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VACCINE SAFETY: UPTAKE AND HESITANCY

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Canada's National Advisory Committee on Immunization (NACI) in 2025: Celebrating 60 years of service, a decade of change, and a dynamic future ahead

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Abstract

Canada's National Advisory Committee on Immunization (NACI) marked its 60th anniversary in 2024, representing six decades of reliable advice supporting Canada's immunization programs. Over the past decade, NACI expanded its mandate to include ethics, equity, feasibility, acceptability, and economic considerations, while adapting its methods to align with international standards and responding to urgent public health needs such as the COVID-19 pandemic. Enhanced collaboration with provinces, territories, Indigenous partners, and global peers has strengthened both the relevance and reach of NACI guidance. With an expanding vaccine landscape, NACI continues to evolve as a trusted national and global resource supporting equitable, evidence-informed immunization policy and practice in Canada.

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Introduction

Canada's National Advisory Committee on Immunization (NACI) has been providing independent advice on immunization to the Government of Canada since 1964 (1). The committee is aligned with the definition of a National Immunization Technical Advisory Group (NITAG) established by the World Health Organization (WHO). However, as one of the longest standing vaccine advisory committees in the world, NACI significantly predates the global alignment of NITAGs (2). The year 2024 marked the 60th anniversary of NACI. This article, written in celebration of NACI's 60 years of remarkable service in Canada, reviews the past decade, a period marked by many significant developments to the committee's mandate, methods, and outputs during both a pandemic response and routine vaccine programs. It also looks ahead to an increasingly expansive vaccine landscape, new collective challenges and opportunities to enhance individual health and strengthen efficiencies in Canada's national, provincial and territorial health systems.

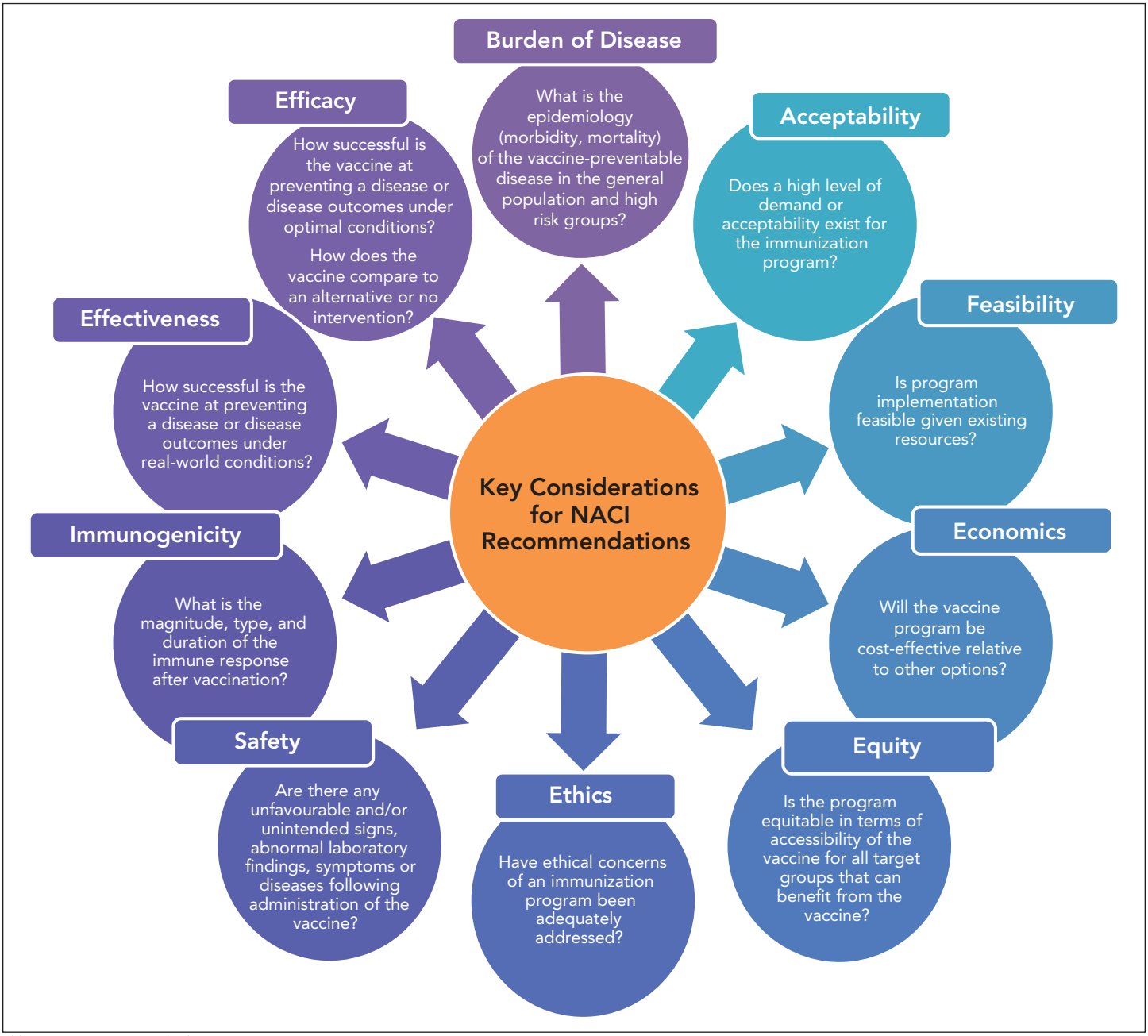
Mandate

The past decade has seen a significant expansion of the NACI mandate, along with several adaptations to reflect the increased complexity of the Canadian immunization program environment. Canada has had a National Immunization Strategy (NIS) in place since 2003 (3). In 2016, the NIS was renewed by the federal government and provincial/territorial Deputy Ministers of Health to include several new objectives, notably, to ensure that "Canadians have timely and

equitable access to immunization," to be accomplished by expanding the mandate of NACI to enhance the timeliness and scope of its recommendations (4). This NIS objective led Dr. Theresa Tam, the Assistant Deputy Minister accountable for NACI at the Public Health Agency of Canada (PHAC) at the time, to announce in 2016 that an expanded mandate for the committee would be developed and fully implemented by 2019. The expanded mandate included five new programmatic factors drawn from the Erickson, De Wals, Farand analytical framework for immunization programs in Canada (5): economics, ethics, equity, feasibility, and acceptability (**Figure 1**).

Prior to 2016, the federal/provincial/territorial Canadian Immunization Committee (CIC) would often publish program assessment statements as part of a two-step process to complement the NACI scientific assessment, but this took several years and could result in delayed decision-making for implementation. Under NACI's expanded mandate, programmatic factors are captured during the assessment of disease burden and vaccine characteristics in order to provide provinces and territories with a more complete package that facilitates timely program implementation decisions. In 2025, under the current model, the CIC (representing the provinces

Figure 1: National Advisory Committee on Immunization Decision Framework



Abbreviation: NACI, National Advisory Committee on Immunization

and territories) is now engaged at three key touchpoints: first when the NACI topic scope is being defined; second, during feasibility assessments in the course of guidance development; and third, in reviewing draft recommendations before they are finalised by NACI.

The NACI Secretariat at PHAC grew since 2016 to support the expanded NACI mandate, including experts in vaccine modelling, health economics, and social sciences. NACI has been very active in providing emergency guidance on vaccines for outbreak responses (including the COVID-19 pandemic, mpox, and measles). Several adaptations were necessary throughout the pandemic to achieve an emergency response model that adapted to the urgency and evolving scientific data during these situations (6).

Ethics, equity, feasibility, acceptability

To implement these new programmatic elements throughout 2016–2019, the NACI Secretariat at PHAC and NACI consulted with CIC to develop evidence-based, peer-reviewed frameworks for assessment and inclusion of ethics, equity, feasibility, and acceptability (EEFA) elements (7). Each programmatic element is addressed by a matrix within the overall EEFA framework. An illustrative example is NACI's use of the equity matrix to identify key populations for prioritization of COVID-19 vaccines (8). In practice, the EEFA framework requires ongoing engagement of provincial and territorial vaccine program experts through CIC. Equity considerations have led to specific recommendations. Tangible examples from NACI's EEFA framework include the prioritization and strong COVID-19 vaccine recommendations for racialized and marginalized populations (2021–present). In 2020, equity considerations also guided early vaccine prioritization for people living with disabilities and for those whose living or working conditions placed them at higher risk of infection with disproportionate consequences (e.g., correctional facilities, agricultural or meat production/packing facilities, congregate living settings, and individuals who are unhoused). Other examples are the inclusion of COVID-19 vaccine for people in or from First Nations, Inuit, and Métis communities (2020–present), strong recommendations for use of respiratory syncytial virus (RSV) prophylaxis for all infants in communities where medical transport can be long and complex (2024–present), and recommendations for pneumococcal conjugate vaccines in adults younger than 65 years of age with risk factors relating to medical conditions or environmental/behavioural factors such as being unhoused (2023–present).

When ethical considerations are particularly complex, NACI has the opportunity to consult the Public Health Ethics Consultative Group (PHECG), an external advisory body to PHAC, for a detailed scenario-based ethical analysis. Throughout the COVID-19 pandemic, NACI consulted PHECG on 13 occasions from 2020 to 2022 on COVID-19 topics, such as extended intervals, population prioritization, boosters, and off-label use in paediatrics. Since then, NACI has continued to benefit from PHECG advice on topics, such as prioritizing doses of mpox vaccine, human papillomavirus (HPV) schedule reductions, and RSV vaccination during pregnancy.

Importantly, NACI continues to issue off-label or expanded use recommendations to improve equity when supported by a public health ethics analysis. This is sometimes accomplished by routine EEFA assessments; in other cases, NACI will request detailed advice from PHECG when the benefits and risks or knowns and unknowns are closely balanced.

Economic evidence

In addition to EEFA programmatic factors, economic evidence was also added into the scope of NACI decision criteria, consistent with practices used by other long-established advisory committees in the United States of America (USA), United Kingdom (UK), Germany, and elsewhere. To support this change, from 2019 to 2023, PHAC and NACI worked with experts to develop two complementary tools: guidelines for the economic evaluation of vaccine programs in Canada (9), aimed at producers of economic evidence, and an interpretation guide (10) to help readers of NACI statements understand the economic evidence summaries.

With the development of these guidelines and processes, NACI began routinely incorporating economic considerations into their guidance. NACI first determines if economic evidence is needed, typically through a prioritization exercise that incorporates input from NACI members and provinces and territories through the CIC (11). Canada does not use a cost-effectiveness threshold for vaccine decisions, and not every NACI statement will include economic evidence (11). For example, several emergency rapid response statements issued by NACI on COVID-19 and mpox did not require economic analyses to support deployment decisions from federal stockpiles. If economic evidence is needed, the approach is tailored based on the specific information required for the recommendation. This may involve conducting a systematic review of economic evaluations (sometimes provided by Canada's Drug Agency, according to PHAC's request and specifications), developing a new model-based economic evaluation, or conducting a multi-model comparison that may include both independent and industry-sponsored models. **Table 1** identifies which NACI statements over the last decade have included health economic evidence, including seven in the most recent year (2024).

After exploring different formats for presenting economic evidence, NACI's current approach involves posting a technical report to a preprint server to document the economic evidence considered during the committee's deliberations, with key findings summarized in the NACI statement. These economic evaluations are often submitted for peer review at a later date and may evolve through that process.

Table 1: Inclusion of economic evidence in National Advisory Committee on Immunization statements, 2014–2024[a]

Year	Statement topic	Statement title	Economic evidence used
2018	Herpes zoster (shingles) vaccine	*Updated recommendations on the use of herpes zoster vaccines*	• Cost-utility analysis
2018	Pneumococcal vaccines	*Update on the use of pneumococcal vaccines in adults 65 years of age and older—A public health perspective*	• Cost-utility analysis
2019	Meningococcal vaccines	*The use of bivalent factor H binding protein meningococcal serogroup B (MenB-fHBP) vaccine for the prevention of meningococcal B disease*	• Review of economic studies
2022	RSV	*Recommended use of palivizumab to reduce complications of respiratory syncytial virus infection*	• Review of economic studies
2023	Pneumococcal vaccines	*Public health level recommendations on the use of pneumococcal vaccines in adults, including the use of 15-valent and 20-valent conjugate vaccines*	• Review of economic studies • Cost-utility analysis • Multi-model comparison
2024	Pneumococcal vaccines	*Recommendations for public health programs on the use of pneumococcal vaccines in children, including the use of 15-valent and 20-valent conjugate vaccines*	• Review of economic studies • Cost-utility analysis
2024	Pneumococcal vaccines	*Statement on the recommendations of the use of pneumococcal vaccines in adults, including PNEU-C-21*	• Review of economic studies • Cost-utility analysis
2024	HPV vaccines	*Updated recommendations on human papillomavirus vaccines*	• Review of economic studies
2024	RSV	*Statement on the prevention of respiratory syncytial virus disease in infants*	• Review of economic studies • Cost-utility analysis
2024	RSV	*Statement on the prevention of respiratory syncytial virus in older adults*	• Review of economic studies • Cost-utility analysis • Multi-model comparison
2024	Influenza vaccines	*Supplemental guidance on influenza vaccination in adults 65+*	• Review of economic studies
2024	COVID-19 vaccines	*Guidance on the use of COVID-19 vaccines during the fall of 2024*	• Cost-utility analysis

Abbreviations: HPV, human papillomavirus; RSV, respiratory syncytial virus
[a] This table includes all NACI statements published between 2014 and 2024 that include formal economic evidence, such as systematic reviews and environmental scans, *de novo* cost-utility analyses, or multi-model comparisons. Statements that include general economic considerations were excluded

Membership

NACI has undergone important changes to membership to reflect the expanded needs of the committee. When EEFA and health economics were added to NACI's mandate, PHAC created new voting member positions for two experts in pharmacoeconomics and one social scientist (medical anthropologist). Furthermore, during the COVID-19 pandemic, NACI selected a geriatrician to join the committee in order to provide perspectives on the increasing number of adult vaccines and formulations designed for older adults. This all resulted in a total membership of 16 (one Chair plus 15 other voting members, including the Vice-Chair).

Liaison organizations to NACI have also been updated over the last decade. NACI now includes liaison representatives from the Indigenous Physicians Association of Canada and the Canadian Indigenous Nurses Association to identify equity considerations and First Nations, Inuit and Métis healthcare perspectives, and from the Canadian Pharmacists Association, given the increasingly important role that pharmacists play in vaccine administration (**List 1**).

In the last ten years, there have been three NACI Chairs: Dr. Caroline Quach-Thanh (2017–2021), Dr. Shelley Deeks (2021–2023), and Dr. Robyn Harrison (2024–2025). All three played significant roles throughout the pandemic as Vice-Chair or Chair, overseeing the development of many COVID-19 updates to address the complex product environment in Canada. **Table 2** shows an updated list of all NACI Chairs since the committee's formation in 1964. With the increased volume of NACI guidance due to public health emergencies and a rapidly expanding vaccine pipeline, together with concerted effort to meet the

List 1: Current liaison organizations to the National Advisory Committee on Immunization

- Association of Medical Microbiology and Infectious Disease Canada
- Canadian Association for Immunization Research and Evaluation
- Canadian Immunization Committee
- Canadian Indigenous Nurses Association
- Canadian Nurses Association
- Canadian Paediatric Society
- Canadian Pharmacists Association
- Canadian Public Health Association
- Centers for Disease Control and Prevention (United States)
- The College of Family Physicians of Canada
- Council of Chief Medical Officers of Health
- Indigenous Physicians Association of Canada
- Society of Obstetricians and Gynaecologists of Canada

Table 2: Chairs of the National Advisory Committee on Immunization

Years	Name
1964–1966	Dr. Andrew Rhodes, Toronto, ON (died February 1995)
1968–1969	Dr. Edward Bynoe (acting), Ottawa, ON (died March 2021)
1972–1989	Dr. J. Michael S. Dixon, Edmonton, AB (died November 2013)
1989–1993	Dr. Susan Tamblyn, Stratford, ON
1993–1998	Dr. David Scheifele, Vancouver, BC
1998–2003	Dr. Victor Marchessault, Ottawa, ON (died March 2003)
2003–2007	Dr. Monica Naus, Vancouver, BC
2008–2011	Dr. Joanne Langley, Halifax, NS
2011–2014	Dr. Bryna Warshawsky, London, ON
2014–2017	Dr. Ian Gemmill, Kingston, ON
2017–2021	Dr. Caroline Quach-Thanh, Montréal, QC
2021–2023	Dr. Shelley Deeks, Halifax, NS
2024–2025	Dr. Robyn Harrison, Edmonton, AB
2026–Present	Dr. Vinita Dubey, Toronto, ON

Abbreviations: AB, Alberta; BC, British Columbia; NS, Nova Scotia; ON, Ontario; QC, Québec

needs for timely complementary advice in relation to product authorizations, the workload of the NACI Chair has substantially increased.

Data submissions

Starting in 2020 during the COVID-19 pandemic, PHAC and NACI were afforded confidential direct access to the COVID-19 vaccine regulatory submission data, in accordance with subsection 21.1 (3) of the Food and Drugs Act and the Privacy Act (12). During the COVID-19 pandemic, access to regulatory materials allowed Health Canada and NACI to conduct parallel reviews, with several same-day decisions (6). Moving forward, however, the preferred model is sequential review. This approach ensures that NACI can draw on the full regulatory decision and product indications before issuing public health advice, and it also supports stakeholder discussions once the vaccine product monograph is publicly available. This allows for an efficient committee review process and will reduce the likelihood of unintentional off-label advice.

