of the roll-out strategy (one-time, age-based, or population-based). There was virtually no difference in the effect of roll-out strategy on the number of cervical cancer cases or deaths, which resulted from the long period (86 years) of the projection and

the comparatively small difference in the time to full implementation of the different strategies. Roll-out strategy had a larger effect on projected increases in CIN2+ detection, up to a 12% relative difference, because of the lower projection interval (20 years).

Potential impact of self-sampling

Switching to HPV primary testing for cervical cancer screening could enable self-testing, which has high acceptability[7] and will potentially increase population participation rates. To evaluate this potential impact of HPV self-testing or other increases in screening uptake with a switch to HPV, an analysis was conducted (increased participation), assuming that the parameter controlling rescreen probability among those participating in screening was increased from 86% to 91% (see Table 1). Table 2 provides summary results of the effect of increased participation on screening volumes, peak colposcopy referral, CIN2+ detection cases, and deaths from cervical cancer averted using the same projection periods as used for earlier analyses. As anticipated, all these measures increased.

Discussion

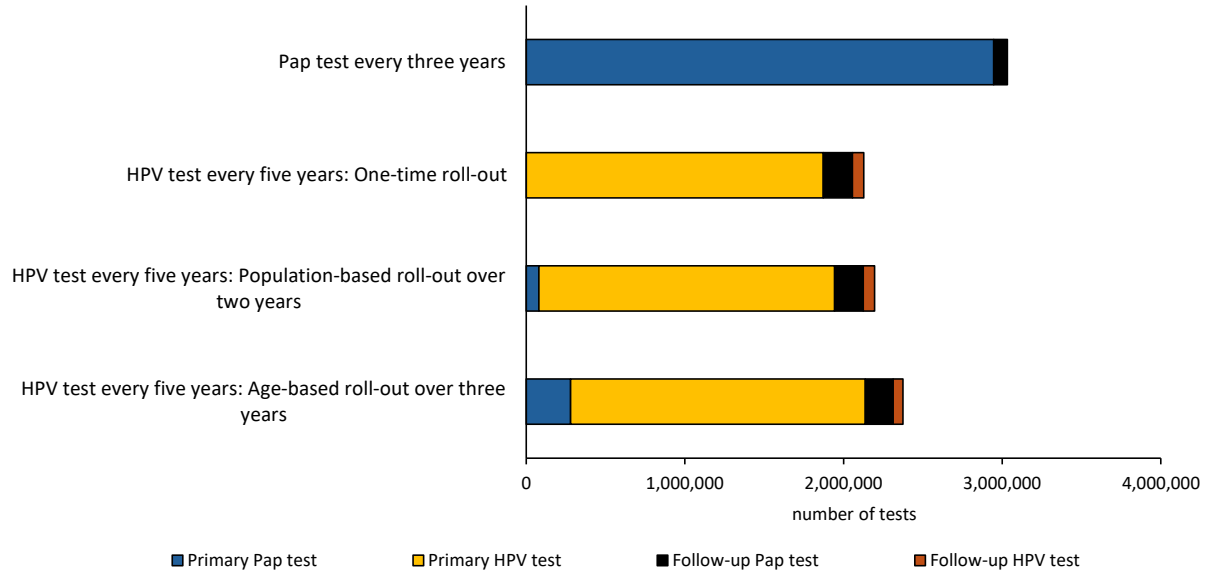
Findings

Switching from Pap primary screening every three years to HPV primary screening every five years was projected to provide significant benefits, including earlier detection of cervical cancer precursors, reduced future cervical cancer and mortality, and reduced lifetime screening requirements. Modelling, such as with OncoSim, can play a crucial role in informing the roll-out of HPV testing by allowing programs to explore different implementation strategies and understand their impact on resources and clinical outcomes. While this study focused on evaluating roll-out options, like phased implementation by age group or population volume, modelling could also explore variations in follow-up pathways for abnormal results or the introduction of self-testing options. For programs concerned about resource strain, particularly regarding colposcopy demand, this study demonstrates that certain roll-out approaches can mitigate these demands while preserving the clinical benefits of HPV-based screening. Colposcopy is an outpatient procedure, and the provision of the service is primarily dependent upon the availability of suitably qualified and experienced practitioners. The elasticity of supply is likely to vary by region—some areas may have difficulty providing increased services associated with the initial transition to HPV-based screening. If wait times for colposcopy increase because of a lack of resources, this may undermine improvements in clinical outcomes associated with a transition to HPV-based screening.

