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Research

Cost-effectiveness modelling of birth and infant dose vaccination against hepatitis B virus in Ontario from 2020 to 2050

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Abstract

Background: The World Health Organization recommends universal birth dose vaccination for hepatitis B virus (HBV), yet only 3 provinces and territories in Canada provide birth dose vaccination, and Canadian-born children in Ontario are acquiring HBV before adolescent vaccination. We sought to determine whether birth and/or infant HBV vaccination is cost-effective.

Methods: We used a dynamic HBV model that incorporates population by year, disease stage, sex and the influence of immigration to quantify the disease and economic burden of chronic HBV infection in Ontario from 2020 to 2050. We compared 4 vaccination scenarios, which included a birth dose vaccine and variations of the 2 subsequent doses (either alone or as a part of the hexavalent vaccine) and a hexavalent-only strategy in infancy with the current adolescent vaccination strategy. Our costing estimates were based on values from 2020.

Results: All 4 infant vaccination approaches prevented an additional 550–560 acute and 160 chronic pediatric HBV infections from 2020 to 2050 compared with adolescent vaccination. Whereas birth dose could be cost-effective, incorporating vaccination into a hexavalent vaccine was cost saving. By 2050, the hexavalent approach led to $428 000 in cost savings per disability-adjusted life years averted.

Interpretation: At the current prevalence in Ontario, a switch to birth dose or infant dose will be cost-effective or even cost saving. Introducing any form of infant HBV immunization in Ontario will prevent acute and chronic pediatric HBV infections.

In Ontario, hepatitis B virus (HBV) ranks fourth on the list of infectious diseases with the greatest burden of illness by years of life lost,[1] and can lead to cirrhosis and liver failure or hepatocellular carcinoma. Infants who acquire HBV have a more than 90% risk of progression to chronic infection.[2] The World Health Organization (WHO) has prioritized birth dose vaccination for HBV as a key tenet of the strategy for HBV elimination. Vaccination within 24 hours of birth and 2 additional infant doses is more than 90% effective at preventing transmission and has decreased global prevalence from 5% to 1% in children under 5 years of age.[2] However, even after 30 years and adoption among more than 100 countries (including the United States, United Kingdom and Australia),[3] only 3 provinces and territories in Canada provide birth dose vaccination: 5 vaccinate in infancy and 5 in adolescence, including in Ontario.[4] It is hypothesized that the rationale for adolescent vaccination is based on 4 assumptions: all pregnant women are screened, all infants born to mothers who are positive for HBV receive postexposure immunization, sexual contact is the only other risk factor, and immunity from birth and infant vaccination wanes.[5]

The National Advisory Committee on Immunization has proposed that each province must monitor for inadequate prenatal screening and preventable pediatric infections.[5] At present, Ontario does not have a centralized database to show that all children born to a mother who is positive for HBV receive birth doses and 2 subsequent doses, in addition to hepatitis B immune

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globulin (HBIg). Our previous research showed that children born in Canada who live in Ontario are acquiring HBV before age 12 (6 cases per 1000); and these infections would likely be prevented with universal birth dose vaccination. This number reflects only diagnosed infections among children, but most children are never tested, making this an underestimate of pediatric infections acquired in Ontario.[6] Children may have been infected through vertical transmission when prenatal screening was missed, or horizontal transmission from contacts who may not have been aware of their infection. Prevalence of HBV is particularly high among newcomers to Canada from HBV-endemic regions.[7–9] Although children should be vaccinated at birth if a household contact or caregiver is known to carry HBV, a high proportion of those living with HBV have not been diagnosed because HBV is largely asymptomatic and not part of the routine Canadian immigration medical examination.[10,11] Several long-term follow-up studies in Asia have reported that people who received birth dose HBV vaccination had similar infection rates as those who were vaccinated in adolescence.[12–14]

We used the PRoGReSs model,[1] a dynamic HBV model that incorporates population by year, disease stage, sex and the influence of immigration. We compared vaccination timing based on direct and health outcomes to determine which approaches would be cost-effective compared with current adolescent vaccination from 2020 to 2050.