For new vaccines that are "same-in-class" or minor indication changes to old vaccines, NACI and PHAC are working on new expedited review pathways to ensure timely vaccine advice can keep pace with a growing pipeline of new vaccines. One such mechanism is a Canadian Immunization Guide (CIG) approvals board to facilitate a sub-structure of NACI to review and approve minor changes to advice in the CIG, accompanied by a summary of updates and evidence but without a full NACI statement. This will leverage clinical submission data from Health Canada, and NACI is currently piloting a clinical dossier submission process whereby vaccine manufacturers can submit a focussed data package directly to the NACI Secretariat to help launch the product reviews, which is not unlike submissions to Canada's Drug Agency (CDA; formerly CADTH).

Evidence reviews

The methods used by NACI have evolved over the last decade alongside international best practices for guidelines and the integration of the expanded program mandate elements in Canada. This includes integration of health economic evidence and EEFA factors (outlined above) and also implementation of the GRADE framework (Grading of Recommendations, Assessment, Development, and Evaluation), which is currently used by peer NITAGs, such as Germany, Australia, and the WHO's Strategic Advisory Group of Experts on Immunization as well as by Canadian advisory committees, such as the Committee to Advise on Tropical Medicine and Travel (CATMAT) and the Canadian Task Force on Preventive Health Care (CTFPHC). With the increasing need for NACI to provide emergency guidance (e.g., COVID-19 and mpox) and a greater volume of statement updates due to a rapidly evolving product landscape, GRADE has not been possible or appropriate to use for every NACI statement.

While the GRADE methodology for immunization programs in its current format is not without its challenges, there is confidence that future collective and collaborative refinements by NITAGs can facilitate the desired aims to allow comparability, transparency, standardization and efficiency of complex public health decisions. By integrating GRADE methodology, where appropriate, in line with peer countries, it becomes possible to share and leverage each other's work. This has already enabled sharing of otherwise time-consuming and labour-intensive systematic reviews so as to maximize efficiency. This includes recent NACI updates on Herpes Zoster program expansion to immunocompromised individuals 18 years and older and for optimal seasonal influenza product use in adults 65 years of age and older. NACI also looks towards use of artificial intelligence (AI) to accelerate evidence reviews as the body of scientific evidence continues to grow and in step with international consensus of best practices. There were early experiments by PHAC and NACI with AI during the pandemic (13) that are now being expanded in order to facilitate more rapid evidence collection and narrative summaries to provide subject matter experts with a timely evidence base to assess.

NACI continues to include fundamental vaccinology principles to guide decisions (e.g., extended intervals during COVID-19), in conjunction with published evidence as part of the GRADE process. NACI is often being asked to integrate evaluations for several products together at one time, such as RSV monoclonal antibody and maternal immunization program options. These complex program assessments can require integration of several parallel policy questions. To support this, NACI

statements are being informed by PHAC evidence reviews of vaccine characteristics, burden of disease, or infectious disease modelling that are published or pre-printed separately in order to streamline the final NACI statements.

As described above in the overview of NACI's expanded mandate, there was significant energy invested into developing a peer-reviewed framework for the systematic integration of EEFA factors into NACI guidance (7). The EEFA tools and supporting evidence are now applied routinely on NACI statements, and analyses of EEFA factors can be found in distinct sections of the NACI statements.

Engagement with end-users, and collaborative guidance development

The world of guideline methods is also evolving to acknowledge the critical role for engagement of key populations and end-users in the guideline development process to inform assumptions about the acceptability of interventions, including vaccines. Historically, NACI would rely on input from liaison members representing different clinical practice groups to provide perspectives on behalf of their respective clinical groups and patient populations. NACI is now piloting models to engage directly with affected populations; for example, there was important direct engagement with a British Columbia organization representing sex workers, and the Ontario Gay Men's Sexual Health Alliance (GMSHA) representing gay, bisexual, and men who have sex with men to understand perceptions of disease risk, vaccine acceptability, and strategies to prevent stigma during the mpox outbreak vaccine response in 2022 and 2023. Similarly, in 2024, NACI sought input on rabies vaccines from outdoor enthusiasts and occupational sectors who are most likely to be in contact with rabies-infected bats and animals. The committee has also considered questions from the Department of National Defence relevant to pre-deployment immunization for rabies protection (2018).

NACI is working with Indigenous health partners to establish a process that would better integrate First Nations, Inuit and Métis evidence and perspectives into the development of NACI statements; this will support national goals of reconciliation with Indigenous Peoples who have historically not been included in many health policy decisions, yet experience a high risk of vaccine-preventable illness due to social, environmental, and economic factors, rooted in the history of colonization and systemic racism in Canada. In 2021, the Indigenous Physicians Association of Canada and the Canadian Indigenous Nurses Association were added to NACI as formal liaison organizations. Informed by input from First Nations, Inuit and Métis health partners, NACI issued RSV statements in 2024 and several COVID-19 statements since 2021, including specific considerations for use in Indigenous communities where burden of illness may be higher based on intersecting structural and social determinants of health. NACI has reiterated in several guidelines that in First Nations, Inuit, and Métis communities, autonomous decisions should be made by Indigenous Peoples with the support of health care and public health partners in accordance with the *United Nations Declaration on the Rights of Indigenous Peoples Act*. Starting in 2026, NACI is launching a two-year pilot project to integrate an Indigenous health and immunization Working Group that will consider overarching principles of immunization for First Nations, Métis, and Inuit Peoples in Canada provide *ad hoc* engagement on specific recommendations for relevant vaccine preventable diseases (VPDs).

NACI and PHAC have found that building relationships with end-users and special population groups during periods between health emergencies is the preferred approach. This builds trust and communication channels that can be exercised during emergencies when guidance development happens much more quickly, leaving very narrow windows to identify and connect with affected populations groups during outbreaks.

Global context

The international vaccine community continues to grow stronger through the Essential Programme on Immunization (14) and WHO's Global NITAG Network. NACI has been working to collaborate through several mechanisms with other countries through both formal and informal approaches. During the COVID-19 pandemic, it became necessary to rely on and expand existing networks of NITAGs, and the research done in their supporting public health agencies. NACI received presentations from other countries such as the United Kingdom, United States, Israel, and Spain to inform decisions for COVID-19 vaccines. These informal networks continue to thrive based on regular touchpoints between several NITAG secretariats, creating a foundation for future rapid responses.

The work of NACI and PHAC has a growing international impact. In recent years, the CIG and NACI statements have been used by immunizers from all over the world. Although the majority of visits to the NACI and CIG web pages come from Canada (85%), both web pages have the same top five countries seeking our publications: United States, France, India, Ireland and the United Kingdom. Of note, traffic coming from outside of Canada to the French language content is significantly higher than to the English content, especially for the CIG webpages.

In 2024, PHAC and NACI launched a formal "NITAG twinning" initiative with the recently established NITAG for Haiti (GTCV-Haiti). This relationship, facilitated by the Pan American Health Organization (PAHO), resulted in productive exchanges and strategic support to decisions for the Haiti immunization program, despite the differences in committee maturity and country contexts.

Given the similar vaccine product environments and extensive connections and travel patterns between Canada and the United States, PHAC and NACI have a longstanding relationship with

the Centers for Disease Control and Prevention (CDC) and the Advisory Committee on Immunization Practices (ACIP) in the United States. For the last several decades, there have been reciprocal liaison representatives across the two committees (NACI and ACIP). Each VPD working group has also historically included reciprocal technical leads from the respective committee secretariats who are able to share and provide insight into their respective country's working group considerations and epidemiological contexts.

Global collaboration in addressing shared public health challenges has contributed to meaningful progress. For example, WHO guidance on HPV and rabies prompted immunization advisory committees worldwide, including NACI, to re-evaluate vaccine schedules and product access.

NACI productivity

Outputs

Throughout the COVID-19 pandemic, there was unprecedented interest in NACI's immunization advice from PHAC, provinces and territories, and the general public. NACI was meeting weekly for much of the pandemic and issuing statements approximately every two weeks throughout the first years of vaccine rollout (6) (**Figure 2**).

Figure 2: Number of National Advisory Committee on Immunization meetings and publications, 2014–2024

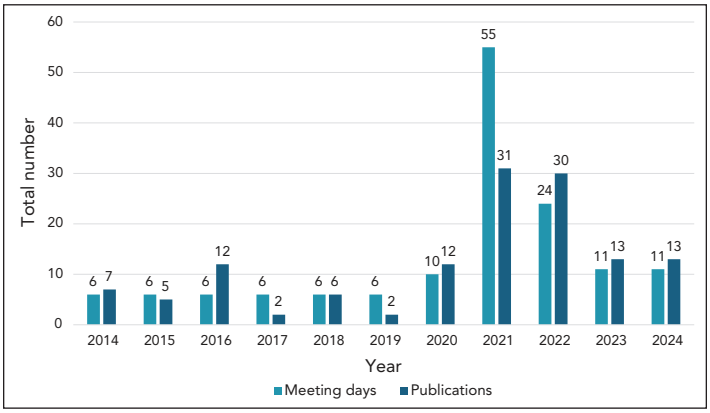


Figure 2 illustrates how the number of NACI statements per year has risen from approximately four per year, surging to 10–30 per year during the pandemic and recent years. There have also been 12 to 20 CIG chapter updates per year in addition to four new chapters in the last decade. It is too soon to tell what the new normal will be in terms of outputs and frequency, but so far, the trend seems to be moving towards approximately 8 to 12 NACI statements per year. This will depend on the vaccine pipeline and also the secretariat resourcing available to support the committee over the next decade. **Table 3** shows the total number of publications by VPD from 2014 to 2024, with some VPDs having received multiple updates while others have not.

Table 3: National Advisory Committee on Immunization publications per vaccine preventable diseases, 2014–2024

Vaccine preventable diseases	Number of publications
COVID-19	67
Influenza	27
Pneumococcal	8
HPV	6
MMRV	5
Meningococcal	4
Diphtheria toxoid, tetanus toxoid & pertussis	3
Smallpox/mpox	3
Hepatitis	2
Herpes zoster	2
RSV	2
Ebola	1
Rotavirus	1

Abbreviations: HPV, human papillomavirus; MMRV, measles, mumps, rubella, and varicella; RSV, respiratory syncytial virus

While the primary target audience for NACI statements is made up of vaccine policy and program decision-makers, the primary audience for the CIG includes front-line immunizers (i.e., physicians, nurses and pharmacists) who look to the CIG for a pragmatic synthesis of NACI's longer evidence-based guidelines. Visits to the CIG more than doubled in 2022 (1,487,642) compared to that of 2020 (702,405). It should be noted that the first version of the COVID-19 vaccine chapter was published on December 23, 2021; prior to this, all COVID-19 vaccine recommendations were only available in NACI statements. Traffic to the CIG last year (2024) was the highest on record at over two million visits. Interest in the CIG has grown steadily in the past decade with a spike in visits prompted by the COVID-19 pandemic. Looking at website visits over the past three years (since July 2022), the top five English language chapters were: COVID-19 vaccines; measles vaccines; recommended immunization schedules; pneumococcal vaccines; and RSV vaccines. Over the same time period, the top five French language chapters were: contraindications and precautions; herpes zoster (shingles) vaccine; measles vaccines; pneumococcal vaccines; and pertussis vaccines.

Prior to the pandemic, NACI web pages would attract approximately 250,000 visits annually. In 2021, with the publication of 27 COVID-19 related statements, traffic to NACI webpages expanded rapidly to over two million visits. Once COVID-19 vaccine guidance became available in a new CIG chapter (end of 2021), visits to the other NACI web pages dropped to just above pre-pandemic levels. Looking at the past three years (since July 2022), the top five English language NACI statements (in terms of visits) were: immunization in pregnancy with tetanus toxoid, reduced diphtheria toxoid

and reduced acellular pertussis (Tdap) vaccine; statement on seasonal influenza vaccine for 2024–2025; guidance on the use of COVID-19 vaccines during the fall of 2024; public health level recommendations on the use of pneumococcal vaccines in adults, including the use of 15-valent and 20-valent conjugate vaccines; and guidance on an additional dose of COVID-19 vaccines in the spring for individuals at high risk of severe illness due to COVID-19. During the same period, the top five French language NACI statements were: Statement on seasonal influenza vaccine for 2023-2024; Statement on seasonal influenza vaccine for 2024–2025; Updated recommendations on the use of herpes zoster vaccines; Recommended use of palivizumab to reduce complications of respiratory syncytial virus infection in infants; and Public health level recommendations on the use of pneumococcal vaccines in adults, including the use of 15-valent and 20-valent conjugate vaccines.

Discussion

Knowledge translation

To improve knowledge translation, an email notification service is available to readers where they can subscribe to receive English or French email alerts with each new NACI publication or CIG chapter update (https://www.canada.ca/en/public-health/services/canadian-immunization-guide/subscribe.html). The publications mailing list now has over 11,300 English language subscribers and 750 French language subscribers. Interest in the subscription service has been increasing annually.

Another strategy to improve knowledge translation was to publish short rapid response interim statements starting in 2021 during the COVID-19 pandemic. For longer statements, PHAC published brief 1–2 page PHAC summaries of NACI's advice online to provide a concise synopsis of the full technical document. The PHAC summaries now serve as a key tool to facilitate rapid public sharing of recommendations from NACI, sometimes receiving more web-visits than the source material in the full detailed NACI statements or rapid response statements.

Growing vaccine pipeline

In the past five years, the number of new vaccine authorizations were more similar to what would be expected over a decade based on historical data from Health Canada. While some of this surge can be attributed to COVID-19 authorizations and strain updates, the vaccine pipeline also produced a flurry of activity around other pathogens, like *Streptococcus pneumoniae* and RSV, among others. Looking ahead, the pipeline of vaccine candidates in or entering phase 3 trials suggests a rapid and progressive expansion of the current vaccine landscape; notably we see a trend towards combination respiratory vaccines (e.g., COVID-19/influenza vaccines); vaccines targeted antimicrobial-resistant organisms (e.g., *Clostridioides difficile*, *Escherichia coli*, *Neisseria gonorrhoeae*); vaccines for special populations (e.g., cytomegalovirus, Group B *Streptococcus*); and new vaccines against vector-borne diseases (e.g., Lyme disease). In addition, improved vaccine formulations against some diseases, including COVID-19, influenza, and invasive pneumococcal disease are anticipated, as well as growth in novel vaccine technologies, particularly mRNA-based platforms.

As the development pipeline grows for new immunizing agents and therapeutic vaccines, PHAC has been working with the CDA to establish a triaging process to help determine whether post-authorization program reviews would be led by NACI or CDA when there is ambiguity. In recent years, PHAC has established a precedent of collaborating with CDA on health technology assessments for monoclonal antibodies to prevent COVID-19. This included an early assessment of the RSV monoclonal antibody nirsevimab (15), followed by a full assessment of the public health program for nirsevimab was conducted by NACI (16). Ongoing collaboration is anticipated to ensure that provinces and territories receive timely advice on each product, supporting informed decisions about funding through either public health budgets or drug plan budgets.

Prioritization of vaccine programs for Canadians

There are now over 20 vaccine preventable diseases, multiple Health Canada authorized products for many of these diseases. There is also increasing attention on the use of immunization to prevent cancer (e.g., human papillomavirus related cancers; cancer related to hepatitis B), chronic diseases (e.g., cardiovascular disease prevention with influenza immunization; prevention of dementia with herpes zoster vaccine), and to improve health system efficiencies by reducing the need for access to acute care, medical transport, outbreaks, and costs through primary infection prevention.

However, the rapidly increasing number of vaccine products is juxtaposed against relatively static public health budgets which makes prioritization more important than ever. In Canada, as in other high-income countries, spending on publicly funded immunization programs is estimated to account for well under 1% of overall health care expenditures (17,18). Prioritization is now identified internationally as a necessity, and various tools are being proposed (19).

Over the last decade, the Canadian process for NACI work plan prioritization has been conducted on a one- or two-year cycle led by the NACI Secretariat at PHAC. There is structured engagement with the provinces and territories (through the CIC and the Council of Chief Medical Officers of Health—CCMOH), engagement with NACI committee members and liaison organisations to conduct ranking of potential workplan topics ahead of and during the two years of the workplan.

A challenge for the decade ahead will be prioritizing the work to gain the most meaningful impacts in the short and long term. Refocusing some priorities on the protection of specific population groups (such as adults, pregnant women and pregnant people, those with frailty, equity deserving individuals, or those at key life stages) may be one path forward, rather than evaluating individual vaccine products in isolation. The committee will also need to continue balancing the tension between predictable and timely advice for each newly authorized product, versus more complex, multi-product comparisons addressing the optimal strategy for a population.

Reconciliation with First Nations, Inuit, and Métis Peoples

The most recent Interim National Immunization Strategy (2025–2030) identified that NACI and PHAC should continue to work on new and improved engagement models for key populations and that: "*NACI considers populations at higher risk of disease or severe outcomes when formulating guidance. When appropriate to the VPD and epidemiology, NACI guidance is developed engaging with immunization experts from First Nations, Inuit and Métis health systems, as well as from populations at higher risk of VPDs or severe outcomes of VPDs where appropriate. NACI guidance development integrates Canadian specific considerations related to ethics, equity, feasibility, and acceptability, as well as cost-effectiveness.*"

The committee has benefitted greatly from the ability to consult a Vaccine Preventable Disease Working Group convened by Indigenous Services Canada (ISC) in recent years to complement the Indigenous Physicians Association of Canada, the Canadian Indigenous Nurses Association, and ISC representation at NACI meetings and the review of NACI statements. There is still much work to be done to build trusting relationships to improve pathways to vaccine access for First Nations, Inuit and Métis Peoples, and to further ensure representation and integration of First Nations, Inuit and Métis perspectives into NACI guidance. The shared goal is to improve health through meaningful reconciliation, achieved through collaborative efforts.

In the methods section above, additional ongoing collaborations between NACI and Indigenous partners have been highlighted.