When comparing the one-time roll-out with age-based or population-based strategies, the projections reveal that one-time implementation results in a peak increase in colposcopy referrals of 60% within one to two years after the switch, relative to cytology testing. By contrast, age-based and

Chart 1

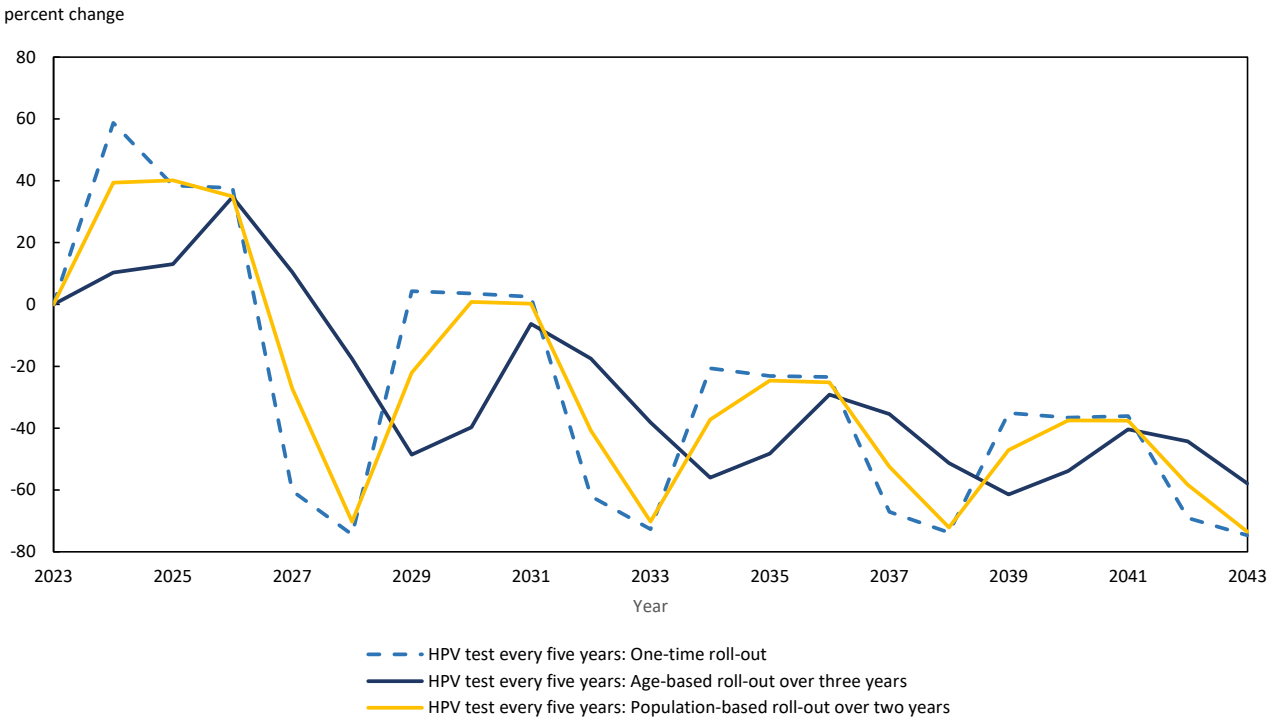
Projected average annual primary and follow-up screening counts in Canada, 2024 to 2033



Note: HPV = human papillomavirus.

Source: OncoSim-Cervix (version 3.6.3.9) simulated results.

Chart 2
Percent change in colposcopy referrals compared with Pap testing every three years, 2023 to 2043