Methods

Study design and setting

To consider the cost and public health implications of a policy change in Ontario, the PRoGReSs model was used. The model has been shown to predict the impact of immunization on both reduced disease transmission and overall disease burden reliably,[15] with results from this model previously validated using longitudinal age-specific prevalence of hepatitis B surface antigen (HBsAg) in 3 countries (US, Iran and China).[16] This model has received feedback from experts in 94 countries, has aided in national elimination planning around the world and has not only been peer reviewed in multiple publications but also underwent annual reviews by other modelling groups while part of the Vaccine Impact Modelling Consortium.[15–22] We based our model inputs on literature review, administrative data, institutional internal data and expert consensus (Appendix 1, Supplementary Table 1S, available at www.cmajopen.ca/content/11/1/E24/suppl/DC1). We entered Ontario population,[23] mortality and historical data in the Ontario HBV disease burden and transmission model (PRoGReSs model), including prevalence of HBsAg by age and sex, HBeAg prevalence and rate of high viral load among women of child-bearing potential, HBIg and birth dose for infants born to mothers who were positive for HBV, the annual number of HBV-related liver transplants, and treatment and diagnosis rates (Appendix 1, Supplementary Methods).[16] We used the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) checklist for reporting economic evaluations of health interventions.[24]

The HBV PRoGReSs model is a dynamic Markov disease burden and transmission model that tracks the distribution of the prevalence of HBsAg by sex, age (1-yr age cohorts), year (1950–2050), disease stage (acute, chronic, cirrhosis, decompensated cirrhosis, hepatocellular carcinoma and death) and viral load (categorical) and accounts for background mortality, disease progression rates, spontaneous viral clearance and fulminant hepatitis[16] (Appendix 1, Figure 1S, Figure 2S). Disease transmission was calculated both horizontally and vertically (by vertical transmission rates). We used data from Statistics Canada[23] and the United Nation's Department of Economic and Social Affairs, Population Division[25] for annual estimates of background population and mortality by sex and 1-year age cohort from 1950 to 2050. We applied epidemiologic estimates for HBV (Table 1) to the background Ontario population.

We assumed a male-to-female ratio of 1.38,[6,8,26] considered the impact of immigration and adjusted for reported prevalence of HBsAg and hepatitis B e antigen (HBeAg) among women who were pregnant,[6] including the proportion with high viral load (≥ 20 000 IU/mL),[27] we estimated the HBsAg prevalence in Ontario at 0.80% in 2017 (Table 2). In that year, there were an estimated 39 623 previously diagnosed cases and 1878 newly diagnosed cases.[26,28] In 2016, the population treated with antivirals was estimated at 11 600 patients and an estimated 25 HBV-related liver transplants were performed in Ontario (Table 2).

We included the impact of diagnostics, treatment and immunization on disease and economic burden in our modelling. Ontario introduced universal adolescent vaccination in 1997,[29] and immunization coverage data for Ontario were either directly available from Public Health Ontario or were linearly extrapolated (Appendix 1, Supplementary Table 2S). For infants born to mothers who were positive for HBsAg, 93.7%[6] received birth dose coverage within the first 24 hours of life, 3-dose coverage and HBIg coverage based on current comprehensive immunization programs.[29] Thirty-eight percent of eligible women received antiviral treatment during their third trimester.[6]

We assessed the HBV disease burden and economic impacts under 5 scenarios. We modelled a base scenario and 4 general population vaccination strategies from 2020 to 2050 under the following conditions (Table 2): current 2-dose adolescent vaccination used in Ontario (base case; scenario 1); birth dose vaccination and individual vaccinations at 1 and 6 months (3 separate vaccines; scenario 2); birth dose vaccination, vaccination at 1 month and a hexavalent 6-month vaccination (DTaP-HB-IPV-Hib; scenario 3) (the recommended WHO schedule with the third dose as a part of the hexavalent); birth dose vaccination, with hexavalent doses at 2 and 6 months (scenario 4); and hexavalent vaccination at 2, 4 and 6 months (currently used in other provinces; scenario 5). Scenario details and a description of the calculation of uncertainty are described in Appendix 1, Supplementary Methods IV and V.