Conclusion

Challenges new and old

Affordability, sustainability, and equity are positioned at the forefront as challenges now and going forward. While it is increasingly clear that vaccine programs are often cost-effective and can be cost-saving, challenges of affordability and budget impact remain. Although cost is not NACI's primary focus, rising vaccine prices and limited budgets inevitably influence the committee's work, as well as the collective prioritization of the immunization and funding communities. Fully capturing the long-term economic and societal benefits of vaccination will require new collaborations and improved data to strengthen the case for vaccines as essential public health investments and to ensure their value is fully reflected in funding and policy decisions.

In conclusion, the opportunities and challenges of the past decade have enabled the already mature NACI to continue to build upon the same initial and founding strengths of NACI in 1964. Over the years, renewed speed and efficiency, enhanced methodologies, and the benefit of additional representation and engagement from key experts and partners in Canada has incrementally expanded the scope and capacity of NACI. This could not be done without the strong foundation and trust that had been built thanks to the service of each of the dedicated NACI participants and leaders over the six preceding decades. The last decade was facilitated by a skilled secretariat, the addition of the expertise required to onboard cost-effectiveness analyses, a focus on equity promotion, improvements in global and domestic vaccine research and development, and vaccine-preventable disease surveillance in Canada. These factors and this foundation, together with the dedicated and expert volunteer committee members, keep the committee moving forward into what might be the most dynamic decade yet ahead.

Authors' statement

All authors contributed to conception of the article, drafting and editing the article, and approved the submitted version.

Competing interests

Matthew Tunis, Marina Salvadori, Kelsey Young, Kaeli Ramotar, Ashleigh Tuite, Krista Wilkinson, Christina Jensen, Adrienne Stevens, Joseline Zafack, and Erin Henry are employed by the Public Health Agency of Canada to work with NACI. Robyn Harrison and Vinita Dubey are the current Chair and Vice Chair of NACI, but not compensated for these roles.

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SCOPING REVIEW

Vaccine uptake and hesitancy among Black people: A scoping review

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Abstract

Background: Vaccination is one of the most cost-effective ways to prevent disease, yet vaccine hesitancy remains a threat to the progress made in tackling vaccine preventable diseases. Black communities have a history of being subjects of unethical research, victims of implicit bias, mistreated by healthcare professionals, and denied access to medical assistance. This study aims to examine vaccine uptake and hesitancy among Black people.

Methods: A scoping review was conducted in 11 bibliographic databases to identify relevant peer-reviewed studies. Articles were screened by two reviewers, with a third resolving conflicts where necessary. Data were extracted from eligible studies and findings were narratively summarized. A PRISMA checklist was adopted, followed by data extraction with the findings then collated, summarized, and reported.

Results: A total of 101 articles (77 quantitative, 16 qualitative, 3 randomized clinical trials, and 5 mixed methods studies) were included in the final analysis. Among these, 95.1% and 4.9% reported findings from North America and Europe, respectively. This review revealed that misinformation affects the acceptability of vaccination programs. Vaccine hesitancy among Black communities is often rooted in fears of potential side effects and long-term consequences. Parental consent was noted as a crucial issue, and the belief that children should not be offered vaccinations without parental consent was indicated as a factor affecting vaccine uptake.

Conclusion: Vaccine hesitancy continues to have a significant impact on global health. Government policies that promote vaccine uptake would help to reduce vaccine hesitancy and maintain high coverage among Black people.

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Introduction

Vaccination is one of the most cost-effective ways of avoiding disease (1), yet vaccine hesitancy is a threat to the progress made in tackling vaccine preventable diseases. Vaccine hesitancy, as defined by the World Health Organization (WHO), is a delay in acceptance or refusal of vaccination despite the availability of vaccination services (2). In 2019, the WHO classified vaccine hesitancy as one of the top 10 threats to global health and stated that the degree of vaccine hesitancy can vary depending on a variety of factors, including the type of vaccine and target population (2). For example, in the United States (US), the Advisory Committee on Immunization Practices has recommended influenza vaccines for all people above six months of age, but the rate of influenza vaccination coverage for adults and children is below the Healthy People 2020 initiative's target of 70% (3).

Vaccine hesitancy is rapidly increasing and often influenced by factors such as geographical accessibility of vaccines, affordability, cultural influence of the population, confidence or trust in the vaccine, safety of the vaccine, and the system that

delivers them (4). For example, the experience of discrimination in health care may contribute to medical distrust, which is associated with a lower likelihood of receiving preventive health service (5). Black communities have a history of being mistreated by healthcare professionals and being denied access to medical assistance (4). In a study conducted in 2019, Jamila *et al.* found the American healthcare system is beset with inequalities that have a disproportionate impact on people of colour and other marginalized groups. These inequalities contribute to gaps in health insurance coverage, uneven access to services, and poorer health outcomes among certain populations. Black adults are significantly less willing to get vaccinated than adults who are White or of other races (6). Decision-making around vaccination entails a complex mix of cultural, psychosocial, spiritual, political, and cognitive factors (7). Reasons for vaccine hesitancy generally fit into three categories: lack of confidence (in effectiveness, safety, the system, or policy makers), complacency, and lack of convenience (with respect to the availability, accessibility, and appeal of immunization services, including time, place, language, and cultural contexts) (8).

Socioeconomic status can affect vaccine uptake. In the US, Black people are more likely to live in poor or low-income neighbourhoods and are less likely to have health insurance than people of other races (9). For example, low-income levels and lack of medical insurance are associated with lower rates of human papillomavirus (HPV) vaccine initiation in young Black women (10). Reduced access to vaccination centres in Black communities compared to White communities is also associated with lower uptake of vaccines (11).

This scoping review seeks to synthesize what is known in the literature on factors that contribute to vaccine hesitancy and uptake among Black people.

Methods

This scoping review was planned and conducted in adherence with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) statement with a focus on health equity (12). The study adopted a comprehensive search strategy that allowed reproducibility, reliability, and transparency on the current state of literature. The review was conducted in five stages, as described below.

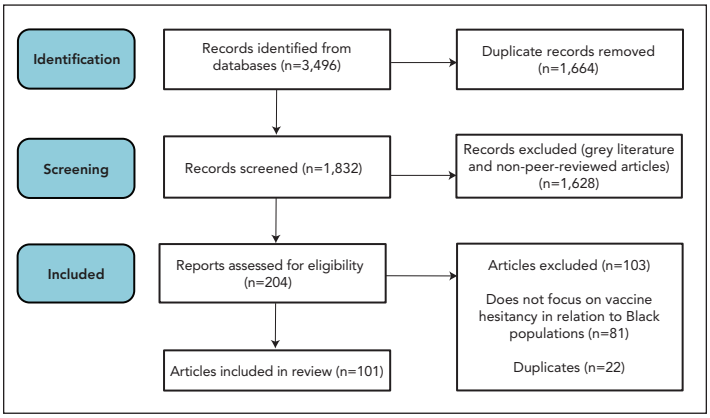
Stage 1: Developing the research question

The research question was: "What is known about vaccine uptake and hesitancy among Black people?"

Stage 2: Identifying the relevant studies

Original peer-reviewed articles from database inception until July 2023 were obtained from systematic searches of several electronic bibliographic databases: MEDLINE (1946–present), Embase (1974–present), PsycInfo (1806–present), Global Health (1910–present), and HealthSTAR (1966–present) via OVID; Cumulative Index to Nursing and Allied Health Literature (CINAHL) (1936–present) and Environment Complete (1950–present) via EBSCOhost; Scopus (1976–present) via Elsevier; Sociological Abstracts (1952–present) and Dissertations and Theses Global (1861–present) via ProQuest; and Cochrane Library (1993–present) via Wiley. These databases were examined using a mixture of natural language vocabulary and controlled terms (subject headings) wherever available, with both derived from three main concepts: 1) vaccine uptake, 2) vaccine hesitancy, and 3) Black population. To increase search sensitivity, publication date and study type restrictions were not applied. In total, 3,496 records were identified through database searching. Duplicate records (n=1,664) were automatically removed upon importation into the systematic review management software, Covidence. The full search strategy has been attached as **Figure 1**.

Figure 1: PRISMA study selection diagram



Abbreviation: PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses

Stage 3: Article selection

Based on eligibility criteria, six research assistants with backgrounds in health sciences screened the articles for selection. The first selection was the screening of the title and abstract and the second screening was a full-text review. All conflicts generated through the screening stages between the reviewers were resolved by a third reviewer. Each eligible article met the following inclusion criteria: 1) focus on vaccine uptake and/or 2) focus on vaccine hesitancy, and 3) focus on the Black population.

Only primary research published in peer-reviewed journals was included. Grey literature and non-peer-reviewed articles were excluded. No language or publication restrictions were applied. The first screening removed an additional 1,628 duplicates, leaving 204 articles for full-text review. Full-text review resulted in the exclusion of 81 articles that did not meet the inclusion criteria and 22 additional duplicate articles, resulting in a total of 101 articles eligible for inclusion in this scoping review. All were written in English. We also reviewed the reference lists of

included articles but found no additional studies that met our inclusion criteria. This information is summarized in detail in the PRISMA flow diagram (Figure 1).

Stage 4: Data charting and data extraction

The following information was extracted from each of the 101 articles: author(s) name, year of publication, country of study, study design, sample size, age, type of vaccine, findings, and conclusion.

Stage 5: Collating, summarizing, and reporting the results

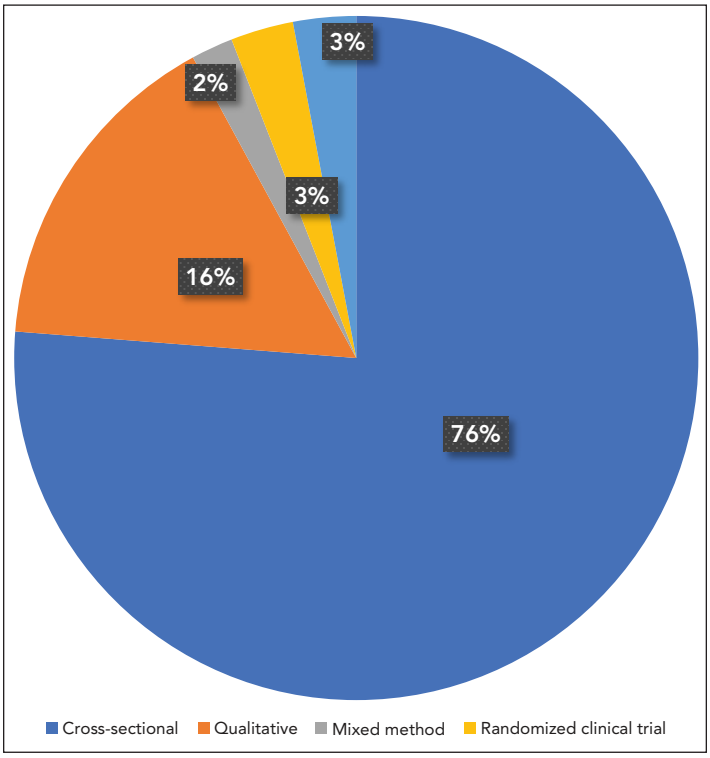
The characteristics and results reported in each included article are summarily described. An overview of existing evidence relating to vaccine uptake and/or hesitancy among Black people is presented.

Results

Characteristics of included studies

The characteristics of the 101 articles included in this review are presented in the **Appendix**, Table S1. The majority of the articles, 76% (n=77), were cross-sectional studies (retrospective and descriptive), while 16% (n=16) were qualitative studies, 2% (n=2) were mixed methods, 3% (n=3) were randomized clinical trials, and 3% (n=3) did not specify the research methodology (**Figure 2**).

Figure 2: Study methods used in the included articles



The study population size ranged from 20 participants to 2.2 million participants. Study participant ages, where reported, ranged from 18 months to >75 years. The articles assessed different types of vaccines, including COVID-19, HPV, pneumococcal, influenza, and measles, mumps, rubella (MMR).

Sentiments toward vaccination vary within the Black community. Overall, all studies identified lower rates of vaccine uptake among Black populations regardless of geographic location. Distinctive themes emerged from this review that highlighted the structural, cognitive dissonance, and behavioural barriers that facilitate vaccine hesitancy within Black populations. Barriers to vaccine uptake were related to: 1) interactions with healthcare providers, 2) cost and insurance status, 3) convenience of immunization, and 4) general knowledge related to vaccine preventable diseases. Furthermore, macro-level themes related to vaccine hesitancy included: 1) distrust in the vaccine development process, 2) safety and efficacy, 3) perceived risk, 4) historical considerations, 5) distrust in the government, and 6) cultural, religious, and family considerations.

Barriers to vaccine uptake in Black communities

Interactions with healthcare providers

Thirteen studies reported on interactions with healthcare providers and related impacts on vaccine uptake. Interactions with healthcare providers have been shown to affect vaccine uptake within Black populations. Healthcare providers who discussed vaccination and offered vaccination as a routine practice contributed to higher vaccine uptake (11,13–18). Decreased vaccine uptake occurred when healthcare providers did not initiate discussions during appointments because patients were reluctant to initiate such conversations (19–21). In addition, male healthcare providers were less likely than female healthcare providers to discuss HPV vaccination with Black patients (22). Healthcare providers were viewed as essential to supporting vaccine uptake and were considered the most influential external factor in vaccination decisions. Indeed, the healthcare provider is the most influential source of information and recommendations promoting vaccine uptake within a client's plan of care and decision-making process (23). Trust is a value measure within the relationship between the healthcare provider and their patients, and healthcare providers were viewed as the most trusted sources of information relating to vaccines (24). A therapeutic relationship between the patient and healthcare provider that fosters discussions related to vaccinations was seen as essential for promoting vaccination and decreasing the occurrence of vaccine preventable diseases within Black communities.

Cost and insurance status

Accessibility, affordability, and willingness to pay are factors that influence vaccine uptake. Eleven studies reported on the impact of vaccination cost and number of doses on vaccine uptake.

Insurance status and fee for services directly affected vaccination, completion of vaccination series, and overall vaccine uptake (25–31). Furthermore, socioeconomic status and income were also important; perceived lack of ability to pay can influence the vaccination decision-making process and vaccination uptake (32,33). Nan *et al.* (2016) reported an increase (32.7%) in vaccine acceptance occurred within the Black community when vaccinations were offered free of charge.

Convenience of immunization

Numerous factors contribute to the convenience of vaccination, including the availability of vaccines and accessibility of vaccination clinics. In two studies (34,35), line-ups, waiting times, and multiple appointments were cited as inconveniences for individuals who did not receive vaccinations. Factors that facilitated accessibility were cited as positive contributors to vaccine uptake, and included considerations such as minimizing multiple appointments, decreased time spent, and short lineups.

General knowledge related to vaccine preventable diseases

Twelve studies investigated the link between knowledge about vaccination and vaccine uptake. Lack of knowledge related to vaccination and vaccine preventable diseases impacts the client's perceived risk and need for vaccination. The success of current immunization programs has created a paradoxical effect resulting in decreased public awareness of the negative outcomes related to vaccine preventable diseases. Limited knowledge related to vaccine preventable diseases and the availability of vaccines impacts vaccine acceptance (30,35–42). Misinformation also affects the acceptability of vaccination programs. As shown by Cooper *et al.* (2017), HPV and HPV vaccination awareness among Black men was low, contributing to low vaccine uptake. Of the men surveyed, 50% had not heard of HPV and 53% were unaware of the vaccine. In conjunction with the lack of knowledge of vaccine preventable diseases was the assumption that HPV vaccination was required for sexual activity. This behavioural association discouraged vaccination of children and adolescents as a preventive measure due to the limited discussions within parental dyads to initiate the vaccination series (26). When knowledge was shared with clients, a positive association existed between willingness to vaccinate a daughter or son based on the newly acquired understanding (43–45). Participant health literacy levels were a critical factor that influenced understanding. Lower levels of health literacy had a negative impact on vaccine uptake, as clients were skeptical and fearful of the vaccination programs being offered (46). The perceived low risk and limited knowledge related to vaccine preventable diseases were evident within geographically diverse Black communities (47,48). Overall knowledge and health literacy are important aspects of vaccine acceptability that impact the perceived value of vaccines and necessity of vaccination within Black communities.

Themes related to vaccine hesitancy in Black communities

Distrust in the vaccine development process

Twelve studies reported on vaccine hesitancy related to the vaccine development process. Black participants reported being hesitant to new vaccinations offered. This hesitancy was often tied to limited knowledge of the historical impact of vaccine preventable diseases and the history of vaccine development (21,24). Reluctance toward new vaccines led individuals to prefer waiting for further research greater public awareness before accepting them (21,24). Fears were often rooted in potential side effects and long-term impacts (41,49–51). Furthermore, within Black communities, mistrust toward expedited vaccination development and trials with emerging vaccines contributed to fears that new vaccines were rushed and therefore unsafe (41,49,52–56). Such feelings were also linked to vaccine testing and willingness to get vaccinated, in particular, thoughts that testing of the COVID-19 vaccine was rushed compared to historical time frames (2,57).

Safety and efficacy

Fifteen studies investigated linkages between vaccine safety and efficacy and vaccination uptake. Vaccine acceptability is often attributed to aspects of vaccine safety, necessity, and effectiveness (58). Black participants expressed concerns regarding the short- and long-term effects of the vaccines (2,5,19,27,35,40,42,43,55,59–61). Participants expressed concerns about vaccinating their daughters against HPV, citing they were too young and that they were worried about the one-size-fits-all vaccination approach (25). A risk-benefit trade-off between vaccines and vaccine preventable diseases is impacted by the perception of vaccine safety. Stern *et al.* (2021) highlighted that Black participants viewed the COVID-19 vaccine as unsafe and a greater safety risk than acquiring COVID-19. Weaver *et al.* (2013) found efficacy had the greatest impact on acceptability to HIV vaccine trials with Black participants, with the acceptability of a high (99%) efficacy vaccine being significantly greater than for a 50% efficacy vaccine (24). Vaccine efficacy is supported by education from trusted sources, such as healthcare providers and government bodies, while reduced trust in health information from government bodies is associated with a decrease in perceived vaccine efficacy (62). Complacency was found to be related to perceived low disease risk and, when coupled with concerns related to vaccine efficacy, resulted in decreased vaccine uptake (52).

