School-Based Immunization Programs: An Effective Strategy for Achieving High Vaccination Rates?

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Introduction

Despite the fact that many vaccines are routinely recommended to school-age children, the proportion of World Health Organization (WHO) Member States implementing school-based immunization programs has only increased slightly between 2012 and 2017 (Feldstein et al., 2020; Vandelaer & Olaniran, 2015; World Health Organization, n.d.). In 2012, of the 174 WHO Member States that had responded to questions in the Joint Reporting Form (JRF) regarding routine vaccine doses in schools, only 95 Member states (or 55%) had reported using school-based immunization programs (Vandelaer & Olaniran, 2015). Five years later in 2017, the proportion increased to 108 of 181 Member States, (or 60%, a slight gain of 5 percentage points) (Feldstein et al., 2020). In addition, not all WHO Member States had included all WHO recommended vaccines for this age group in their school-based programs (Feldstein et al., 2020; World Health Organization, 2019b, 2019c).

In Canada, school-based immunization programs have been implemented for more than a decade. In fact, while a mandatory approach or regulatory approach to school vaccinations has been implemented in some Canadian provinces, there are differences between the programs (Walkinshaw, 2011). Although immunization programs in all Canadian provinces and territories have been successful in reducing the prevalence of many infectious diseases (Public Health Agency of Canada, 2016), vaccine-preventable disease outbreaks still occur occasionally in school settings or in unvaccinated and geographically clustered communities (Naus et al., 2015).

For example, in 1989, a major measles outbreak hit a school in eastern British Columbia where almost all the students were unvaccinated against the disease due to their religious beliefs (BC Centre for Disease Control, 2016; Sherrard et al., 2015). Similarly, a measles outbreak also occurred in Québec in the 1990s, but the reason for non-vaccination was mostly related to a lack of access to vaccination services rather than the active refusal of the vaccine (Monnais, 2019). As a result of these outbreaks, some Canadian provinces and territories began strengthening their measles vaccination programs, including the implementation of catch-up programs in schools (Canadian Public Health Association, n.d.). These events reinforced the public health standard of offering childhood vaccinations in schools (Bettinger et al., 2013; Government of Canada, 2019a; Government of New Brunswick, 2018; Government of Ontario, 2019; Government of Québec, 2020a, 2020b; MacDougall et al., 2014; Sherrard et al., 2015). According to UNESCO, this target group is called the school-age population[1]. This population can be further divided according to their school level (primary, secondary, or post-secondary education).

[1] According to the UNESCO glossary, the school-age population is defined as the "Population of the age group theoretically corresponding to a given level of education as indicated by theoretical entrance age and duration." (http://uis.unesco.org/en/glossary-term/school-age-population).

Despite this widely accepted approach to delivering vaccines in schools, coverage rates are still below national target goals. Vaccine hesitancy is identified as a challenge to achieving high coverage rates through school-based immunization programs (Canadian Public Health Association, n.d.), and as a result, there are many initiatives in Canada that address ways to increase vaccine acceptance and uptake (Walkinshaw, 2011; F. L. Wilson et al., 2012; S. E. Wilson et al., 2013), such as Kids Boost Immunity (Public Health Association of BC, 2019). Thus, we have yet to see the full potential of school-based immunization programs in Canada.

This literature review will provide an overview of Canada's school-based immunization programs, the benefits of school-based vaccination programs, the specific challenges involved in the delivery of vaccines in the school setting, as well as ways to optimize these programs. All references included in this literature review are presented in the Appendix tables.

Context

In the Canadian context, there are different types of school-based immunization programs that exist (Walkinshaw, 2011) as a result of being created at the provincial or territorial level rather than at a national level (Bettinger et al., 2013). Additional differences in school-based immunization programs can be observed during seasonal or cyclic outbreaks that affect school-aged children; this can initiate preventive public health measures where catch-up vaccines may be provided (Gilca et al., 2012). In fact, these programs are developed based on population and epidemiological needs and analyses. Vaccine-preventable disease outbreaks could also partially explain why some jurisdictions (i.e., Manitoba, Ontario and New Brunswick) moved toward the implementation of more restrictive school-based immunization policies (Walkinshaw, 2011).