Statistical analysis

We applied cost data to disease burden outcomes to determine the economic impact of each scenario. Direct costs included those for health care, screening, immunization, diagnosis and

Table 1: Model parameters: disease and economic inputs for Ontario

Parameter	Year	Value	Source	Low	High
Disease burden input					
HBsAg+ prevalence	2017	0.80 (determined)		0.29%	1.6%
HBsAg+ prevalence (male:female)	2017	1.38	Kwong et al. 2017[1]	–	–
HBeAg+ among HBsAg+ women of child-bearing age	2012–2016	18.9	WHO 2022[2]	9.1%	24.0%
Viral load ≥ 20 000 UI/mL among people who are HBeAg+	2002–2008	90	WHO 2021[3]	–	–
Viral load ≥ 20 000 UI/mL among people who are HBeAg–	2002–2008	13	WHO 2021[3]	–	–
Total diagnosed	2003–2013	39 623*		–	–
Newly diagnosed	2017	1878	Kwong et al. 2017[1]	–	–
Total treated	2018	6520†	Kwong et al. 2017,[1] PHAC 2022[4]	–	–
Annual liver transplants	2016	264‡		–	–
Liver transplants due to HBV	2016	9.3‡		–	–
HBV vaccination timely birth and 3-dose coverage rates for infants born to HBsAg+ mothers	2016	93.7*	NACI 2021[5]	–	–
HBIg coverage rate for infants born to HBsAg+ mothers who also received timely birth dose	2016	93.7*		–	–
Economic input					
Disability weight					
Decompensated cirrhosis	2020	0.178	Biondi et al. 2020[6]	–	–
HCC	2020	0.466	Biondi et al. 2020[6]	–	–
Liver transplant	2020	0.024	Biondi et al. 2020[6]	–	–
Value of a statistical life-year, 2020 Can$					
GDP per capita	2020	62 138	Coffin et al. 2019[7]	–	–
Screening and laboratory cost per test, 2020 Can$					
HBsAg	2020	10.25§			
HBeAg	2020	10.25§			
Viral load testing	2020	100.00*			
ALT testing	2020	10.00§			
CBC/creatinine/bilirubin	2020	29.00§			
Abdominal ultrasonography	2020	135.9¶	Statistics Canada 2017[8]	68.39	271.8
HBV treatment and prophylaxis cost, 2020 Can$					
Treatment (annual)	2020	5770	Wong et al. 2013[9]	3509	8031
HBV vaccination (children)	2020	11.16*		10.92	11.40
HBV vaccination (adult)	2020	7.44*		7.28	7.60
HBIg	2020	287	Lapointe-Shaw 2021[10]	230	344
Annual health state cost, 2020 Can$					
Chronic HBV	2020	1150	Health Management Branch 2009[11]	1048	1341
Compensated cirrhosis	2020	2517	Health Management Branch 2009[11]	2013	3760
Decompensated cirrhosis	2020	15 113	Health Management Branch 2009[11]	11 184	22 059
HCC	2020	17 970	Health Management Branch 2009[11]	14 279	23 134
Liver transplantation	2020	133 346	Health Management Branch 2009[11]	126 969	143 801
After liver transplantation	2020	51 475	Health Management Branch 2009[11]	45 015	62 035

Note: ALT = alanine transaminase, CBC = complete blood cell count, GDP = gross domestic product, HBeAg = hepatitis B e antigen, HBIg = hepatitis B immune globulin, HBsAg = hepatitis B surface antigen, HBV = hepatitis B virus, HCC = hepatocellular carcinoma, NACI = National Advisory Committee on Immunization, WHO = World Health Organization.
*Expert consensus achieved through Delphi process (Appendix 1, Supplementary Table 1S, available at www.cmajopen.ca/content/11/1/E24/suppl/DC1).
†Treatment rate for British Columbia based on internal review from the BC Centre for Disease Control applied to data from Ontario, with adjustment for population and prevalence rate ratio.
‡Unpublished data: internal analysis conducted at London Health Sciences Centre and Toronto General Hospital within hepatology divisions from 2001 to 2017.
§Provincial reimbursement.
¶Cost adjusted based on 67% of the infected population receiving abdominal ultrasonography based on age guidelines (≥ 40 yr for men and ≥ 50 yr for women) and model-estimated proportion of patients in this age range.