Perceived risk

Eleven studies investigated the perceived risk of negative outcomes related to vaccination. The perceived risk of acquiring vaccine preventable diseases has been shown to be directly linked to vaccine uptake. One study (63) found that

the most common reason for not being vaccinated was a low perception of personal risk for vaccine preventable disease, the belief that healthy behaviours were sufficient to mitigate the risk. Furthermore, decreased vaccination was due to the perception was that they would not become seriously ill if they acquired the disease (64–66). Perceived risk was linked to limited knowledge related to vaccine preventable disease and complications (25,27,52,61,65,67).

Historical considerations

Two studies explored historical practices in health research within the Black community and their impact on vaccine hesitancy. Participants expressed considerable and well-founded mistrust of the medical establishment, scientific research communities, and pharmaceutical companies, based on their knowledge of historic mistreatment and lack of representation in studies that adversely affected Black patients and participants (68). Participants reported that their overall mistrust of these entities made them less willing to consider getting a COVID-19 vaccine, no matter how safe it was proven to be (2,69).

Distrust in the government

Seven studies investigated the relationship between trust in government and vaccination uptake. Trust in government agencies regarding vaccination development and programs has been shown to impact vaccine acceptance. Black participants indicated that their vaccine hesitancy was directly related to distrust in the government (2,9,52,58,70,71). Political involvement within the vaccination development process (i.e., vaccine approval) also created mistrust within Black communities. Moreover, the environment associated with political and associated racial injustice in the US, further decreased confidence in vaccination related to COVID-19 (72). Mupandawana *et al.* (2016) found that participants had a general distrust of Western societies and vaccines associated with them. The lack of trust in government agencies increased the belief in conspiracy theories, resulting in the use of naturalism as an alternative to vaccination (40).

Cultural, religion, and family considerations

Five studies investigated the cultural and religious implications of vaccine uptake. Culture has an impact on the decision-making process related to vaccination. Pierre Joseph *et al.* (2014) found Black family structures featured limited parent-adolescent communication about sexual activity and, for African American and Haitian men in particular, this resulted in decreased vaccination. Furthermore, Galbraith-Gyan *et al.* (2019) found the health behaviour and decision-making of African participants had deep cultural roots (52). Parental consent was seen as vital for vaccine acceptance, and the belief that children should not be offered vaccinations without parental consent was indicated to impact vaccine uptake (35,69). Furthermore, the vaccination decision-making process in Black communities may include members outside of the traditional nuclear family, such as cultural leaders, elders, and grandparents (10).

Religious values and cultural norms influenced vaccine decision-making in Black families, with fathers acting as the ultimate decision-makers (52). The risk of judgment from cultural and religious groups with which people identify impacted enrolment within vaccine trials due to potential stigmatization related to disease status (40). Furthermore, vaccination status, particularly for HPV, was seen to be linked with sexual activity, leading some parents of adolescents to express fear that vaccination might encourage promiscuity (52,73).

Discussion

This scoping review indicates vaccine uptake is influenced by multi-level factors, including the influence of the healthcare provider; convenience related to cost, insurance status, or the number of doses and visits required; and knowledge or lack of knowledge pertaining to vaccinations. Furthermore, the findings show vaccine hesitancy is influenced by factors such as the perception that the vaccine development process was rushed or too novel; concerns around safety and efficacy; perceived risk; hesitancy based on unethical historical practices in research toward the Black community; mistrust in government; and cultural, religious, or family structure. Collectively, these identified themes highlight vaccine uptake and hesitancy in Black communities as dynamic concerns with significant implications with respect to both short- and long-term health outcomes of Black people. Considering the ongoing threat of COVID-19, the high rates of infection and mortality in Black communities, as well as the increased prevalence of COVID-19 vaccine hesitancy among racial and ethnic minority groups (74), this paper is timely and relevant in its contribution to current public health discourse.

The factors identified as barriers to vaccine uptake are reflective of health service barriers experienced by Black communities, particularly those related to accessing primary care and other preventive health services (75–78). In a qualitative study on access to care as a barrier to Black women's use of mammography, location and transportation, lack of insurance, healthcare costs, inadequate information, wait times for an appointment, and failure of the healthcare provider to disclose mammography information or recommend mammography were some of the notable barriers shared by the participants (75). Similar barriers are documented for colorectal cancer screening (77), primary care use among African American men (78), and HPV immunization for Black adolescents (76).

For Black populations, the prevalence of conversations with healthcare providers about vaccines is disproportionate to levels of vaccine awareness; even in circumstances in which Black people report higher rates of vaccine-related conversations with their healthcare providers than their White counterparts, they conversely report lower rates of vaccine awareness (77,79), raising concerns about the quality of conversations between patients and providers. Unfortunately, clinicians sometimes provide incomplete information about vaccines and, when met with reluctance, sometimes fail to follow-up or engage

their patients in further discussion (6). Providers also report simply deferring discussions about vaccines when resistance is perceived (76,80). In this way, patient-provider communication may impact patients' exposure to information about vaccines and their level of understanding.

Considering the reliance on providers as a trustworthy source of vaccine information (81), poor patient-provider communication may influence vaccine uptake in Black populations (6,82). The provision of information and appropriate recommendations about preventive care measures by healthcare providers is influential to the accessibility of services (34,35). The combination of insufficient information from healthcare providers, misinformation, and lower health literacy rates in Black populations all contribute to a lack of knowledge and the inability to make informed decisions about vaccinations (6,29,75–76). Moreover, patient-physician communication has been identified as an underlying factor in racial disparities in healthcare (83). Black patients consistently experience poorer communication, information provision, client participation, and participatory decision-making compared to White patients (83,84). Incidentally, patient-provider racial concordance is associated with improvements in these areas (83).

Issues of convenience, such as location, hours, cost, transportation, scheduling, wait times, and number of visits can serve as barriers or facilitators to the utilization of health services (65,75–78,81,85). Black people systematically have higher rates of unemployment, fewer opportunities, poorer compensation and benefits, and greater job instability than their White counterparts (86). Lower positions within their organizations and poorer benefits (86,87) result in lower utilization of paid time off and other forms of leave that would facilitate flexibility and convenience with respect to accessing care services (88,89). Additionally, comprehensive health insurance, which is typically associated with employment for many, directly impacts health service costs (75,81,90).

Trepidation toward public health interventions and the government is not unfounded, considering the persistent barriers to health services in Black communities and the tumultuous historical relationships between Black people and medicine (88). Significant incidents of abuse and mistreatment of Black populations by the medical community have been documented (91). The resulting mistrust now serves as a deterrent to health service utilization, especially preventive measures such as screenings and vaccinations (88,90). Additionally, medical mistrust, compounded with routine experiences of racism in accessing health services, cumulatively fosters hesitancy in healthcare utilization (92,93). It is reasonable that distrust and other beliefs regarding the healthcare system contribute to skepticism about vaccine development, concerns about safety, and perceptions of risk (81,94).

Black communities also have very strong cultural, religious, and family ties that inform their perspectives and worldviews on various issues related to health (95). In some instances, family, friends, and community leaders are a source of anti-vaccine sentiments; religious beliefs may object to vaccines or restrict vaccine utilization, and community conversations contribute to anti-vaccine propaganda (81,96). Dynamics within cultural, religious, and family structures also impact who has the authority to make decisions about vaccine uptake (14,27,55). Concerns about stigma or assumptions of health status from the community also further discourage engagement with vaccines (55,65).

Racial disparities in child and adult immunization rates have grown over time (81,97,98), in part due to this complex, multi-level influence on how Black populations engage with vaccinations. This review corroborates the existing literature on issues affecting rates of vaccine uptake and the prevalence of vaccine hesitancy in Black populations. Ultimately, identifying these influential factors within the Black population provides a stronger basis for developing policies, programs, and strategies to address vaccine hesitancy, increase vaccine uptake, and reduce racial health disparities.

Implications for research, policy, and practice

Medical mistrust among African Americans is derived from historical, discriminatory, and harmful racial experiences associated with the healthcare system and government. This has led to avoidance of healthcare as a self-protective coping strategy. Black communities are more willing to be vaccinated when it is recommended by a trusted healthcare provider (7,8,99). Although evidence indicates that Black populations have higher rates of vaccine hesitancy, no research has systematically synthesized the factors driving this hesitancy. Future research should explore the association between vaccine hesitancy, cultural and behavioural patterns, the longer-term support that people who hesitate to get vaccines may need, and how best to provide that support. Vaccine hesitancy continues to have a significant impact on global health (100). For example, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus that causes COVID-19 first appeared in 2019 in Wuhan, China and then spread to nearly all countries of the world in only a few months (101). The high rate of infectivity of COVID-19 makes the estimated mortality rate and impact on the economy unprecedented. Importantly, the mortality rate from COVID-19 is 2.7 times higher in Black vs. White Americans (102). The reasons for the disproportionate effect on Black people likely stem from racism and other social determinants of health, such as low income, mass incarceration, infant mortality, limited healthcare access, and health-related conditions including heart disease, diabetes, stroke, kidney disease, respiratory illness, and HIV (103).

The devastating effects of COVID-19 on the Black community underscore the importance of governments establishing vaccination uptake policies and recommendations that would encourage greater vaccination coverage among the Black population. This measure will help reduce the Black community's death rate from disease and illness, keep coverage rates high, and curb the spread of disease. In the case of COVID-19 in particular, it will lessen the risk that the healthcare system will be overrun by the disease load from this virus and prevent the overstretch of limited healthcare resources. In addition, healthcare providers should make cultural safety a priority in their work to earn the Black community's trust and boost vaccination rates among this population. Efforts to implement interventions, such as home vaccination programs and initiatives to improve vaccine and health literacy, should particularly focus in individuals who are apprehensive about vaccination within Black communities. More Black people would be vaccinated if Black vaccinators were used (104).

Strengths and weaknesses of this review

This scoping review employs rigorous methods, as it combines results from a large number of studies conducted using both qualitative and quantitative techniques. The research findings revealed many challenges to getting Black people vaccinated, which put them into the categories of structural, cognitive, behavioural, and sociocultural problems. This review provides an in-depth analysis of how trust in doctors, government bodies, and the vaccine creation process influences people's decisions about vaccination. Furthermore, this review examines the issue on both personal and societal scales, providing a comprehensive understanding of the issue. The use of various types of vaccines in different regions enhances the effectiveness of vaccines in public health globally.

On the other hand, since most studies are cross-sectional, the review cannot correctly identify the reasons for increased vaccine hesitancy or its temporal changes. Despite a thorough assessment of how well the studies were carried out, the available evidence is taken at face value. Although thematic analysis involves considerable detail, the scoping review does not always combine the findings from studies to draw general conclusions or identify the most critical barriers.

Authors' statement

FOluwasina — Data curation, formal analysis, methodology, validation, software, resources, writing–original draft, review & editing
SM — Data curation, formal analysis, validation, resources, writing–original draft, review & editing
MO — Data curation, formal analysis, methodology, validation, writing–original draft, review & editing
FOjo — Data curation, formal analysis, methodology, validation, writing–original draft, review & editing
OS — Data curation, formal analysis, methodology, validation, writing–original draft, review & editing
LD — Writing–original draft, review & editing
MTB — Methodology, validation, supervision, writing–review & editing
AR — Methodology, validation, supervision, writing–review & editing
UA — Methodology, supervision, writing–review & editing
BS — Conceptualization, funding acquisition, investigation, validation, project administration, methodology, supervision, writing–review & editing

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Competing interests

None.

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Appendix

Supplemental material is available upon request to the author: folajinm@ualberta.ca

Table S1: Characteristics of included studies

Promoting influenza vaccination among health professionals in Canada: Results of an online survey on Facebook

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Abstract

Background: Vaccination rates of healthcare workers in Canada against influenza are below the national target of 80%. The objective of this study was to identify the preferred promotional formats and types of information that healthcare professionals would consider when deciding whether to get immunized against influenza. The goals of this survey were to 1) inform the design of a social marketing campaign to help healthcare professionals make informed decisions about influenza vaccination, and 2) inform future education and promotional work by vaccination stakeholders.

Methods: A bilingual survey was implemented online using Facebook ads to recruit healthcare professionals across Canada. The survey consisted of 15 mixed multiple-choice and open-ended questions. Eligibility requirements included being a practising Canadian healthcare professional, such as a medical doctor, nurse, pharmacist, nurse practitioner, midwife, or dentist.

Results: A total of 265 healthcare professionals completed the study, with a majority (51.3%) being nurses and practising in Ontario (32.1%). Infographics were viewed as the promotional format most likely to influence their decision-making (33.6%). Healthcare professionals relied on news from various media outlets and peer-reviewed journals (15.8%) to make their decisions. Finally, respondents indicated that influenza vaccine effectiveness was the most relevant information with respect to their decision-making (80.8%).

Conclusion: Infographics may be an important method for promoting influenza vaccination among healthcare professionals. These visual representations should focus on up-to-date information about influenza vaccine effectiveness to respond to the information needs of healthcare professionals. The next steps will be to design a marketing campaign focused on vaccine effectiveness, using infographics as a promotional format.

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Keywords: influenza, Facebook, vaccination, misinformation, health professionals

Introduction

Influenza is ranked among the top 10 leading causes of death in Canada (1). It is associated with an estimated 12,200 hospitalizations and 3,500 deaths per year (1). Vaccination remains the most effective preventive strategy to reduce death and hospitalizations due to influenza-related complications in people at high risk of infection (2). The National Advisory Committee on Immunization (NACI) recommends that all healthcare professionals receive an influenza vaccine to minimize influenza transmission to people at high risk, such as older adults and young children (3). Influenza vaccination among healthcare professionals is considered an essential component of the standard of care for their patients (2) however, most recent

available vaccination rates for healthcare professionals vary between 32.7 for hospital staff (2024–2025, Ontario) (4) and 20.5% (February 2025, Nova Scotia) (5), which is below the national target of 80% coverage among healthcare professionals (6). Data available on the breakdown of vaccine uptake by health profession are rare. In a national cross-sectional study pooling data from the 2007 to 2014 cycles of the Canadian Community Health Survey (7), which has been conducted annually by Statistics Canada since 2007, 50% of healthcare professionals reported receiving a seasonal influenza vaccination in the previous 12 months. Vaccination rates varied by occupation type: 72% of family physicians and general practitioners reported receiving the flu shot in the past year, compared to only 4% of chiropractors, midwives, and practitioners of natural healing. Among other groups, 59% of licensed practical nurses and 50% of pharmacists reported being vaccinated.

Strategies to increase vaccination rates among healthcare professionals have included facilitating workplace support for vaccination by increasing access to vaccines, vaccination mandates, and promotion (8–10).

Barriers to influenza vaccination among healthcare professionals include perceptions of low risk of infection, concerns about vaccine safety and effectiveness, and misinformation circulating on social media and online networks (10). In fact, social media and online networks can be useful in developing professional networks and for patient care and education (11,12). However, social media and online networks also provide a medium for disseminating misinformation (13), as there are no measures in place to control the quality of the content shared on such portals (14). Following Guess and Lyons (15), this study defines misinformation as constituting a claim that contradicts or distorts common understandings of verifiable facts. Such misinformation, when spread on social media, can incite negative emotions toward vaccines and may lead to an increase in vaccine hesitancy (16–18).

Given the potential health risks associated with sharing inaccurate or out-of-date information, technology companies themselves have taken a position and changed their policies. For example, since February 2019, Pinterest, Facebook, Instagram and Google have addressed anti-vaccine content on their sites and have acknowledged the detrimental role they have played in spreading misinformation about vaccines (19). These companies have attempted to reduce access to misleading information about vaccines and promote accurate educational content from expert organizations (20–22).

It is in this vein that the Canadian Public Health Association (CPHA) obtained support, in the form of marketing credits, from Facebook Canada to increase awareness of credible vaccine information on social media. The CPHA and Immunize Canada met with project team researchers, including an expert in social marketing campaigns, to discuss the research project's design and implementation, emphasizing the importance of clearly identifying a target behaviour and audience. Based on numerous discussions and a review of the literature, CPHA and Immunize Canada determined it would launch two distinct campaigns: one that provided credible information to parents of at least one child between 8 and 15 years of age concerning their need to be immunized with the Human Papillomavirus (HPV) vaccine, and another that provided credible information to healthcare professionals concerning their need to be immunized with the annual seasonal influenza vaccine. The results of the HPV campaign were published in 2023 (23). The current article focuses on the influenza survey that was performed to prepare the campaign.

A Facebook survey was conducted with healthcare professionals (e.g., nurses, doctors, pharmacists) to collect baseline information on their preferred promotional formats and types of information they would consider when deciding whether to receive an influenza vaccination. The goals of this survey were to 1) inform the design of a social marketing campaign to help healthcare professionals make informed decisions about influenza vaccination (the results of this study will be used to conduct a post-survey campaign to assess the effectiveness of the intervention in a future study), and 2) inform future education and promotional work by vaccination stakeholders. The research questions for this study were: a) what promotional formats do healthcare professionals prefer to receive information about influenza vaccination? and b) what types of information do healthcare professionals consider in their decision-making process to get immunized against influenza?

Methods

Participant recruitment

Recruitment took place over an 11 month period, from March 2021 to February 2022. Participant email addresses were collected for a raffle and follow-up survey after the marketing campaign. Informed consent was collected through the Facebook page and by completing the survey. All responses were deidentified before analysis. The project was approved by the Research Ethics Board of the University of Guelph for compliance with federal guidelines for research involving human participants (REB #24-08-004).