In the United States, the U.S. Department of Health and Human Services has established a Community Preventive Services Task Force (CPSTF) that provides evidence-based findings and recommendations about community preventive services, programs, and other interventions aimed at improving population health (Community Preventive Services Task Force, n.d.). Its recommendations are based on rigorous and reproducible systematic reviews of the scientific literature. One of these recommendations to school immunization program managers was the requirement for the immunization of children attending licensed daycare, elementary and secondary schools (Community Preventive Services Task Force, 2016). This recommendation is consistent with the more stringent policies in place in certain Canadian provinces.

School-Based Immunization Programs in Canada

School-based immunization programs in Canada can be defined as the routine administration of vaccines in schools that exclude those vaccinations carried out during community or mass campaigns (Feldstein et al., 2020). The origin of these programs can be traced back to when community immunization programs were first implemented. However, immunization was a requirement for school entry in at least one province (Ontario) in the early 1920s ("Canadian Public Health Association: Policy Statement on Immunization," 1965). For a complete history of vaccination in Canada, please visit the Canadian Public Health Association website (https://www.cpha.ca/immunization-timeline).

Today, the federal government can provide immunization programs directly with supplemental funding but ultimately, it is up to the provinces and territories to decide how to spend it. Routine immunization and catch-up programs are developed and implemented in that respect (Government of Canada, 2019a)[2]. Information on immunizations provided in school settings are available on provincial/territorial government websites, as well as in a full table schedule offered by the Public Health Agency of Canada[3], which is updated on a quarterly basis (Table 1). School programs differ from jurisdiction to jurisdiction (Bettinger et al., 2013), but at present there are three provinces that have strengthened their school immunization policies through legislation that applies strictly to school-age children: Ontario and New Brunswick require vaccination against several diseases, including diphtheria, tetanus, polio, pertussis, measles, mumps, rubella, meningococcal disease (meningitis), and varicella (chickenpox) (only in Ontario - required for children born in 2010 or later) (Government of Ontario, 2019; Vitalité Health Network, n.d.), whereas Manitoba only requires vaccination against measles (Born et al., 2014). However, the laws in each of these three provinces include a clause that allows parents to exempt their children from being vaccinated due to medical or religious/philosophical reasons. In the event of an outbreak, unvaccinated children may not be allowed to attend school.

In the Northwest Territories, children who will pursue post-secondary education outside the territory must receive the quadrivalent meningococcal conjugate vaccine at the age of 12 (Government of Northwest Territories, 2018). In Ontario, two (2) doses of the human papillomavirus (HPV) vaccine are given as early as grade 7, but there is also a catch-up program available for girls aged 8–12 and boys aged 10 (Government of Ontario, 2019). In addition, during vaccine shortages in Newfoundland and Labrador, the vaccine Tdap-IPV-Hib (tetanus, diphtheria, acellular pertussis, inactivated poliomyelitis virus and *Haemophilus influenzae* type B) can be replaced by the vaccine Tdap-IPV (tetanus, diphtheria – with reduced dose of toxoid, acellular pertussis – with reduced antigenic content, and inactivated poliomyelitis virus). In Québec, personal vaccination records are updated in grade 9 for diphtheria, pertussis, tetanus, poliomyelitis, measles, rubella, mumps, meningococcal C infections, chickenpox, hepatitis A, hepatitis B and HPV infections.

[2] A catch-up program is defined by the Government of Canada as a temporary measure to implement a new immunization program for a certain age cohort.

[3] Since its first publication in 1979, the Canadian Immunization Guide has provided a summary of the recommendations of the National Advisory Committee on Immunization (NACI).