Table 2: General population hepatitis B virus immunization intervention scenarios for Ontario

Scenario	Administration	Predicted immunization coverage					
		2021	2022–2023	2024–2050	2021	2022–2023	2024–2050
		Birth dose coverage, %			Three-dose coverage, %		
1. Base (current adolescent schedule)	Two pediatric HBV vaccine doses in grade 7	0	0	0	0	0	0
2. Three individual doses (0, 1 and 6 mo)	Three pediatric HBV vaccine doses in the first year of life	75	90	95	75	90	95
3. Two individual, 1 combined (0, 1 and 6 mo)	Two pediatric HBV vaccine doses, final dose hexavalent vaccine on the same schedule as current pentavalent vaccine	75	90	95	75	90	95
4. One individual, 2 combined (0, 2 and 6 mo)	One dose of pediatric HBV vaccine, 2 doses of hexavalent vaccine on the same schedule as current pentavalent vaccine	75	90	95	75	90	95
5. Three combined (2, 4 and 6 mo)	Three doses of hexavalent vaccine on the same schedule as current pentavalent vaccine	0	0	0	75	90	95

Note: HBV = hepatitis B virus.

treatment. Health care costs by disease stage were reported previously;[30] however, we adjusted these to remove the reported cost of medications for cases classified as chronic HBV (Fibrosis score of F0–F3) and compensated cirrhosis, as the treated population was tracked separately. Costs for HBV medication were reported previously[31] and were adjusted based on the distribution of patients by treatment regimen at the Toronto Centre for Liver Disease from 2010 to 2019. We based indirect costs on the value of a statistical life year (gross domestic product [GDP] per capita = Can$62 138, http://api.worldbank.org/v2/en/country/CAN?downloadformat=csv; Table 2) and disability-adjusted life years [DALYs][32] incurred owing to years of life lost because of premature mortality and years lived with disability (Table 2). All costs were inflated to 2020 Canadian dollars based on the consumer price index for health care,[33] and indirect costs were discounted at a standard 3% rate.[32] We analyzed economic outcomes to 2050 to account for lag time between the implementation of infant immunization on disease burden effects and economic changes.

We used Crystal Ball release 11.1.2.3.500 in our sensitivity analysis to calculate high-level disease burden and economic impact outcomes. We used β-PERT distributions for all uncertainty intervals. We used a Monte Carlo simulation to estimate key drivers of uncertainty for the cost per DALY averted for scenario 5 compared with the base scenario, with input ranges based on published estimates and expert input (Table 1).[16] The key drivers of uncertainty (Figure 1) account for more than 99% of the variation around cost per DALY averted when comparing the hexavalent approach to the adolescent vaccination.

Ethics approval

This study did not include people and did not require ethics approval.

Results

With the current adolescent vaccination strategy, we found that acute HBV infections were projected to decrease from 110 in 2020 to 16 in 2050 (85% decline); this was largely due to an overall decrease in unvaccinated adults because of immunization rates of over 70% in school-based programs in Ontario since 1997. Despite this, 1500 acute and 520 chronic infections (Table 3) would still occur over the 30-year time frame owing to infections in the pediatric population under 12 years of age, new infections in those who either did not receive or were not eligible for adolescent vaccination and imported cases as a result of immigration. In comparison, all infant scenarios prevented 560–570 acute and 160 and chronic cases by 2050 (Table 3). As a result of those already infected in 2020, imported cases and new adult chronic infections, liver-related deaths increased until 2042 when they peaked at 780 deaths, declining thereafter.

We compared both annual costs and cumulative direct costs (2020–2050) between scenarios. For all proposed scenarios, we found that annual direct medical costs were estimated at $142 million (in 2020 Canadian dollars) and were projected to decrease by about 50%. This is partially related to an annual 3% discount rate but would occur owing to a decrease in prevalence with any vaccination strategy. Direct