Measures

The survey consisted of 15 multiple-choice and three open-ended questions, and took approximately 15 minutes to complete (see survey questions in the **Appendix**, **Supplemental A**). SimpleSurvey was used as the survey platform, with randomized questions. The following topics were covered:

1. Sociodemographic information (e.g., age, province/territory where their practice is located, sex, gender, job title)
   Influenza vaccine decision-making process

2. Influenza information sources
3. The advertising formats most likely to influence the decision-making
4. Trust in public health messages

This article focuses on topics 3 and 4, as the answers for these topics were required to implement the marketing campaign. Items specific to social media sources, preferred promotional formats, and the type of information healthcare professionals would consider in their decision-making process (questions 3 and 4) were developed in collaboration with Immunize Canada, a national coalition of non-governmental, professional, health, government, and private sector organizations dedicated to promoting the benefits of immunization and questions (24). At the end of the questionnaire, participants were invited to provide their email addresses to be recontacted for the post-campaign survey.

Mitigation of online surveying issues

Online recruitment for surveys can present challenges, including fraudulent participants, low recruitment rates, incomplete responses, and high attrition. To address low recruitment, the recruitment period was expanded. To identify fraudulent participants, participant lists were reviewed by two team members to identify fraudulent email addresses (e.g., ones that used inappropriate words or those bounced when trying to recontact the participant), which were discarded. Respondents who did not complete at least 80% of the survey were also removed. To reduce attrition, team members sent two reminders to non-responders to optimize the response rate. Finally, survey responses were monitored while the survey was still live, and the number of participants was updated during team meetings.

Data analysis

Survey responses were analyzed using a deductive and inductive approach. To select variables, the data set was reviewed to identify the variables. Once the key questions necessary to launch the marketing campaign were identified, the team discussed the variables that might be relevant to answer the research questions and reached a consensus on which to include in the research. A threshold of 20% or more non-completion rate was adopted. Variables were checked to identify univariate outliers. The responses to questions about influenza information sources were grouped into two main variables: 1) social media sources, and 2) "other" sources. Social media sources combined the responses of participants who stated that they relied on Facebook, Twitter, Instagram, Pinterest, and/or Reddit to obtain credible information about vaccines and vaccination for influenza. Other sources combined the responses of participants who relied on scholarly and/or non-scholarly sources that were not considered social media to obtain credible information about vaccines and vaccination for influenza (see **Table 1** and **Table 2** for more details).

Table 1: Frequency table of social media sources that survey participants rely on to obtain credible information about influenza vaccines and vaccination

Social media source	Participants ranking social media first	Percent (%)	Valid percent (%)
Facebook	77	29.1	38.1
Twitter	17	6.4	8.4
Instagram	11	4.2	5.4
Pinterest	7	2.6	3.5
Reddit	15	5.7	7.4
Other	75	28.3	37.1
Total	202	76.2	100.0
Missing	63	23.8	N/A
Total	265	100.0	N/A

Abbreviation: N/A, not applicable

Table 2: Frequency table of "other" sources that survey participants rely on to obtain credible information about influenza vaccination

Sources	N	Percent (%)
Non scholarly sources	64	65.3
Scholarly sources	34	34.7
Total	98	100.0

Results

Participant demographics

A total of 524 healthcare professionals participated in the study. A total of 259 were excluded because up to 80% of their forms were not completed. Finally, 265 healthcare professionals completed the survey, with a majority (51.3%) of them being nurses. A total of 83.4% of respondents were female and 50.6% were in the range of 25–44 years old. Most of the participants practiced in Ontario (32.1%) and Québec (19.6%), and only a few were practicing in the territories (Yukon [n=1; 0.4%] and Nunavut [n=1; 0.4%]). These results are summarized in **Table 3**.

Social media sources that participants rely on to obtain credible information about vaccines and vaccination for influenza

The survey was conducted on Facebook. This platform was the primary social media source that most surveyed healthcare professionals reported relying on to find credible information about influenza vaccines and vaccination (29.1%; n=77) (See Table 1). "Other" was selected as the second most relevant source (28.3%; n=75). Twitter is the third most relevant social media source (6.4%; n=17).

Table 3: Frequency table of the demographic characteristics of survey participants[a]

Demographics characteristics	Number of respondents (n)	Percent (%)
Age (years)	**248**	**93.6**
18–24	13	4.9
25–34	67	25.3
35–44	67	25.3
45–54	51	19.2
55–64	44	16.6
65–74	6	2.3
Missing	17	6.4
Total	265	100.0
Sex	**248**	**93.6**
Female	221	83.4
Male	24	9.1
Choose not to respond	3	1.1
Missing	17	6.4
Total	265	100.0
Gender	**248**	**93.6**
Woman	220	83.0
Man	25	9.4
Other	3	1.1
Missing	17	6.4
Total	265	100.0
Province of residence	**247**	**93.2**
Alberta	30	11.3
British Columbia	32	12.1
Manitoba	16	6.0
New Brunswick	7	2.6
Newfoundland and Labrador	2	0.8
Nova Scotia	13	4.9
Nunavut	1	0.4
Ontario	85	32.1
Québec	52	19.6
Saskatchewan	8	3.0
Yukon	1	0.4
Subtotal	247	93.2
Missing	18	6.8
Total	265	100.0
Job title	**248**	**93.6**
Medical doctor (MD)	17	6.4
Nurse	136	51.3
Pharmacist	10	3.8
Dentist	4	1.5
Other	81	30.6
Missing	17	6.4
Total	265	100.0

[a] A total of 265 (100%) healthcare professionals completed the survey. Of these, 247 (93.2%) answered the question related to their location, and 18 did not provide a response (missing data: 6.8%, n=18), leading to a total of 100%

Promotional formats used to provide influenza vaccination information that may influence healthcare professionals' decision-making

Participants were asked to rank a series of promotional formats used to provide information about vaccination for influenza in order of most likely "1" to least likely "5" to influence their decision-making, ensuring that no two formats received the same score (i.e., two promotional formats could not both be scored the same). The data was then combined to identify the promotional format that each participant ranked first. Infographics were the most frequently selected format, with 89 participants ranking them first as the influential. "Other" sources (e.g., scientific papers), were ranked second (total of 42), "videos" were ranked third (total of 34), and "narratives/stories" were ranked fourth (total of 21) (see **Table 4**).

Table 4: Frequency table of promotional formats used to provide influenza vaccination information from most likely "1" to least likely "5" to influence decision-making

Promotional formats	Participants ranking the format first	Percent (%)	Valid percent (%)
Videos	34	12.8	17.3
Images	11	4.2	5.6
Infographics	89	33.6	45.2
Narratives/stories	21	7.9	10.7
Others	42	15.8	21.3
Total	197	74.3	100.0
Missing	68	25.7	N/A
Total	265	100.0	N/A

Abbreviation: N/A, not applicable

Other sources identified by participants as potentially influencing their decision-making about influenza vaccines and vaccinations were grouped into two main categories: scholarly sources and non-scholarly sources. Scholarly sources included peer-reviewed journals, reports and the websites of government agencies. Non-scholarly sources included social media, audio and video messages, and personal experiences. The majority of participants (65.3%, n=64) relied on non-scholarly sources, while 34.5% (n=34) relied on scholarly sources (see Table 2). Among non-scholarly sources, healthcare professionals relied mainly on news from various media, such as audio broadcasts, videos and press releases (20.3%; n=13). They also relied on information from their workplace (14.1%; n=9). Finally, 6.3% of healthcare professionals (n=4) reported that promotion materials do not influence their decision-making. These results are summarized in **Table 5**. The themes and categories are presented in the supplemental material.

Table 5: Frequency table of non-scholarly sources the participants rely on to obtain credible information about influenza vaccination

Non-scholarly sources	N	Percent (%)
News	13	20.3
Personal experience	3	4.7
Information from the healthcare system	9	14.1
Posts on social media	2	3.1
Ad non-influential	4	6.3
Other, non-classifiable sources	10	15.6
Don't know	11	17.2
None	12	18.8
Total	64	100.0

Information that healthcare professionals consider when making decisions about influenza vaccination

The most frequently sought information by healthcare professionals when deciding whether to receive an influenza vaccine was vaccine effectiveness (n=214), followed by clinical trial data (n=156). The potential side effects of vaccines were the third most frequent option selected (n=148). Who monitors vaccine safety (n=107) and who regulates vaccine safety (n=107) were also ranked as important. How to minimize vaccine injection pain and fear did not have a high ranking (total of 19), and neither did the alternative influenza vaccination schedule (total of 18). These results are summarized in **Table 6**.

Table 6: Information that healthcare professionals consider when making their decisions about vaccination for influenza[a,b]

Information healthcare professionals look for to make their decisions about vaccination for influenza	Number of respondents (n)	Percent (%)
Effectiveness of vaccines	214	80.8
Clinical trial data	156	58.9
Potential side effects of vaccines	148	55.8
Who monitors vaccine safety	107	40.4
Who regulates vaccine safety	107	40.4
How vaccines are tested	86	32.5
Vaccine ingredients	71	26.8
How to minimize vaccine injection pain and fear	19	7.2
Alternative vaccination schedules	18	6.8
Don't know/Not sure	11	4.2
Homeopathic remedies	2	0.8
Total	265	100.0

[a] Respondents could select multiple responses
[b] Mean=1.00; Median=1.00

Discussion

The objective of this study was to explore the promotional formats and types of information that healthcare professionals consider when making their decision about influenza vaccines and vaccination. The study found that healthcare professionals surveyed considered infographics the most influential format for supporting their decision-making about regarding influenza vaccines and vaccination. They also identified the vaccine effectiveness as the most relevant information for this process.

An infographic is a visual representation of educational content (25). Infographics are commonly used to share complex information, communicate scientific facts, and drive behavioural change (25). When infographics are designed properly, they can engage both specialists and lay persons (26). Li *et al.* suggest that an infographic that is properly designed can illustrate concepts, clarify data patterns, and provide aesthetic pleasure. Visually simple infographics—in which the visual message presents orderliness, balance, and clarity—may be more effective in driving behavioural change compared to ones that are complex (26).

Even if a vaccination campaign focusing on educating and promoting influenza vaccination may be sufficient to change some of the underlying misconceptions about influenza and vaccine use, information alone will not result in significant changes in behaviour (27). In a recent study aiming to analyze strategies to increase vaccination coverage in healthcare workers, Schumacher *et al.* (28) noted that vaccination campaigns focusing on education and promotion of influenza vaccination only increased vaccine coverage from 25% to 40% in studies with low initial vaccine coverage. They also noted that education and promotional aspects were used as the basis of all campaigns, but when implemented as the sole key intervention, absolute vaccine coverage did not exceed 40%. These authors suggest that campaigns based on education and promotion, or on-site-vaccination, should be combined with other approaches, such as vaccination stands and incentives to achieve high overall vaccination coverage.

Effectiveness of influenza vaccines is the main information that healthcare professionals seek when making their decisions about influenza vaccines and vaccination. Each year, researchers conduct studies to determine how well influenza vaccines work to protect against influenza. However, estimates of how well an influenza vaccine works vary based on study design, outcome(s) measured, population studied, and type of influenza vaccine (29). Influenza vaccine effectiveness primarily depends on the vaccinated individual's characteristics, such as age and health status, and how closely the vaccine matches the prevalent virus strains circulating in the community (29). It can also depend on the infection history of an individual (30). Therefore, influenza vaccine effectiveness can vary from season to season. In Canada, NACI provides annual recommendations regarding

the use of authorized influenza vaccines to the Public Health Agency of Canada (31). These recommendations are based on up-to-date information on influenza epidemiology, immunization practices and influenza vaccine products authorized and available for use in Canada. The outcomes of the survey from the current study support the importance of sharing this up-to-date information about influenza vaccine effectiveness and associated recommendations with healthcare professionals. However, healthcare professionals must be vaccinated at the start of influenza season, when relevant vaccine effectiveness estimates are not yet available and typically become known only after the influenza season has ended. Therefore, it might be relevant to share general influenza vaccine effectiveness statistics, including those from the previous year, with healthcare professionals. The outcomes of the survey also suggest that the use of the infographics may be important in communicating this information.

This study demonstrated a number of strengths. As far as is known, this study is the first conducted in Canada to identify the preferred format and type of information that healthcare professionals will consider when deciding whether to receive an influenza vaccination. As such, the main strength of this study is to contribute to increase the body of knowledge on strategies to increase influenza vaccination uptake among healthcare professionals using Facebook. Since healthcare professionals across the country participated in the study, the diversity of the sample makes the results applicable to various healthcare settings. The study's focus on the promotional formats and types of information that healthcare professionals are looking when deciding on influenza vaccination adds practical significance to its results, as it could direct the decisions related to the goal of improving influenza vaccination among healthcare professionals.

Limitations

The study was limited in several ways. Since the study was underway at the start of COVID-19, participant responses may have been influenced by "survey fatigue" (32) due to their involvement in multiple studies. This shortcoming was mitigated by allowing participants to complete the study at their own pace and within a reasonable time.

Facebook surveys themselves have reliability issues, such as incidences of fraudulent participants and the use false emails by participants, out of concern that their information may be distributed to third parties and misused (33). Validating participant identities by matching IP addresses to reported provinces or territories would have been helpful to identify more false emails.

On Facebook, the users' opinions are easily accessible to other users. This may have led participants to being influenced by the opinions of other people. Also, participants may have responded with what they believe researchers wanted to hear, rather than honestly expressing their own thoughts (33).

In addition to a small sample of a social media platform users, most respondents reported being female and nurses located in Ontario or Québec, which is not representative of the entire breadth of healthcare professionals in Canada. Therefore, the limited representation of many sectors of the health profession makes it difficult to generalize the study's results to all healthcare professionals.

The percentage of missing data could affect the generalizability of the results. This bias was mitigated by reporting both the percentage and valid percentage in the tables to reflect the actual data.

Finally, one limitation that arose as part of the work is the challenge of reliably coding the preferred media type used in communication. Future research could include developing a focused coding process that aims to address the issue of preferential communication in interventions (34).

Conclusion

The results of this study suggest that infographics may be an important method for promoting influenza vaccines and vaccination among healthcare professionals on Facebook. These visual representations should focus on vaccine effectiveness to respond to the information needs of healthcare professionals. However, because influenza vaccine effectiveness can vary from season to season, and this information is only available after the influenza season, it appears important to share up-to-date information or general statistics about influenza vaccines effectiveness and recommendations with healthcare professionals when designing infographics. The next steps will be to design a marketing campaign focused on vaccine effectiveness, using infographics as a promotional format. Following the marketing campaign, it will be possible to measure healthcare professionals' knowledge, attitudes and perceptions of influenza vaccine and vaccination, allowing for an assessment of the social marketing campaign's effectiveness in using infographics as a communication tool.

Authors' statement

MTD — Conceptualization, methodology, data analysis, writing–original draft, writing–review & editing
KO — Conceptualization, funding acquisition, supervision, methodology, data analysis, writing–review & editing
LMB — Conceptualization, funding acquisition, supervision, methodology, data analysis, writing–review & editing
BG — Conceptualization, supervision, methodology, data analysis, validation, visualization, writing–review & editing

The content and view expressed in this article are those of the authors and do not necessarily reflect those of the Government of Canada.

Competing interests

The authors declare no competing interests.

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Appendix

Supplemental material is available upon request to the author: mtantcho@uoguelph.ca

Supplemental A: Facebook Survey with Health Professionals on Influenza Vaccination

What do parents of school-aged children want to know about HPV vaccination in Canada? Results of an online survey on Facebook

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Abstract

Background: To identify the source of information, preferred promotional formats, and the type of information parents of school-aged children eligible for human papillomavirus (HPV) vaccination would consider in their decision-making process.

Methods: A bilingual (English and French) pre-campaign survey employing Facebook advertisements was used to recruit parents of school-aged children aged between 9 and 15 years across Canada to participate in the study. The survey consisted of 20 closed-ended and two open-ended questions. Recruitment on Facebook occurred between March 2021 and February 2022. Participants meeting specific requirements were eligible to participate in the study.

Results: A total of 764 parents participated in the study, and 554 met the eligibility criteria. Representation was obtained from nine provinces and two territories. The majority of respondents (24.9%; n=138) indicated that they turned to sources other than social media platforms when it came to making decisions about HPV vaccination. Among other sources, respondents first considered the recommendations made by their healthcare providers (17.5%; n=38). Respondents also reported infographics as the format most likely to influence their decision-making (20.8%; n=115), over other types of resources. Finally, potential side-effects associated with HPV vaccines versus HPV infection outcomes were among the main topics of information the respondents looked at in their decision-making process.

Conclusion: Infographics can be an important social marketing component for educating parents about the vaccination of school-aged children against HPV. These visual representations should focus on HPV vaccine safety, to respond to the information needs of parents. This intervention should be combined with healthcare provider recommendations.

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Keywords: HPV, vaccination, misinformation, Facebook, social media, social marketing, infographics, survey

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Introduction

Human papillomavirus (HPV), a sexually transmitted infection, is the cause of several cancers, including cervical cancer (1–3). It is estimated that 550,000 Canadians are infected with HPV each year, and almost 80% of females of reproductive age will be infected at some point in their life (4). Cervical cancer causes over 400 deaths in Canada per year, and more than 1,300 Canadians are diagnosed each year (5). Preventive interventions, such as vaccination and screening, are known to reduce the risk of cervical cancer and death.

The HPV vaccination is part of routine, school-based immunization programs in Canada. The efficacy of the vaccine is optimal (close to 100%) when it is administered before exposure to the targeted HPV types (6,7). Provinces and territories in

Canada have typically offered a two-dose HPV vaccination program for children in grades 4 through 10 (8).