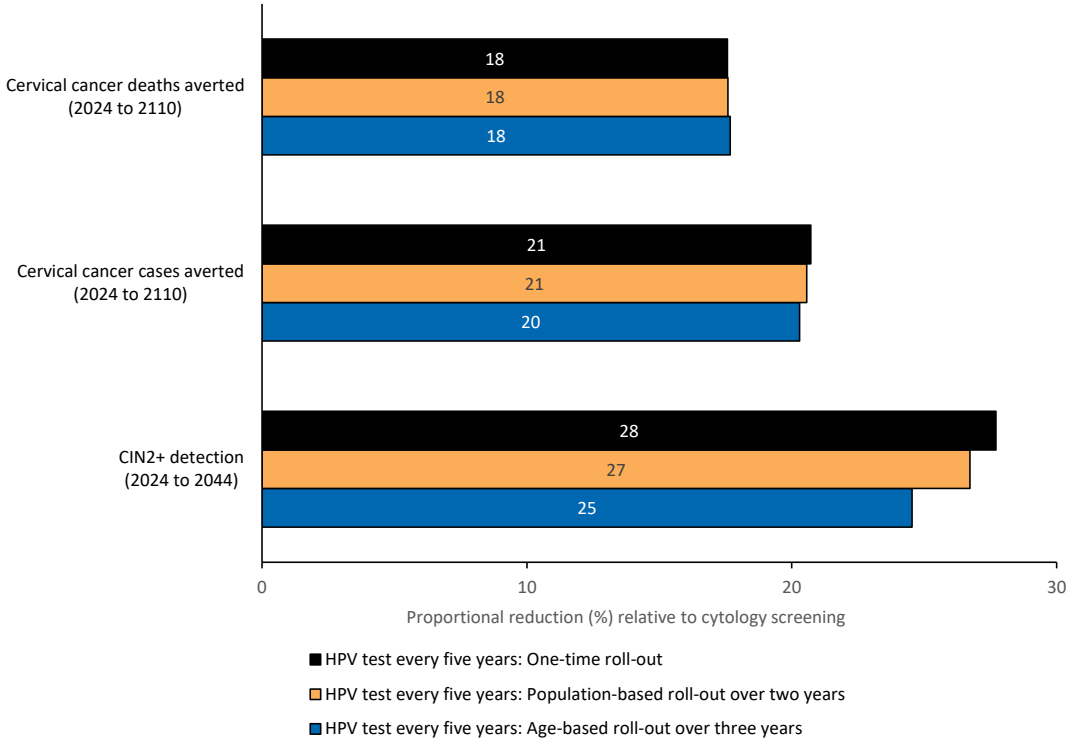
Note: HPV = human papillomavirus.
Source: OncoSim-Cervix (version 3.6.3.9) simulated results.

population-based roll-out strategies exhibit significantly smaller peaks—40% for a two-year population-based roll-out, and 35% for a three year age-based roll-out, relative to cytology testing. These peaks occur later than in the one-time roll-out scenario. The population-based and age-based approaches appear to distribute the initial surge in colposcopy demand more evenly over time, potentially easing the transition to HPV screening for health care providers. It can be anticipated that variation in time between consecutive screens seen in the general population will mitigate the projected troughs and peaks seen in colposcopy demand after the initial implementation period. These findings emphasize that implementing any roll-out strategy for HPV testing is preferable to inaction because all approaches yield similar long-term clinical benefits (e.g., cervical cancers detected, cervical cancer deaths prevented). For programs concerned about short-term surges in resource demand, modelling can serve as a valuable tool to explore tailored strategies that align with available capacity.

Published literature demonstrates that HPV testing offers significantly higher sensitivity, compared with cytology, enabling it to detect abnormal results more effectively. However, its lower specificity leads to reduced precision in distinguishing the severity of lesions.[20,21] Previous studies that compare the results of HPV screening with cytology screening have shown that both the algorithm used for cytology screening and that used for HPV screening will impact the rate of referral for colposcopy.[22] The cytology screening algorithm used in this study (Figure 2-A) is not used throughout Canada, with the management of low-risk cytology findings varying between jurisdictions. Similarly, the HPV screening algorithm assumed in this study (Figure 2-B) may not be adopted in all Canadian jurisdictions, and differs from that used in the FOCAL randomized control trial conducted in Canada.[22] Similarly, HPV inclusive screening algorithms evaluated in a recent CISNET modelling analysis in support of the United States Preventive Services Task Force used a variety of different algorithms.[9]

When comparing the analysis results performed using OncoSim-Cervix with results from an analysis using the CISNET Cervical models, both sets of analyses projected benefits regarding the switch from cytology to HPV testing for primary cervical cancer screening.[23] Detailed comparisons between CISNET and OncoSim results are difficult because of differing assumptions, scenarios, and contexts. Despite these differences, four CISNET models predict superior performance of five-year HPV screening, compared with triennial cytology.[9] Another analysis using the OncoSim model,[24] which focused on the elimination of cervical cancer in British Columbia, found

Chart 3
Clinical outcomes compared with Pap testing every three years



Note: HPV = human papilloma virus, CIN = cervical intraepthelial neoplasia.
Source: OncoSim-Cervix (version 3.6.3.9) simulated results.

qualitatively similar results to those presented here, although declines in disease and peak increases in colposcopy were greater in that other study because of higher assumed rates of compliance to screening and recommended follow-up.