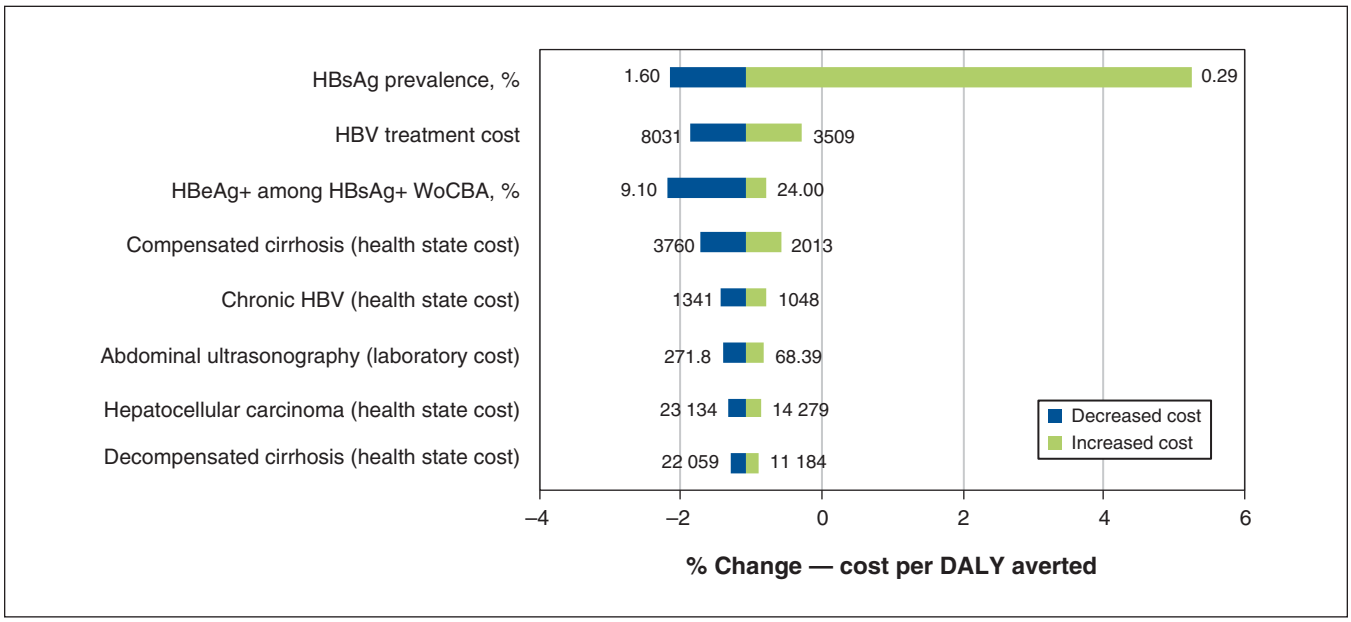

Figure 1: Comparison of key drivers of uncertainty (model inputs) for % change in cost per disability-adjusted life year (DALY) averted for scenario 1 (base) to scenario 5 (vaccines at 2, 4 and 6 mo as a part of the hexavalent approach to adolescent vaccination). Note: HBeAg = hepatitis B e antigen, HBsAg = hepatitis B surface antigen, HBV = hepatitis B virus, WoCBA = women of child-bearing age.

Table 3: Number and impact of acute and chronic cases of hepatitis B virus, by scenario

Scenario	No. of cases of acute HBV	No. of cases of chronic HBV	Cumulative burden 2020–2050			
			Cumulative direct costs, millions of Can$	Cumulative costs averted, millions of Can$	DALYs averted	Cost per DALY averted, Can$
1. Base (current adolescent schedule)	1500	520	3333	–	–	–
2. Three individual doses (0, 1 and 6 mo)	940	360	3424	91	54	1 675 000
3. Two individual, 1 combined (0, 1 and 6 mo)	940	360	3370	62	54	671 000
4. One individual, 2 combined (0, 2 and 6 mo)	940	360	3339	6	54	103 000
5. Three combined (2, 4 and 6 mo)	950	370	3310	–23	54	–428 000

Note: DALY = disability-adjusted life year, HBV = hepatitis B virus.

medical costs for adolescent vaccination over 30 years was $3.333 million (Table 3). These costs decreased depending on the type of alternative vaccination strategy used and in a stepwise fashion depending on whether the HBV vaccine was given as a separate dose or as part of the hexavalent vaccine. For example, for the scenario involving the recommended birth dose schedule and delivery of all 3 as separate vaccines, direct costs increased to $3.424 million, whereas if the hexavalent strategy was included, direct costs were less than adolescent immunization at $3.310 million (Table 3). Annual cost savings peaked in 2022, with savings ranging from $1.3 to $4.4 million.

We found that annual immunization costs were estimated at $2.4 million in 2020 under all scenarios and declined by 65% for adolescent vaccination to $0.91 million in 2050 because of the application of a standard 3% discount rate. Costs were incurred during the 12-year catch-up period (infant and birth plus adolescent) for all scenarios (Figure 2). Annual costs for the 2 strategies that included birth dose and 1-month vaccine dosing had greater costs every year from 2020 to 2050, leading to cumulative immunization costs increasing by up to 160% (from $46 to $119 million). However, the 2 strategies that had at least 2 of 3 vaccine doses as part of the hexavalent immunization had costs below the