The SARS-CoV-2 pandemic led to a disruption in routine vaccination programs, resulting in many children missing doses of HPV vaccine (9). The impact of the pandemic on vaccination coverage rates against HPV for school-aged children has been examined by public health experts. For example, in Ontario, 3.0% of 12-year-old students received HPV vaccine for the 2020–2021 school year (10). This proportion increased to 16.6% in 2021–2022 and 47.8% in 2022–2023 (10). Before the pandemic, a pooled analysis showed that national vaccine coverage for HPV was approximately 55.91% (4). Despite the existing free and nationally available school-based programs and strategies developed across the country to catch up on missing vaccinations, the hesitancy of parents towards HPV vaccination for their children can compromise HPV vaccine uptake (11).

The HPV vaccine safety, side-effects, and effectiveness are among the primary concerns of vaccine-hesitant parents (11–15). While many parents perceive their healthcare providers to be a key source of information and advice about HPV vaccines (14,16), they can also consult online platforms and social networks to search for other information and share their doubts about vaccines (17). The downside is that social media and online social networks are the medium for disseminating information that maximizes engagement (18), without measures to control the quality of the content shared on such portals (19). A well-established pitfall of social media and online social networks is the propagation of misinformation. Following Guess and Lyons (20), this study defines misinformation as constituting a claim that contradicts or distorts common understandings of verifiable facts. Such misinformation, when spread on social media, can incite negative emotions towards vaccines, and may lead to an increase in vaccine hesitancy (21–23).

In this context, social marketing represents a relevant approach to help address vaccine hesitancy among parents of school-aged children eligible for HPV vaccination (24). This approach could assist in designing unique communication strategies for parents, to help increase HPV vaccine uptake (24). This project results from collaboration between researchers from the University of Guelph and the Canadian Public Health Association (CPHA). The objective of this research was to identify the preferred promotional formats and type of information that parents of school-aged children eligible for HPV vaccination would consider in their decision-making process to vaccinate their children against HPV. As far as available information indicates, there are no recorded studies examining what Canadian parents want to know about HPV vaccination to inform their decision. Instead, previous studies have primarily focused on parents' perceptions, knowledge, attitudes and/or behaviours regarding HPV vaccination for their children (25–29), and a few on the effects of psychosocial determinants on parental decision-making (30,31).

Methods

Participant recruitment

The CPHA's Facebook page was used to display advertisements to recruit a convenience sample of parents of school-aged children on Facebook, over an 11 month period, from March 2021 to February 2022. The advertisements led participants to a Facebook landing page where they consented to participate in the study.

Participants meeting the following requirements were eligible: 1) Must be 18 years of age or older; 2) have at least one child between 9 and 15 years of age in their care; 3) live in Canada; and 4) be able to respond to questions in English or French. A sample of 1,250 parents (n=1,000 for the English sample and n=250 for the French sample) were targeted, based on the participation rates of parents of school-aged children from previous projects. This represents a convenience sample compared to the Canadian population estimated at 36.3 million in 2021 (including citizen and non-citizen) (32). All responses were anonymized. Two reminders were sent to non-responders to optimize the response rate.

Measures

The survey consisted of 20 closed-ended and two open-ended questions and took approximately 15 minutes to complete (see the survey questionnaire in the **Appendix**, **Supplemental material**). Components of the Vaccine Hesitancy Scale (VHS) (33) were adapted to the COM-B model for behaviour change (34,35), to develop the questionnaire. The VHS has face validity, and its psychometric properties and validity have been assessed in low-income and developed countries (36,37). Additionally, adapted versions of the tool have been used in studies across the world, revealing that VHS is a reliable tool for measuring vaccine hesitancy (38–42).

The COM-B model (34,35) is a behaviour change framework that builds upon 19 behaviour change framework, suggesting that the following three components are important for a behaviour to occur:

1. Capability, which refers to the knowledge, skills and abilities to engage in the behaviour

2. Opportunity, or external factors that make performing the behaviour possible

3. Motivation, or internal processes that influence decision-making and direct the behaviour

The framework's reliability has been well-established, and it is widely used to develop behavioural interventions. Items specific to social media sources, preferred promotional formats, and the type of information parents would consider in their decision-making were developed in collaboration with Immunize

Canada, a national coalition of non-governmental, professional, health, government, and private sector organizations dedicated to promoting the benefits of immunization. This work focuses on HPV information sources, HPV promotional formats, and relevant information that parents of school-aged children, who are eligible for the HPV vaccine would prioritize in their decision-making process. The answers to these questions were crucial for the researchers to implement an effective social marketing campaign.

Data analysis

The collected data were compiled and analyzed using SPSS software. Data cleaning consisted of checking the data to identify and remove problematic cases. Cases with a 20% or more non-completion rate were deleted. There were 210 respondents were excluded because they did not meet at least one of the eligibility criteria or had a 20% or higher non-completion rate. Variables were checked for univariate outliers. The responses to questions about HPV information sources were grouped into two main variables: 1) social media sources, and 2) "other" sources. Social media sources combined the responses of participants who stated that they relied on Facebook, Twitter, Instagram, Pinterest, and/or Reddit to obtain credible information about vaccines and vaccination for HPV. Other sources combined the responses of participants who relied on scholarly and/or non-scholarly sources that were not considered social media to obtain credible information about vaccines and vaccination for HPV (see **Table 1** for more details). The results were reported with frequency distributions.

Table 1: Frequency table of social media and other sources the participants relied on to obtain credible information about human papillomavirus vaccines and vaccination

Social media source	N[a]	Percentage (%)
Other	138	24.9
Facebook	129	23.3
Reddit	43	7.8
Twitter	32	5.8
Pinterest	15	2.7
Instagram	5	0.9
Total	362	65.3
Missing	192	34.7
Total	554	100.0

[a] Number of respondents who checked the box

Results

Participant demographics

Among the 554 parents who met the eligibility criteria and were included in the study, 53.8% of respondents (n=298) had one child between 9 and 15 years of age, while only 2.3% (n=13) had four children between 9 and 15 years of age. Most respondents (92.6%; n=513) were female caregivers or mothers; only 6.3% (n=35) identified as male. Representation was obtained from nine provinces and two territories. These results are summarized in **Table 2**.

Social media and other sources the participants relied on to obtain credible information

A majority of participants reported relying on "other" sources of information to obtain credible information about HPV vaccines and vaccination (24.9%; n=138) (see Table 1). They chose Facebook as the second most used source (23.3%; n=129). Reddit was the third social media source caregivers relied on (7.8%; n=43), with being Twitter (now known as X) being the fourth (5.8%; n=32).

The "other" sources were grouped in **Table 3** into two main categories: scholarly sources and non-scholarly sources. These were sources other than social media that participants specified as influencing their decision-making about HPV vaccines and vaccination. Among respondents who selected the "other" option, 48.4% (n=105) relied on non-scholarly sources, while 17.1% (n=37) relied on scholarly sources (see Table 3). Among non-scholarly sources, parents stated that they relied mainly on information from healthcare providers (17.5%; n=38). Parents also stated that they relied on information from search engines and websites (11.1%; n=24). Only 0.7% (n=4) relied on personal experience to obtain credible information about HPV vaccines and vaccination. Finally, 20.3 % (n=44) of parents stated that they do not consult social media for vaccine information. These results are summarized in **Table 4**.

Table 3: Frequency table of "other" sources the participants relied on to obtain credible information about human papillomavirus vaccines and vaccination

Source	N	Percent (%)	Valid percent[a] (%)
Non-scholarly sources	105	19.0	48.4
Non-classifiable	75	13.5	34.6
Scholarly sources	37	6.7	17.1
Total	217	39.2	100.0
Missing	337	60.8	N/A
Grand total	554	100.0	N/A

Abbreviation: N/A, not applicable
[a] Percentage after missing responses are disregarded

Promotional formats used to provide human papillomavirus vaccination information that could influence parents' decision-making

Infographics were reported as the format most likely to influence a participant's decision-making (n=115); other sources (e.g., information from healthcare professionals and public health

Table 2: Frequency table of the demographic characteristics of the participants

Demographics characteristics	Sample size (N)	Percentage (%)
Ages (years)	**553**	**99.8**
25–34	28	5.1
35–44	317	57.2
45–54	198	35.7
55–64	10	1.8
Missing	1	0.2
Sex	**553**	**99.8**
Female	513	92.6
Male	35	6.3
Chose not to respond	5	0.9
Missing	1	0.2
Gender	**554**	**100.0**
Woman	508	91.7
Man	36	6.5
Other	3	0.5
Chose not to respond	7	1.3
Level of education	**554**	**100.0**
Some high school	6	1.1
High school	32	5.8
Some college or university	64	11.6
College diploma	127	22.9
Apprenticeship training and trades	17	3.1
Professional certification	37	6.6
Undergraduate degree	162	29.2
Graduate degree	109	19.7
Province of residence	**552**	**99.6**
Alberta	90	16.2
British Columbia	75	13.5
Manitoba	36	6.5
New Brunswick	21	3.8
Newfoundland and Labrador	6	1.1
Northwest Territories	2	0.4
Nova Scotia	27	4.9
Ontario	194	35.0
Québec	49	8.8
Saskatchewan	48	8.7
Yukon	4	0.7
Total	552	99.6
Missing	2	0.4
Number of children ages 9–15	**551**	**99.5**
1	298	53.8
2	197	35.6
3	43	7.8
4	13	2.3
Missing	3	0.5

Table 2: Frequency table of the demographic characteristics of the participants (*continued*)

Demographics characteristics	Sample size (N)	Percentage (%)
Number of children ages 9–15, female	**548**	**98.9**
0	211	38.1
1	259	46.8
2	70	12.6
3	6	1.1
4	2	0.4
Missing	6	1.1
Number of children ages 9–15, male	**548**	**98.9**
0	204	36.8
1	260	46.9
2	71	12.8
3	12	2.2
4	1	0.2
Missing	6	1.1

Table 4: Frequency table of non-scholarly sources parents relied on to obtain credible information about human papillomavirus vaccines and vaccination

Sources	N	Percent (%)	Valid percent[a] (%)
Don't consult social media for vaccine information	44	7.9	20.3
Healthcare providers	38	6.9	17.5
Scholarly sources	37	6.7	17.1
Other	31	5.6	14.3
Search engines and websites	24	4.3	11.1
News and videos	16	2.9	7.4
Public health organizations	14	2.5	6.5
Personal experience	4	0.7	1.8
Blogs	1	0.2	0.5
Applications	7	1.3	3.2
Drug label	1	0.2	0.5
Total	217	39.2	100.0
Missing	337	60.8	N/A
Grand Total	554	100.0	N/A

Abbreviation: N/A, not applicable
[a] Percentage after missing responses are disregarded

organizations, and personal experience) ranked second (n=86), narratives/stories (n=67) ranked third, and videos ranked fourth (n=50). Images were ranked fifth (n=19) (see **Table 5**).

Table 5: Frequency table of the promotional formats used to provide human papillomavirus vaccination information, in order from most likely "1" to least likely "5" to influence decision-making

Promotional formats	N[a]	Percent (%)	Valid percent[b] (%)
Infographics	115	20.8	34.1
Others	86	15.5	25.5
Narratives/stories	67	12.1	19.9
Videos	50	9.0	14.8
Images	19	3.4	5.6
Total	337	60.8	100.0
Missing	217	39.2	N/A
Grand total	554	100.0	N/A

Abbreviation: N/A, not applicable
[a] Number of participants ranking the format first
[b] Percentage after missing responses are disregarded

Information that parents considered to make their decision about human papillomavirus vaccination

Side-effects of HPV vaccines was the main information topic parents searched for when making decisions about HPV vaccination (359 respondents selected this option); HPV infection outcomes (e.g., cancer) followed (263 respondents). Information on the chances of getting HPV infection (233 respondents) and how HPV vaccines are tested (203 respondents) was also important. Homeopathic remedies (29 respondents) and alternative HPV vaccination schedules (61 respondents) were reported as among the least valuable information (see **Table 6** for the results and the predefined responses). The main findings of this study are summarized in the Supplemental material.

Table 6: Information that parents looked for to make their decision about human papillomavirus vaccination

Information parents looked for in order to make their decision about HPV vaccination	N[a]
What are the side-effects of HPV vaccines?	359
HPV infection outcomes (e.g., cancer)	263
Chances of getting HPV infection	233
How are HPV vaccines tested?	203
Who regulates HPV vaccine safety?	190
Who monitors HPV vaccine safety?	185
Is it safe to get more than one vaccine at the same time?	170
What are HPV vaccine ingredients?	169
Can someone get sick from an HPV vaccine?	139
Who is providing the vaccine (e.g., doctor, nurse, etc.)?	136
Are additives in HPV vaccines safe?	135
How is the HPV vaccination schedule tested?	104
How to minimize HPV vaccine injection pain and fear?	82
Alternative HPV vaccination schedules	61
Other	33
Homeopathic remedies	29
Don't know/Not sure	21

Abbreviation: HPV, human papillomavirus
[a] Number of participants who checked the box

Discussion

This study was conducted to identify the source of information, the preferred promotional formats, and type of information parents of school-aged children eligible for HPV vaccination would consider in their decision-making process.

The study revealed that parents (respondents) relied first on sources other than social media to obtain credible information about HPV vaccines and vaccination. They considered their healthcare providers to be the most important source of information in influencing their decision-making around HPV vaccines and vaccination for their children. These results confirmed that, on average, parents value the information and recommendations provided by their children's healthcare providers (43) more than what is posted on social media. Therefore, healthcare providers may be crucial in improving HPV vaccination uptake rates among school-aged children (44). The impact of this result can be twofold. First, when healthcare providers are concerned about parents' potential negative reactions to an HPV vaccination recommendation, these findings should provide reassurance (43). At the same time, healthcare providers will need to be prepared to provide accurate information on HPV vaccination to both pro-vaccine and vaccine-hesitant parents (43). Second, a healthcare provider's vaccine concerns, hesitancy, and inadequate knowledge could hinder them from encouraging parents to get their children vaccinated (44). Public health organizations should ensure that healthcare providers have the support and education they need to be informed about HPV vaccination, to reduce any vaccine hesitancy that they themselves may have (44).

Parents also reported infographics as the promotional format most likely to influence their decision-making regarding HPV vaccines and vaccination. An infographic is defined as a visual representation of educational content (45). Infographics are commonly used to deliver complex information, communicate scientific facts, and foster behavioural change (45). When designed properly, infographics can engage both specialists and laypersons (46). Li *et al.* (46) suggest that an infographic that is properly designed can illustrate concepts, clarify data patterns, and provide aesthetic pleasure. Research shows that visually simple infographics, when the visual message presents orderliness, balance, and clarity, are more effective in driving behavioural change, compared to messages that are complex (46). For example, in a large longitudinal study involving young adults, Garcia-Retamero *et al.* (47), conducted an eight-hour educational intervention. They examined the impact

of the intervention on the efficacy of a message for promoting condom use. The authors noted that simple brochures featuring visual aids changed attitudes and behavioural intentions as effectively as an extensive intervention. These findings suggest the importance of making the visual message simple when designing infographics on HPV vaccination and countering manipulative and false messages.

Finally, side-effects of HPV vaccines were the main information topic that parents sought when making their decision about HPV vaccination. These results align with previous work. For example, a study from the United States National Cancer Institute showed an increase in the percentage of parents who declined the HPV vaccine for their children due to safety concerns, from 13% in 2015 to 23% in 2018. However, reports of serious health issues after HPV vaccination were consistently rare during the same period (48). The authors hypothesize that rising vaccine safety concerns among parents drive increased social media use and parents' reliance on online sources to find vaccine information. Therefore, it might be relevant to address parents' concerns regarding vaccine safety online.

Limitations

As with most research studies, the current study has many limitations, with some of the most relevant being the following. The recruitment process was extended to 11 months due to the heightened risk of fraud resulting from false identification of participants. This limitation was mitigated by excluding participants who did not complete sociodemographic questions and did not respond to the survey within a reasonable period. The study was underway at the beginning of the COVID-19 pandemic. Survey participants may have been approached more frequently within a short period, leading them to produce suboptimal responses (49). The limited information gathered on study participants and the high percentage of missing information could affect the validity of the results of the study. To mitigate this bias, careful selection of statistical methods that minimize the impact of missing data, such as including the valid percentage in the analysis, were carried out. Results were derived from a small sample of Facebook users, therefore, generalizability should be contextualized accordingly.

Conclusion

The results of the current study suggest that infographics can be an important social marketing component for educating parents about the vaccination of school-aged children against HPV. These visual representations should focus on vaccine safety to respond to the information needs of parents. However, focusing this intervention on parents may not increase vaccine uptake (50). Infographics are more effective in increasing vaccine uptake in combination with other strategies, such as clear and accurate healthcare provider recommendations (50–52). Healthcare providers should also know about common misinformation/disinformation circulated in social media and be prepared to address this through appropriate educational techniques, such as attitudinal inoculation (53). Further research into how to use social marketing approaches to address such misinformation/disinformation may provide valuable insights on how to improve vaccination rates among school-aged children.

Authors' statement

MTD — Conceptualization, methodology, data analysis, writing–original draft, writing–review & editing
BG — Conceptualization, supervision, methodology, data analysis, validation, visualization, writing–review & editing
KO — Conceptualization, funding acquisition, supervision, methodology, data analysis, writing–review & editing
AP — Writing–review & editing

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Competing interests

The authors declare no competing interests.

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Appendix

Supplemental material is available upon request to the author: mtantcho@uoguelph.ca

OVERVIEW

Tracking Canada's 2015 vaccine research and development priorities: Where are we a decade later?

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Abstract

Background: In 2015, Public Health Agency of Canada (PHAC) identified a set of priorities for research and development (R&D) of new and improved human and animal vaccines. Thirty human pathogens were grouped by vaccine development timeline (short: 0–6 years; medium: 7–12 years; long: 13 years or longer) and ranked by R&D priority (high, medium, low).

Objective: To characterize the vaccine development pathway for these 30 pathogens to inform a 2025 update to PHAC's vaccine R&D priorities.