Table 1. School-Based Immunization Programs in Canada

Province	Program's name	Vaccine coverage	Link
Alberta	Alberta Health Services	• HPV (grade 6) – 2 or 3 doses • Hepatitis B (grade 6) - 3 doses • Tdap (grade 9) • Men-C-ACYW-135 Meningococcal (grade 9)	http://immunizealberta.ca/i-want-immunize/when-immunize
British Columbia	B.C. Immunization schedules	• Chickenpox (catch-up, grade 6) • Hepatitis B (catch-up, grade 6) • HPV (grade 6) • Men-C-ACYW-135 Meningococcal (grade 9) • Tdap (grade 9)	https://www.healthlinkbc.ca/tools-videos/bc-immunization-schedules#school
Manitoba	Health, Seniors and active living	• Men-C-ACYW-135 Meningococcal (grade 6) • Hepatitis B (grade 6) – 2 doses • HPV (grade 6) – 2 doses • Tdap (grade 8 or 9)	https://www.gov.mb.ca/health/publichealth/cdc/div/schedules.html
New Brunswick	Office of the Chief Medical officer of Health (Public Health)	• HPV (grade 7) • Tdap (grade 7) • Men-C-ACYW-135 Meningococcal (grade 9) • Varicella second dose (grade 9)	https://www2.gnb.ca/content/gnb/en/departments/ocmoh/for_healthprofessionals/cdc/NBImmunizationGuide.html
Newfoundland and Labrador	Health and Communities Services	• Men-C-ACYW-135 Meningococcal (grade 4) • Hepatitis B (grade 6) • HPV (grade 6) • Tdap (grade 9)	https://www.health.gov.nl.ca/health/publichealth/cdc/immunizations.html

Northwest territories	Immunization/ Vaccination	• HPV (grade 4,5 or 6)
		  ○ 9 to 14 years – 2 dose series
		  ○ 15 years and older – 3 dose series
		• Tdap (grade 7)
		• Men-C-ACYW-135 Meningococcal (grade 12)
			https://www.hss.gov.nt.ca/en/services/immunization-vaccination

Nova Scotia	Routine Immunization Schedules for Children, Youth & Adults	• HPV (grade 7) • Tdap (grade 7) • Hepatitis B (grade 7) • Men-C-ACYW-135 Meningococcal (grade 7)	https://novascotia.ca/dhw/cdpc/immunization.asp
Nunavut	Nunavut Recommended Childhood Immunization Schedule	• HPV (grade 6) • Tdap (grade 6) • Varicella (catch up grade 6) • Men-C-ACYW-135 Meningococcal (grade 9)	https://www.gov.nu.ca/health/information/immunization

Ontario	Vaccines for children at school	• HPV (grade 7) • Hepatitis B (grade 7) • Men-C-ACYW-135 Meningococcal (grade 7) • Tdap (between 14 and 16 y/o) (catch-up program)	https://www.ontario.ca/page/vaccines-children-school
Prince Edward Island	Immunization Program	• HPV (grade 6) • Tdap (grade 9) • Men-C-ACYW-135 Meningococcal (grade 9)	https://www.princeedwardisland.ca/en/information/health-and-wellness/childhood-immunizations
Québec	Vaccination schedule for school-age children	• Varicella (4–6 years old) • Hepatitis A and B (grade 4) • HPV (grade 9) • Tdap (grade 9) • Men-C-C (grade 9)	https://www.quebec.ca/en/health/advice-and-prevention/vaccination/quebec-immunisation-program/#c24030
Saskatchewan	Immunization services	• Hepatitis B (grade 6) • HPV (grade 6) • Men-C-ACYW-135 Meningococcal (grade 6) • Varicella (grade 6) • Tetanus (grade 8) • Diphtheria (grade 8) • Pertussis (grade 8)	https://www.saskatchewan.ca/residents/health/accessing-health-care-services/immunization-services
Yukon	Yukon Immunize	• HPV (grade 6) • Men-C-ACYW-135 Meningococcal (grade 9) • Tdap (grade 9)	http://www.yukonimmunization.ca/diseases-vaccines/grade-6-9-school-based-immunization
Note:	HPV: Human Papillomavirus vaccine Men-C-C: Meningococcal conjugate (Strain C) vaccine Men-C-ACYW-135: Meningococcal conjugate (Strains A, C, Y, W135) vaccine Tdap: Tetanus, diphtheria (reduced toxoid), acellular pertussis (reduced toxoid) vaccine		

In the boxes below, we will first present two school-based immunization programs in provinces with non-restrictive policy (British Columbia and Québec). Then we will present two programs with restrictive policy (Ontario and New Brunswick) requiring all children entering school or an approved daycare centre to be immunized in accordance with the law.