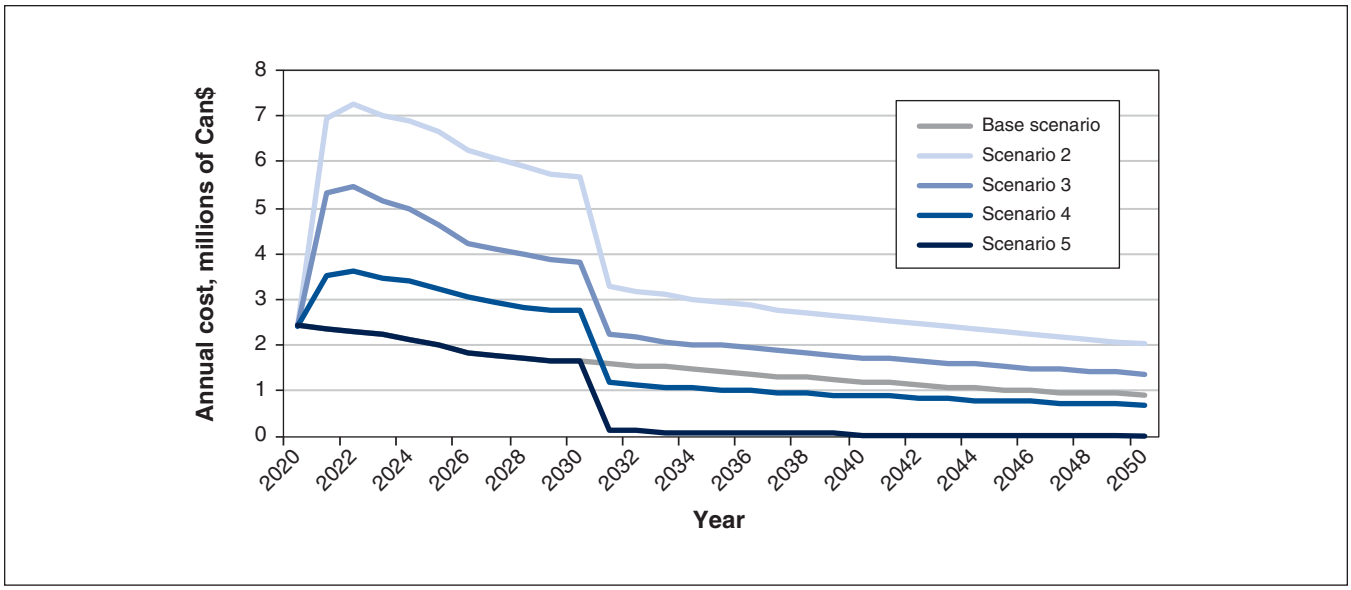

Figure 2: Costs for hepatitis B virus (HBV)–related immunization in Ontario from 2020 to 2050, by scenario.

Table 4: Cumulative costs related to hepatitis B virus in Ontario, by category and scenario (2020–2050)

	Direct cost, millions of Can$						
Scenario	Health care	Treatment and laboratory	Screening	Immunization	Total direct cost	Total indirect cost, millions of Can$	Total costs, millions of Can$
1	2246	932	109	46	3333	15 098	18 431
2	2245	950	111	119	3424	15 098	18 522
3	2245	932	109	83	3370	15 098	18 467
4	2245	932	109	52	3339	15 098	18 436
5	2245	932	109	23	3310	15 098	18 408

current adolescent costs by 2030 (Figure 2). The hexavalent strategy also decreased cumulative costs by 50%, from $46 to $23 million. Cumulative immunization costs represented 1.4% of direct medical costs for adolescent vaccination and between 0.70% (3 hexavalent immunizations) and 3.5% (3 individual doses including birth dose) of costs under the vaccination scenarios.

Indirect costs were based on the value of a statistical life year ($62 138) applied to DALYs incurred by each scenario. Indirect costs accounted for 75% of total (direct and indirect) costs in 2020 ($600 million), peaking at 85% of annual total costs in 2045 under all scenarios. Total indirect and direct costs were $18.431 million for adolescent vaccination, increasing to $18.522 million for 3 individual doses and $18.408 million when using the 3-dose hexavalent approach (Table 4). Total cumulative costs were $62 million higher with 3 individual doses than for adolescent vaccination, whereas 3-dose hexavalent strategy led to cost savings of $23 million by 2050 (Table 3).