Methods: For each pathogen, we conducted a targeted search for vaccines authorized in Canada since 2015 using the Health Canada Drug Product Database and Canadian Immunization Guide and for candidates in clinical trials, in the registry, ClinicalTrials.gov (primary completion date of May 1, 2015 or later). Search results were downloaded and filtered by study status, phase and type. For select pathogens, we conducted additional searches in published (PubMed) and grey literature (other trial registries, industry press releases, and Web searches).

Results: Seven pathogens had at least one newly authorized vaccine since 2015: three of 13 high-priority (influenza, n=4; *Streptococcus pneumoniae*, n=2; respiratory syncytial virus, n=3); two of eight medium-priority (herpes zoster, n=1; meningococcal serogroup B, n=1); and, two of nine low-priority pathogens (dengue, n=2; human papillomavirus, n=1). Nineteen pathogens had no authorized vaccine in Canada or elsewhere, although five had candidates in phase 3 trials (*Clostridioides difficile, Neisseria gonorrhoeae, Borrelia burgdorferi*, norovirus and cytomegalovirus).

Conclusion: Although some of the pathogens on the 2015 list now have authorized vaccines or candidates in late-stage clinical development, important gaps persist, which will inform PHAC's 2025 vaccine R&D update.

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Introduction

In 2015, the Public Health Agency of Canada (PHAC, "Agency") published a set of priorities for research and development (R&D) focusing on new and improved human and animal vaccines (1). The Agency consulted expert groups in a three-stage process to establish a final list of pathogens/diseases ("pathogens") of low, medium and high-priority for vaccine R&D based on their public health impact in the Canadian context and framed within likely time horizons of a vaccine coming to market.

Since 2015, significant advances in technology and data science have led to substantial progress in vaccine development. The COVID-19 pandemic further accelerated vaccine development by enabling the widespread adoption of mRNA vaccine technology while highlighting the necessity of strengthening all stages of the vaccine life cycle (2). Moreover, the pandemic demonstrated that, with adequate resources and coordinated efforts, vaccine development timelines can be significantly shortened (3). During the pandemic period between 2020 and 2024, 45 vaccines were authorized in Canada (30 were for COVID-19 vaccines), which is considerably higher than the decades prior (2000–2009, 31 authorizations; 2010–2019, 34 authorizations) (4). It is unclear whether such timelines are sustainable in a non-emergency setting.

In light of the changing vaccine landscape, progress in vaccine development was examined for the 30 human pathogens on the 2015 R&D priority list, the majority (n=21, 70%) of which did not have an authorized vaccine in Canada in 2015. A more detailed examination was conducted of vaccines targeting high-priority pathogens, as well as those in advanced stages of clinical testing (i.e., at phase 3) for medium- and low-priority pathogens. The primary aims in mapping pathogens designated as priorities in 2015 to the current vaccine landscape are to generate evidence to inform the 2025 update to PHAC's vaccine R&D priorities and to provide strategic guidance to investigators engaged across different phases of the research lifecycle.

Methods

First, vaccines authorized in Canada for each human pathogen were identified using the Canadian Immunization Guide (5) (listed under the section "Preparations authorized for use in Canada") and the Health Canada Drug Product Database (6). Then, for pathogens lacking authorized vaccines in Canada, the United States (US) clinical trials registry, ClinicalTrials.gov (7), was searched for vaccine candidates still undergoing testing. Targeted searches of published literature were also conducted in PubMed, in addition to grey literature searches across other databases and select clinical trial registries. Details on data sources, search parameters and date limits are provided in the **Appendix**, Table A1 (8).

Results

Since 2015, two pathogens (respiratory syncytial virus [RSV] and dengue virus) from the 2015 R&D list, which did not have existing authorized vaccines, had newly authorized vaccines for human use, though only RSV vaccines received approval in Canada. Based on publicly available information as of April–May 2024, 19 pathogens still had no authorized vaccine in Canada or elsewhere, though five had candidates in phase 3 trials (*Clostridioides difficile, Neisseria gonorrhoeae*, *Borrelia burgdorferi*, norovirus and cytomegalovirus [CMV]). **Figure 1** presents updates on all 30 human pathogens by the most recent research stage achieved as of 2024, while **Figure 2** highlights the potential implications of this progression for R&D across the research lifecycle. The following sections also provide comprehensive summaries of the most advanced candidates of the high-priority pathogens that lacked authorized vaccines in Canada in 2015. For medium- and low-priority pathogens, a detailed overview is provided for phase 3 or newly authorized vaccine candidates only. Brief updates on all pathogens with existing authorized vaccines in 2015 are provided in the Appendix (8).

High-priority pathogens: Overview

Of the 13 high-priority pathogens on the 2015 list, among those that had existing authorized vaccines in Canada, there were new approvals for influenza and *Streptococcus pneumoniae*, phase 3 candidates for tuberculosis (TB) and label changes for *Bordetella pertussis*. In addition, RSV, for which there was no vaccine in 2015, received its first Canadian authorization in 2023. Among the remaining eight high-priority pathogens, two had at least one candidate in phase 3 testing (*C. difficile, N. gonorrhoeae*), three were in phase 2 (*Staphylococcus aureus*, HIV, universal influenza) and three were in phase 1 (Group A streptococcus, hepatitis C, *Chlamydia trachomatis*) (Figure 1).

Details of the most advanced candidates are described below for the nine high-priority pathogens lacking an authorized vaccine in 2015. Additional information for all the high-priority pathogens is available in the Appendix (8).

High-priority pathogens: Status for those lacking authorized vaccines in 2015 in Canada

Respiratory syncytial virus (RSV): Three vaccines for RSV have been authorized since 2015: two subunit vaccines containing a stabilized prefusion confirmation of the RSV F glycoprotein (ABRYSVO® by Pfizer and AREXVY® by GlaxoSmithKline [GSK]); and one mRNA vaccine encoding the RSV F glycoprotein (mRESVIA® by Moderna). In Canada, all three vaccines were approved for older adults for the prevention of RSV-associated lower respiratory tract disease, while ABRYSVO was also approved for pregnant individuals to protect infants from birth to six months of age against RSV-associated lower respiratory tract disease.

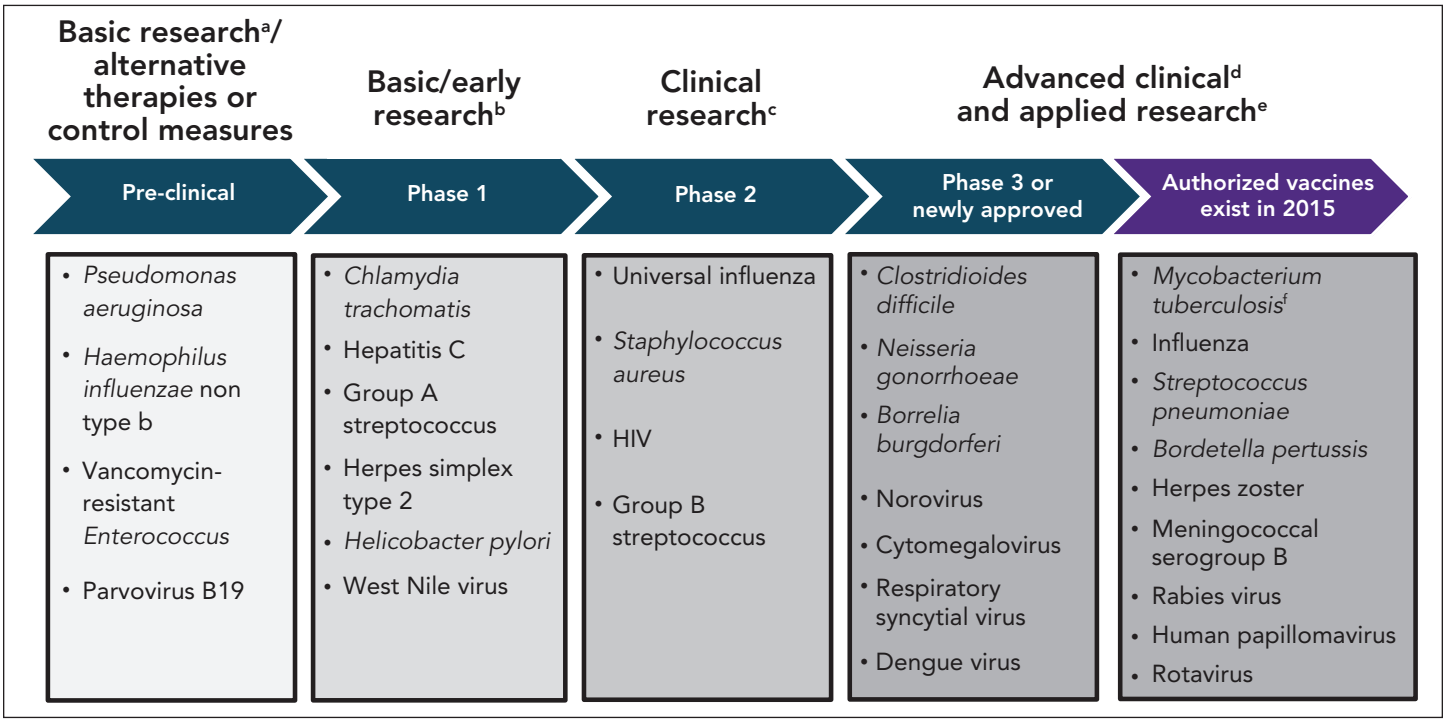
***Clostridioides difficile*:** One toxoid-based vaccine candidate for *C. difficile* was tested in a phase 3 trial in older adults (NCT03579459, NCT03090191, NCT03918629). In their most recently reported data, Pfizer's PF–06425090 did not meet its primary efficacy endpoint (prevention of primary *C. difficile* infection), though the candidate was deemed safe and well tolerated and showed potential clinical benefit by reducing severe outcomes like *C. difficile* infection requiring medical attention (9). Pfizer is currently evaluating next steps for this vaccine (10).

Figure 1: Status of vaccine development of all human pathogens from the 2015 research and development (R&D) list as of 2024[a,b,c,d,e]

Rank in 2015	Pathogen	Authorized existing vaccine in 2015?	Current status by latest stage reached (2015–2024)				
			Pre-clinical	Phase 1	Phase 2	Phase 3	Approved
HIGH	Respiratory syncytial virus	No					■
	Clostridioides difficile	No				■	
	Neisseria gonorrhoeae	No				■	
	Universal influenza	No			■		
	Staphylococcus aureus	No			■		
	HIV	No			■		
	Chlamydia trachomatis	No		■			
	Hepatitis C	No		■			
	Group A streptococcus	No		■			
	Mycobacterium tuberculosis	Yes					■
	Influenza	Yes					■
	Streptococcus pneumoniae	Yes					■
	Bordetella pertussis	Yes					■
MEDIUM	***Borrelia burgdorferi***	No				■	
	Norovirus	No				■	
	Herpes simplex type 2	No		■			
	Helicobacter pylori	No		■			
	Pseudomonas aeruginosa	No	■				
	***Haemophilus influenzae* non type b**	No	■				
	Herpes zoster	Yes					■
	Meningococcal serogroup B	Yes					■
LOW	Dengue virus	No					■
	Cytomegalovirus	No				■	
	Group B streptococcus	No			■		
	West Nile virus	No		■			
	Vancomycin-resistant *Enterococcus*	No	■				
	Parvovirus B19	No	■				
	Rotavirus	Yes					■
	Rabies virus	Yes					■
	Human papillomavirus	Yes					■

[a] Pathogens shown in bold are those that lack authorized vaccines in 2024 (possible candidates for 2025 list)
[b] "Authorized existing vaccine in 2015" refers to status in Canada in 2015: No=new vaccine required; Yes=existing vaccine could be improved
[c] "Approved" as a "Current status" refers to any approval for human use in Canada or outside Canada in 2015 or later. Those with existing vaccines in 2015 are all marked "approved"
[d] For *Mycobacterium tuberculosis*, earliest year of marketing of the Bacille Calmette-Guérin (BCG) vaccine in Canada is 1961, as noted by Health Canada's Drug Product Database. Though the Canadian Immunization Guide lists the BCG vaccine as a "Preparation authorized for use in Canada," most provinces and territories discontinued routine use in the 1970s; however, BCG is part of the publicly funded childhood vaccination program in the Northwest Territories and Nunavut; in other parts of Canada, it is also used for tuberculosis prevention in infants in high risk communities. The BCG vaccine may also be considered in exceptional circumstances, such as for persons at high risk of repeated exposure, for certain long term travellers to high prevalence countries and in infants born to mothers with infectious tuberculosis disease
[e] Results for *Haemophilus influenzae* non type b are from the last search on May 2024. A phase 1 trial (NCT06465420) was registered in ClinicalTrials.gov in June 2024, which was after the last search was conducted

Figure 2: Human pathogens from the 2015 research and development (R&D) list grouped by most advanced vaccine development stage to guide future research efforts[a,b,c,d,e,f]



[a] "Basic research" in "Basic research/alternative therapies or control measures" refers to focusing on laboratory and animal testing. Sample research questions can address basic biology or immunology (e.g., characterizing pathogen biology, transmission dynamics and host immune responses, identifying novel antigens and vaccine targets, developing and validating animal models for vaccine testing). Main stakeholders include basic science or academic research institutes or wet lab scientists

[b] "Basic/early research" focuses on safety, preliminary immune response and dosage in humans. Sample research questions can focus on immunology and vaccine design (e.g., proof-of-concept studies to validate immunological mechanisms and immune response, optimizing vaccine formulations and dosages, adjuvants and delivery platforms, investigating immune escape mechanisms and antigenic variation to inform vaccine design). Key contributors are typically academic or government research institutes, early-stage biotech companies and manufacturers

[c] "Clinical research" refers to a focus on expanded safety and immunogenicity. Sample research and development (R&D) questions can focus on immunological performance of the vaccine in targeted or general populations (e.g., immunogenicity studies, dose and schedule optimization studies), as well as ongoing safety monitoring. Key contributors include clinical research networks, academic medical centers and manufacturers

[d] "Advanced clinical" in "Advanced clinical and applied research" refers to research focusing on establishing efficacy and safety in large clinical trials along with assessments of vaccine quality required for authorization (phase 3 and onwards). Large efficacy studies are most often led by manufacturers

[e] "Applied research" in "Advanced clinical and applied research" refers to research focusing on implementation and post-market surveillance: questions address programmatic factors (e.g., assessing acceptability and barriers to uptake, optimal delivery mechanisms, cost-effectiveness) and post-licensure surveillance (e.g., ongoing monitoring of effectiveness, safety in real-world settings). Post-authorization studies can also address vaccine response and safety in special populations not previously studied in clinical trials (e.g., people who are pregnant, immunocompromised or children), concurrent administration with other vaccines, alternate schedules and duration of protection. Routine post marketing surveillance are best addressed by federal/provincial/territorial health authorities. Observational effectiveness studies are best addressed by research networks or institutes of academic partners

[f] For *Mycobacterium tuberculosis*, though the Canadian Immunization Guide lists the Bacille Calmette-Guérin (BCG) vaccine as a "Preparation authorized for use in Canada", most provinces discontinued routine use in the 1970s. However, BCG is part of the publicly funded childhood vaccination program in the Northwest Territories and Nunavut; in other parts of Canada, it is also used for tuberculosis prevention in infants in high risk communities. The BCG vaccine may also be considered in exceptional circumstances, such as for persons at high risk of repeated exposure, for certain long term travellers to high prevalence countries and in infants born to mothers with infectious tuberculosis disease

Note: Groups correspond to the most advanced stage reached as of 2024 and serve as broader, illustrative themes. They are not intended as exhaustive or rigid classifications. Specific R&D questions, stakeholder roles and study designs frequently vary or overlap based on vaccine-specific and pathogen-specific factors. Examples of R&D questions and key stakeholders at each stage are in footnotes above

***Neisseria gonorrhoeae*:** We identified two platforms for *N. gonorrhoeae* vaccine candidates currently in active phase 3 trials (8). Developed by GSK using a Generalized Modules For Membrane Antigens (GMMA)-based platform, NgG is the only candidate to specifically target *N. gonorrhoeae*, as all other trials are investigating whether an existing meningococcal B vaccine, 4CMenB (Bexsero), is effective in preventing *N. gonorrhoeae* infection. NgG is currently in phase 1–2 trials (NCT05630859) and being tested in healthy adults aged 18–50 years. One phase 2 trial of Bexsero (NCT04722003) is being conducted in both male and female adults, while all other trials (NCT04415424, NCT05294588, NCT05766904) have sex/gender restrictions, involving only males, nonbinary individuals, trans women or those assigned male at birth. Both phase 3 trials of Bexsero (NCT04415424, NCT05766904) had listed completion dates in 2025.

Universal influenza: Five candidate universal influenza vaccines (OVX836, chimeric hemagglutinin (HA) construct, M2SR, INFLUENZA G1 and FLU-v) meeting our eligibility criteria had completed phase 2 trials. Developed by Osixav, OVX836, is a novel recombinant universal influenza vaccine candidate based on a nanoparticle platform that targets the internal nucleoprotein. In its phase 2 trial (NCT05060887), OVX836 appeared to be safe and well-tolerated, eliciting humoral and cellular nucleoprotein-specific immune responses and a preliminary signal of protection against influenza (11). Both chimeric HA construct and M2SR are based on influenza virus-based platforms and have completed phase 2 trials in healthy adults (EudraCT 2017–001584-20, EudraCT 2017–004971–30, respectively), as have INFLUENZA G1 (NCT05901636) and FLU-v (NCT03180801, NCT02962908), which both use recombinant-based platforms.

While results from some of these trials are still being reported, future activities and progression to phase 3 testing are unknown.