British Columbia

In British Columbia, school-age children are vaccinated in grades 6 and 9 (ImmunizeBC, 2017). The following vaccines are currently available for school-age children in grade 6: HPV, chickenpox (those who have already received two doses, or who have had the disease or shingles after age 1, do not need the vaccine), and hepatitis B (those who have received 3 doses at a younger age do not need the vaccine). The following vaccines are routinely offered to all grade 9 students: the combined tetanus, diphtheria, and acellular pertussis (Tdap) vaccine and the quadrivalent meningococcal vaccine (Men-C-ACYW-135). School-age children with chronic diseases may need additional vaccines or additional doses of certain vaccine(s).

Parents can therefore consult their health care provider about additional vaccines that their child may need. With rare exceptions, all school-aged children should receive all routine vaccines according to the recommended schedule, which the parents should respect.

Routine vaccines for school-age children are administered in their school clinics by public health nurses and are provided free of charge. If children happen to the miss the vaccination sessions at school, or do not feel comfortable getting vaccinated in a school setting or are home-schooled, an appointment can be made with their local health unit, medical office or pharmacy to get vaccinated for free.

School-age children are given a paper record of the vaccinations they receive at school, but parents must keep this record up to date for their child. Beginning in the 2019–2020 school year, parents and guardians are requested to provide Public Health with immunization records for students enrolled in the provincial school system.

Québec

As early as 1982, the Government of Québec had implemented an immunization policy for school-age children as outlined in Directive 1982-093 of the then Ministry of Social Affairs (1982). The Ministry had set out clear guidelines to develop a protocol for immunizing 2-year-old children and those who are in daycare, kindergarten and primary school. The health or community services network was responsible for verifying the vaccination of children entering and leaving primary school, as well as that of any new students (Remis & Bédard, 1987). Unfortunately, this initiative, which was intended to guide the community health departments (DSCs) and local community service centres (CLSCs), experienced difficulties. According to Remis and Bédard (1987), this was partly due to the fact that the DSCs were responsible for infectious disease control but did not have any jurisdiction over the CLSCs, who controlled all the resources. Since the DSCs did not have the authority to delegate the role of fighting infectious diseases and implementing school-based immunization programs to the CLSCs, an impasse was reached.

In view of these shortcomings, the Ministry of Health and Social Services (1991) sent a new Directive (1991-079) to the director generals and heads of the DSCs specifying the health network's responsibilities in the vaccination of adults and school children, as well as the requirements to relay the information of vaccinated persons to the DSCs. Therefore, the DSCs are now responsible for the assessment of vaccination coverage within their territory's target populations, particularly 2-year-olds and children attending primary and secondary schools. For school-based immunization, the DSCs must monitor the vaccination coverage based on the information of vaccinated school-age children provided by CLSCs and private doctors.[4] The implementation of school-based immunization programs has thus become a basic preventive service and a state responsibility that institutions in the health network cannot avoid; this requires close collaboration between all partners.

The aim of the school-based immunization program in Québec is to prevent morbidity and mortality associated with infections in school-age children. It is therefore selective and targets a specific group, unlike other universal programs that target the entire population.

Today, these programs target students in grade 4 and grade 9 (Government of Québec, 2020b). Every year, the Health and Social Services Centres (CSSS) carry out vaccination activities in primary and secondary schools. Grade 4 students are vaccinated against HPV, as well as hepatitis A and B (HAHB). Grade 9 students are vaccinated against hepatitis B (HB), tetanus, diphtheria, and acellular pertussis (Tdap), and meningococcus C (Men-C-C). The hepatitis B immunization program for children in grade 4 began in 1994. Since 2008, children have been receiving the Twinrix® vaccine, which protects against both hepatitis A and hepatitis B (Government of Québec, 2020b).