We found that about 3% of all DALYs were incurred from years lived with disability, and 97% were incurred owing to years of life lost (liver-related death). In 2020, there were an estimated 9650 annual DALYs incurred owing to HBV, increasing to 11 100 annual DALYs by 2050 with the current adolescent strategy, an increase of 15%. This increase is largely the result of the impacts of the liver-related disability and death for the current chronically infected population, as well as chronic infections among newcomers to Canada between 2020 and 2050. Total cumulative DALYs using adolescent vaccination were estimated at 360 000 during 2020–2050 (Figure 3) and, by 2050, all 4 infant scenarios had averted the same number of DALYs (≥ 54 DALYs) (Table 3). As the model did not use a lifetime horizon, the major contributor to DALYs averted was immunization costs from 2020 to 2050. Cost per DALY incurred ranged from $104 000 to $1.68 million (birth dose plus separate individual vaccines at 1 mo and 6 mo), whereas hexavalent dosing at 2, 4 and 6 months was cost saving at $428 000 per DALY averted (Table 3). We conducted a sensitivity analysis for the cost per DALY averted in the hexavalent approach compared with adolescent vaccination (Appendix 1, Supplementary Methods V). Prevalence of HBsAg, the cost of HBV treatment and the prevalence of HBeAg among women of child-bearing age

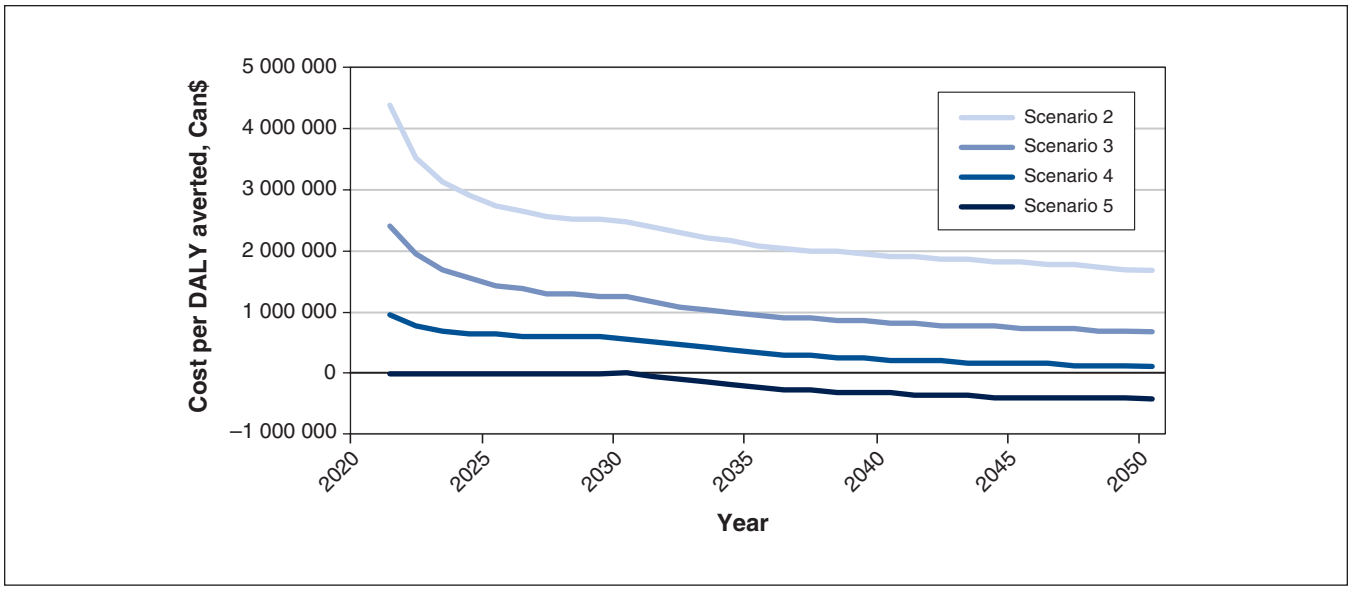

Figure 3: Cost per disability-adjusted life year (DALY) averted in Ontario from 2020 to 2050, by scenario.

who were positive for HBsAg were the key drivers of uncertainty, accounting for 95% of variation (Figure 1). Prevalence alone accounted for more than 80% of observed uncertainty (Appendix 1, Supplementary Material Section III).

Interpretation

In 2020, we reported that there is epidemiologic evidence to reconsider the current adolescent HBV vaccination strategy in Ontario.[6] Herein, we have shown that incorporating infant immunization into our current vaccination schedule would prevent acute and chronic infections. Incorporating immunization into a hexavalent vaccine given at 2, 4 and 6 months could also be cost saving, based on the assumptions made in our modelling.