The OncoSim-Cervix analysis projections presented here suggest that implementing HPV testing every five years, whether through one-time or phased roll-out strategies, improved clinical outcomes by increasing the detection of high-grade precancerous lesions, and reducing cervical cancer incidence and mortality. Similarly, the CISNET Cervical analysis projected that HPV-based screening could lower cervical cancer rates by enabling earlier detection of persistent HPV infections, which are more likely to progress to cancer.[23] Both sets of analyses identified a temporary increase in colposcopy referrals following the switch to HPV screening because of its higher sensitivity, though phased roll-outs in the OncoSim-Cervix analysis helped mitigate these peaks more effectively. The consistency across both models reinforces the conclusion that HPV testing is a viable and effective alternative to cytology, particularly when strategic roll-out approaches are used to manage health care system impacts.

Strengths and limitations

This study has several strengths worth noting. The study uses the OncoSim model, which was specifically developed to simulate cancer risk and management in Canada and was developed using published literature and Canadian data with input from multiple stakeholders. This is one of the few Canadian studies to simulate the resource and clinical impact of switching to HPV testing for cervical cancer, which is highly relevant to current policy initiatives such as the Action Plan for the Elimination of Cervical Cancer.[2] The study addresses both short-term and long-term implications, offering practical recommendations for policy makers and health care planners. Additionally, the inclusion of projections that anticipate increases in participation associated with HPV self-testing highlights OncoSim's ability to adapt analyses for local contexts and to test the impact of varying assumptions on outcomes. This flexibility in modifying assumptions and inputs makes OncoSim a versatile and valuable tool for strategic health care planning.

Table 2
Sensitivity analysis of increasing screening participation in human papillomavirus testing

HPV testing every five years /Scenario	Average annual primary screening count (2024 to 2033)	Percent increase[1]			
		Peak colposcopy referral	CIN2+ detection (2024 to 2044)	Cervical cancer cases averted (2024 to 2110)	Cervical cancer deaths averted (2024 to 2110)
	million	percentage			
Base case					
One-time roll-out	1.9	60	28	21	18
Population-based roll-out over two years	1.9	40	27	21	18
Age-based roll-out over three years	2.1	35	25	20	18
Increased participation					
One-time roll-out	2.2	80	43	35	33
Population-based roll-out over two years	2.3	60	42	35	33
Age-based roll-out over three years	2.4	55	38	34	32

1. Represents the difference between the status quo (Pap testing scenario) and the HPV testing scenario.
Notes: HPV = human papillomavirus: CIN2+ = cervical intraepithelial neoplasia grade 2 or higher.
Source: OncoSim-Cervix 3.6.3.9 version simulated results.

A primary limitation of this study is the reliance on a model-based approach to project health care resource demands and clinical outcomes, which depends on the quality of input data and underlying assumptions. Although these projections aim to support scenario planning, uncertainty grows over time, and precise forecasting is inherently challenging—a limitation common to all projection modelling. The present analysis does not limit resource availability (i.e., all colposcopy referrals can be addressed), thereby ignoring real-world resource constraints that can delay follow-up testing and subsequently impact clinical outcomes. Additionally, the present analyses assumed strict adherence to screening schedules, which may not capture the variability in adherence observed in real-world settings. Lastly, this analysis does not address disparities in health care access or regional variations in screening policies, such as differences in screening start and end ages or intervals, which may influence pan-Canadian outcomes. Future research could address these gaps by focusing on underserved populations and exploring alternative screening policies.

Conclusion

Switching from cytology primary screening every three years to HPV primary screening every five years increases colposcopy referrals over the short term but decreases them over time. Different roll-out strategies impact the colposcopy surge, yet all HPV testing scenarios offer superior clinical outcomes, compared with Pap screening every three years, with minimal variation. Modelling could help programs explore options for managing the initial surge in colposcopy volume or other planning concerns.

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