***Staphylococcus aureus*:** In the past decade, several candidates using diverse platforms and antigens from *S. aureus* have been tested but none has been successfully authorized. As of May 2024, two candidate vaccines have reached phase 2 in different settings and for different outcomes: rFSAV, a recombinant five-antigen vaccine was tested in elective surgery patients in China (Chi CTR2200066259) (12) after completing phase 1 trials (NCT02804711 and NCT03966040); and Biomed rTSST–1, a recombinant toxic shock syndrome toxin-1 variant vaccine, completed its phase 2 trial in January 2021 in healthy adults for prevention of staphylococcal toxic shock syndrome (NCT02814708) (13). Both vaccines were reported to be safe, well-tolerated and immunogenic in their target populations, though future testing activities are unclear.

Human immunodeficiency virus (HIV): Of the 66 potential trials identified from the general and targeted search for HIV vaccine candidates, only two were considered relevant and both were at very early stages (phase 1/2a) of testing in adults. The HIV–CORE0051 study utilizing a chimeric T cell epitope insert (HIVACAT T-cell immunogen or HTI) with sequential administration of a replicative defective chimpanzee adenoviral vector (ChAdOx1) and Modified vaccinia Ankara (MVA) vector, completed phase 1/2a testing in August 2022 (NCT04563377). VIR–1388 (NCT05854381), utilizing a CMV vector, will be tested in phase 1 trials in adults living with asymptomatic CMV. Two other candidates (Ad26.Mos4.HIV, ALVAC-HIV) which were tested in healthy adults in phase 2b/3 trials were both discontinued for failing to protect against HIV acquisition (14,15).

***Chlamydia trachomatis*:** *C. trachomatis*, which was at a pre-clinical stage in 2015, had one candidate, CTH522, which completed phase 1 testing (NCT02787109) in female adults aged 18–45 years. A recombinant protein subunit vaccine, CTH522 was tested for safety and immunogenicity in unadjuvanted or adjuvanted (either with cationic liposomal adjuvant CAF01 or aluminium hydroxide) forms. Both adjuvanted forms were found to be safe, well-tolerated and immunogenic, although CTH522/CAF01 had a better immunogenicity profile (16). Plans for future testing and development are unclear.

Hepatitis C virus (HCV): Hepatitis C virus, which had candidates in phase 2 testing in 2015, had only one candidate that met our eligibility criteria. AdCh3NSmut/MVA-NSmut completed phase 1 trials in various study populations (NCT02568332, NCT02362217, NCT03688061, NCT01296451). This vaccine used a sequential, heterologous prime-boost vaccination regimen based on a replicative defective chimpanzee adenoviral vector and MVA vector encoding non-structural proteins (NS3, NS4, NS5A and NS5B) of HCV genotype–1b. In its phase 1 trial, AdCh3NSmut/MVA-NSmut generated very high levels of both CD8+ and CD4+ HCV-specific T cells targeting multiple HCV antigens (17); however, results from a phase 2 trial in people who inject drugs (NCT01436357) failed to demonstrate protection against chronic HCV infection, although there was some virological evidence of partial HCV control in vaccine recipients (i.e., lower peak HCV RNA levels during acute infection in vaccine recipients vs. placebo) (18). Future testing activities related to AdCh3NSmut/MVA-NSmut are unclear.

Group A streptococcus: As of May 2024, Group A streptococcus had three vaccine candidates in phase 1 trials in healthy adults, all targeting antigens of the M-protein, a key virulence factor. StreptAnova is a 30-valent recombinant vaccine targeting M-proteins found on the surface of 30 Group A streptococcal serotypes. In a phase 1 trial at Dalhousie University (NCT02564237), StreptAnova was reported to be well-tolerated and immunogenic and did not elicit autoimmune or cross-reactive antibodies (19). Another candidate, MJ8VAX, also demonstrated safety and immunogenicity in its phase 1 trial (ACTRN12613000030774) (20), while the phase 1 trial status of a related candidate, P*17/S2 combivax, is listed as "active, not recruiting" (NCT04882514) with an estimated completion date of December 2025.

Medium-priority pathogens: Candidates undergoing phase 3 testing

Six medium-priority pathogens lacked authorized vaccines in 2015 and of these, two (*B. burgdorferi* and norovirus) progressed to phase 3 trials.

***Borrelia burgdorferi* (Lyme disease):** VLA15, a recombinant protein vaccine by Pfizer and Valneva, targets six *B. burgdorferi* serotypes and is currently undergoing a phase 3 trial among participants aged five years and older in North America and Europe in areas where Lyme disease is highly endemic (NCT05477524). This vaccine is also being tested separately for safety in a phase 3 trial in healthy children aged 5–17 years in the US (NCT05634811).

Norovirus: Of the six unique vaccine candidates for norovirus that met our eligibility criteria, two have progressed the furthest and are being tested in study populations of young children. HIL–214 utilized a 2-dose bivalent virus-like particle formulation and is undergoing phase 2b/3 testing (NCT05281094) in children aged five months, while another candidate, Human Norovirus Bivalent (G I.1/G II.4) vaccine, a bivalent recombinant vaccine, is in phase 3 testing (NCT05916326) in children aged six months to 13 years.

Low-priority pathogens: New authorizations or undergoing phase 3 testing

Six of the low-priority pathogens lacked any authorized vaccines in 2015 and, of these, two demonstrated progress, either

by receiving authorization in other jurisdictions outside of Canada (e.g., dengue) or by reaching phase 3 trials (e.g., CMV).

Dengue vaccines which received authorizations outside Canada include Sanofi's Dengvaxia®, approved in the US in 2019 (21) and Takeda's Qdenga®, which was authorized in the European Union in 2022 (22). Both these vaccines are designed to protect against all four serotypes of the dengue virus (DENV–1, DENV–2, DENV–3 and DENV–4); however, the authorized age ranges differ, with Qdenga indicated for individuals as young as four years old and Dengvaxia indicated for those aged nine years and older. Dengvaxia is also not recommended for dengue-naive individuals, while Qdenga can be given regardless of prior infection or exposure history.

For CMV, only Moderna's mRNA candidate, mRNA–1647, reached phase 3 testing (NCT05085366), though several other vaccines candidates were at earlier phases of development. mRNA–1647 was being tested for safety, immunogenicity and efficacy in preventing primary CMV infection among healthy women aged 16–40 years.

Discussion

Vaccine development was monitored for the 30 human pathogens that were included in PHAC's 2015 R&D list due to their associated disease burden, public health impact and/or concerns of antimicrobial resistance. Between 2015 and 2024, two pathogens (RSV and dengue) received their first-ever vaccine approvals (RSV in Canada and dengue in some other countries); however, 19 pathogens remain without a licensed vaccine in Canada or globally, underscoring ongoing gaps in vaccine R&D. Despite the limited number of new authorizations for the pathogens in the 2015 R&D priority list, progress was observed for five pathogens (*C. difficile, N. gonorrhoeae, B. burgdorferi*, norovirus and cytomegalovirus) that are now at phase 3 testing.

Progression through clinical phases is not linear. Though advances were noted among several high-priority pathogens that lacked vaccines in 2015 (RSV, *C. trachomatis*, *N. gonorrhoeae*), four actually regressed (i.e., were at an earlier clinical phase in 2024 compared to 2015: Group A streptococcus, HIV, hepatitis C and universal influenza). Of these, HIV and universal influenza were at phase 3 in 2015 but had receded to phase 2 in 2024, while Group A streptococcus and hepatitis C were at phase 2 testing in 2015, but at phase 1 in 2024. It is possible that some vaccine candidates identified in this paper will not proceed further along the pipeline; however, despite lack of progress in vaccine approvals for some high-priority pathogens since 2015, there were other notable non-vaccine achievements in prevention and disease control, especially for higher-risk priority populations, such as chemoprophylaxis for HIV (23–25), *C. trachomatis* (26) and *N. gonorrhoeae* (26) and highly curative treatments with shorter regimens for hepatitis C (27).

The Canadian vaccine R&D landscape is complex and multifaceted, requiring coordinated efforts among different stakeholders depending on the stage of development. To guide future research efforts, pathogens were grouped by their latest stage of development. It is worth noting that once human testing has begun, only 33.4% of candidates are successfully licensed (28), with the highest risk of failure ("valley of death") lying between phases 2 and 3 (29,30), when primary outcomes expand beyond safety and immunogenicity (focus of phase 2) to include efficacy in larger study populations (phase 3). Pathogens at opposite ends of the development spectrum require distinct research approaches and stakeholders. Pre-clinical candidates require basic science investigations in academic settings to establish animal models and identify vaccine targets, while phase 3 candidates require large clinical trials for regulatory approval, ongoing post-market surveillance and applied implementation research for provincial/territorial authorities (details of setting, stakeholder and type of questions to address are shown in Figure 2 and its footnotes). By this reasoning, seven pathogens can be classified as requiring a focus on advanced clinical and applied research because they have candidates in phase 3 testing or have recent new authorizations, along with nine other pathogens that had existing vaccines in 2015. On the other end of the research lifecycle are those best suited to a focus on basic research or alternative therapies or control measures, which include the four medium or low-priority pathogens that had no candidates in clinical testing (i.e., were at the pre-clinical stage): *Haemophilus influenzae* non type b; *Pseudomonas aeruginosa*; Vancomycin-resistant *Enterococcus*; and parvovirus B19 (Figure 1 and Figure 2). Of note, all high-priority pathogens had at least one vaccine candidate in active clinical trials (phase 1 onwards).

Strengths and limitations

Strengths of this study included a thorough, reproducible search of data sources most relevant to the Canadian context (Canadian registries or databases or those from the US or other similar high-income settings) supplemented with a targeted search of published literature and reports. The results of the quality crosscheck and careful review from multiple data sources also ensured the final results are accurate and complete. Nevertheless, because trial registries rely on self-report from investigators and results are limited by the specific search parameters applied, it is possible candidates included in the final results had been terminated or will not progress further or that relevant trials were registered after the search dates.

These inherent limitations of cross-sectional registry searches are partially offset by the continuous monitoring approach of multiple data sources (reports, registries, press releases and published literature) for priority pathogens to inform the 2025 R&D update. The requirement by regulatory agencies (Health Canada, US Food and Drug Administration) to register vaccine trials before reviewing for authorization also ensure that any significant progress for our pathogens of

interest will be captured. It should be noted that because this work is very specific to the Canadian context, major international milestones (e.g., malaria vaccines) were not captured. Finally, while the 2015 R&D initiative mentions some pathogens with pandemic or outbreak potential (e.g., influenza, either as universal influenza or porcine influenza A), others like mpox and SARS-CoV-2 were not mentioned because they caused widespread outbreaks after the publication of the list.

Conclusion

This study enabled the description and tracking of progress in vaccine development for pathogens in the 2015 Canadian R&D list, ensuring the 2025 update builds on past lessons rather than starting anew. Even though some of the pathogens now have authorized vaccines or candidates in late-stage clinical development, important gaps persist which will inform PHAC's 2025 vaccine R&D update and have potential implications for investigators involved in different phases of the research lifecycle.

Authors' statement

NM — Conceptualization, data curation, methodology, supervision, visualization, validation, writing–original draft, review & editing
KL — Conceptualization, data curation, methodology, investigation, formal analysis, validation, writing–original draft
SCK — Data curation, investigation, formal analysis, validation, writing–original draft, review & editing
HB — Validation, writing–original draft, review & editing
SD — Validation, visualization, writing–original draft, review & editing
AG — Data curation, writing–review & editing
BW — Validation, visualization, writing–original draft, review & editing
MT — Validation, writing–review & editing
KW — Conceptualization, methodology, supervision, validation, writing–original draft, review & editing

Competing interests

None.

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Appendix

Supplemental material is available upon request to the author: nasheed.moqueet@phac-aspc.gc.ca or via the link included in reference 8.

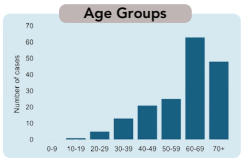
Vector-borne Disease Surveillance in Canada, 2024

MOSQUITO-BORNE DISEASES

190
West Nile virus cases

Sex
64% 36%

Age Groups



Other mosquito-borne diseases

4
Eastern equine encephalitis virus (EEEV) cases

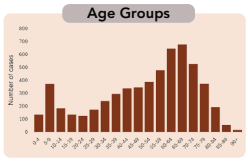
2024 had the **highest** number of **EEEV** cases reported in one year in Canada.

TICK-BORNE DISEASES

5,809
Lyme disease cases

Sex
56% 44%

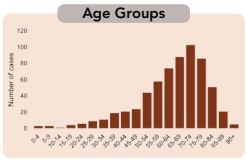
Age Groups



673
Anaplasmosis cases

Sex
61% 39%

Age Groups

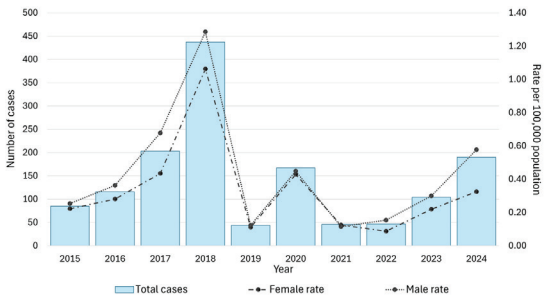


Other tick-borne diseases

10
Babesiosis cases

3
Powassan virus disease cases

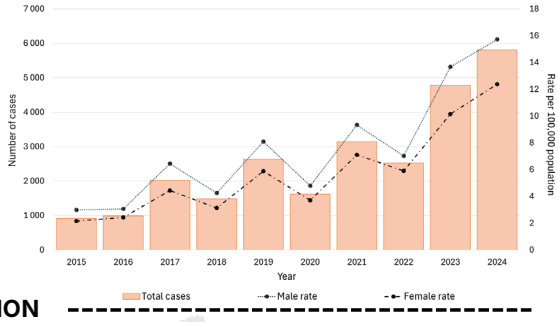
Reported **West Nile virus** cases and rates, **2015 to 2024**



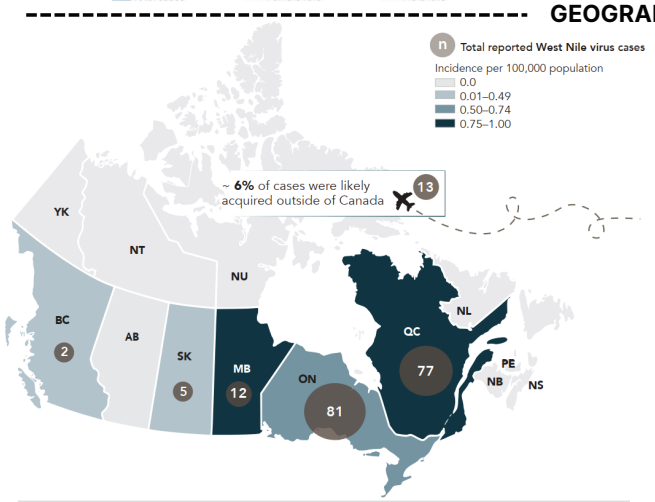
2024 case counts were **HIGHER** than the 2019–2023 5-year average (n=82)

2024 case counts were **HIGHER** than the 2019–2023 5-year average (n=2,942)

Reported **Lyme disease** cases and rates, **2015 to 2024**

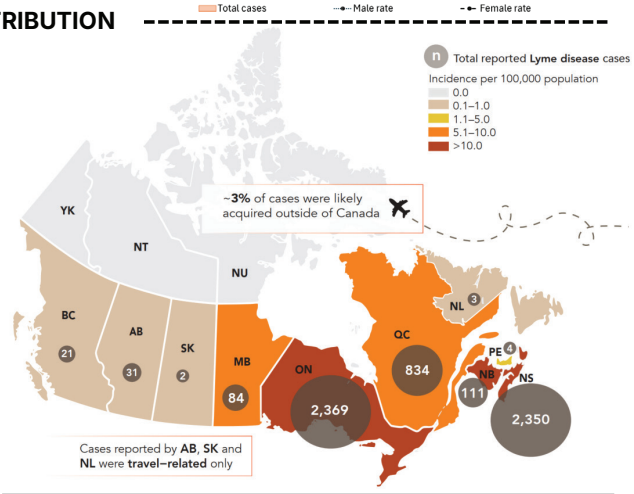


GEOGRAPHIC DISTRIBUTION



Other mosquito-borne diseases

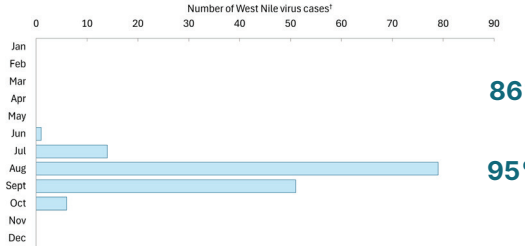
EEEV cases were reported in **Ontario** and **Québec**.



Other tick-borne diseases

Of the **673** cases of **anaplasmosis**, over 93% were reported in **Nova Scotia (69%)** and **Ontario (24%)**.

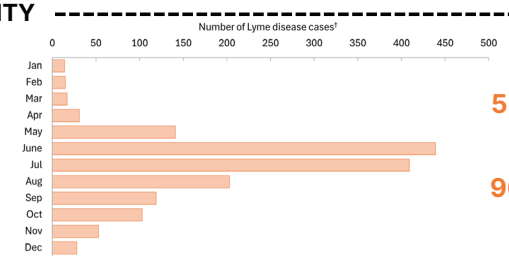
SEASONALITY



86% Illness onset in **August** and **September**

95% Illness onset between **July** and **September**

†Case records where date of illness onset was not provided (n=26) are not included in this analysis



54% Illness onset in **June** and **July**

90% Illness onset between **May** and **October**

†Case records where date of illness onset was not provided (n=4,237) are not included in this analysis

For more information, visit the Vector-borne Disease Surveillance in Canada dashboard pages:
https://health-infobase.canada.ca/?category=Zoonoses

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