We evaluated 5 scenarios for HBV vaccination strategies. The impact of immigration, as it relates to immigration to Canada from HBV-endemic countries, was included. Although birth or infant vaccination does not eliminate the impact of imported cases, it could prevent early childhood transmission from caregivers who may have unknown HBV. All vaccination strategies led to an overall decline in chronic cases by 2050. However, switching to any form of birth or infant vaccination would prevent 37% to 38% of acute and 30% to 31% of chronic cases in Ontario by 2050. All models include continuation of HBV screening of pregnant women (about 94%), and universal birth dose and HBIg for children born to mothers known to be HBsAg positive.

To switch from 2-dose adolescent to 3-dose birth or infant vaccination, there would be a 12-year period where vaccination was occurring in both groups to ensure all children were vaccinated. A single birth dose strategy was cost-effective, as the cost per DALY was less than the standard willingness-to-pay threshold of 2 times GDP per capita ($124 000).[34] In this approach, the hexavalent vaccine at 2 and 6 months would replace our current pentavalent strategy that does not include HBV, costing less per year than the adolescent strategy after the 12-year catch-up period (after 2032). However, switching to a hexavalent approach at 2, 4 and 6 months now would not lead to additional immunization costs and thus no additional costs during the catch-up period (Figure 2).

Visits for pediatric immunizations are typically incorporated into well-baby visits in primary care and pediatrics or at local health units, whereas school-based adolescent vaccination requires additional infrastructure. Even in the context of school vaccination programs, adolescent immunization coverage is suboptimal and much lower than infant. The 2017 Childhood National Immunization Coverage Survey (published by the Public Health Agency of Canada in 2019) reported an uptake of other 3-dose infant programs of 90%,[35] whereas HBV adolescent coverage in Ontario in recent years has been as low as 67% (Appendix 1, Table 2S). Furthermore, during the COVID-19 pandemic, school-based vaccination rates were severely disrupted, with low rates of 16.8% and 25% for 2019–2020 and 2020–2021, respectively).[36] Not only would incorporating HBV vaccination into well-baby visits reduce the number of injections children would receive and be cost saving, but this approach would follow the provincial strategy for primary care providers to administer most immunizations in Ontario and increase overall HBV immunization coverage.[37]

There is existing evidence that birth dose or infant immunization reduces both acute and chronic HBV in children; yet adoption varies by province. British Columbia has been immunizing children in infancy for 20 years,[38] and early analysis of the impact of infant vaccination showed benefit.[39] Nunavut, a region with historically high prevalence, has also been providing birth dose and infant vaccination for over 20 years. The first serosurvey results in the postvaccination era were published in 2017 and documented a reduction in the prevalence of hepatitis B core antibody (a marker of exposure) from 19.8% to 1.8%, and a decrease in HBsAg prevalence from 2.5% to 0.3%.[40]

Limitations

We assumed that estimates of HBV prevalence for foreign-born Ontario residents to be similar to the prevalence in their country of origin;[41] however, this assumption may not be accurate in some populations.[42] Our model likely underestimates the cost of disease burden because it does not account for HIV/HBV, HBV/hepatitis C virus and HBV/hepatitis D virus co-infections, all of which can lead to faster disease progression. Although hepatocellular carcinoma can still develop after clearance of HBsAg,[43,44] the current model does not account for the small number of people with chronic infection who clear HBsAg.[45–48] Using a 30-year time horizon, most HBV-related deaths and costs of end-of-life care are not included. A lifetime time horizon would increase benefits without increasing costs, making all strategies more cost-effective. Although we did not evaluate using this model, additional cost savings are likely, including eliminating the logistics, supplies and personnel for the school-based HBV vaccination program; the likely higher cost of adult versus pediatric vaccine doses; and the buying power of Ontario, which could potentially benefit other Canadian jurisdictions that use the hexavalent vaccine.

Conclusion

We have shown previously that children born in Canada and living in Ontario are acquiring HBV before adolescent immunization; a lifelong disease that is completely preventable. Here we show that birth dose vaccination is cost-effective and infant immunization is cost saving. Considering the minimal increase in cost, a shift to birth dose vaccination is necessary to achieve the fewest number of preventable new infections in children. Based on these data, a policy change to include birth dose HBV immunization is needed and should become the standard of care as well as publicly funded.

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