Vaccines are administered in schools in the fall and spring, and are provided by the school nurse. The schools provide all relevant information to parents at the beginning of the school year. Before vaccinating a child, the school nurse must obtain the consent of the parent or guardian. However, school-age children 14 years of age and older may give their own consent. If children are absent from school on the day of vaccination, their parents can have them vaccinated free of charge by following the school nurse's instructions or by making an appointment at their CLSC.

Ontario

All children aged 4 to 17 attending school must be vaccinated in accordance with Ontario's vaccination schedule under the *Immunization of School Pupils Act*, 1990 (Government of Ontario, 2017). During the 2009–2010 school year, 84% to 92% of students aged 7 to 17 were vaccinated in Ontario (Walkinshaw, 2011). After vaccination, it is recommended that parents discuss the vaccination experience with their child and contact their doctor if they have any concerns. Children who are not fully immunized may not be allowed to attend school.

Children attending primary or secondary school must be vaccinated against diphtheria, tetanus, polio, measles, mumps, rubella, meningitis (meningococcal infection), pertussis, and chickenpox (required for children born in 2010 or later). Children aged 4 to 6 years must be vaccinated against tetanus, diphtheria, pertussis, polio, measles, mumps, rubella and chickenpox. In grade 7, they must be vaccinated against meningococcal disease (conjugate vaccine - Men-C-ACYW-135), hepatitis B, and HPV. Adolescents aged 14 to 16 years must be vaccinated against tetanus, diphtheria, and pertussis.

[4] It should be noted that the lack of public primary care facilities relative to private polyclinics and practices led to the creation of CLSCs to make social, preventive, health and community services accessible to all.

Non-compliance may result in a fine of up to $1,000 (Walkinshaw, 2011). Parents must provide proof of their child's immunization to the local public health office and keep all vaccination records up to date. Children who are not vaccinated can be sent home from school during an outbreak of vaccine-preventable diseases. However, under the *Immunization of School Pupils Act* (R.S.O. 1990, Chapter I.1), the child may be exempt from vaccination due to medical reasons and convictions based on religion or conscience.

For example, parents who want to put their child in an approved daycare centre but decide not to have their child vaccinated for the above reasons, must provide the centre with a valid exemption certificate. However, during a disease outbreak at the centre, the child will be sent home until the outbreak is over. If a medical reason is involved, parents must complete a Statement of Medical Exemption form, have it signed by a doctor or nurse practitioner, and submit it to their local public health unit. This form must specify the reason for the exemption, such as a medical condition that prevents the child from receiving vaccines, or evidence of immunity to the disease that makes further vaccination unnecessary, or any conviction based on religion or conscience.

As of September 1, 2017, parents who wish to have an exemption based on religion or conscience must go to their public health unit for a comprehensive education session covering basic immunization information, vaccine safety, immunization and community health, and immunization legislation in Ontario (Government of Ontario, 2017).

New Brunswick

Regulation 2009-136 under the New Brunswick *Public Health Act* requires all children entering school for the first time to provide proof of immunization against diphtheria, tetanus, polio, pertussis, measles, mumps, rubella, chickenpox and meningococcal disease, as described in the policy on the immunization status of children entering New Brunswick schools for the first time (Government of New Brunswick, 2009). The school principal must ensure that proof of immunization against the above diseases is provided for each child entering the school for the first time.

Proof of immunization is not required when the child's parent or guardian provides either one of the following documents: a form provided by the Minister declaring a medical exemption and signed by a physician or nurse practitioner, or a written statement on a form provided by the Minister, signed by the parent or legal guardian stating their objections to the immunization (Government of New Brunswick: Department of Education and Early Childhood Development, 2002).

Regulation (2009-136) also states that all children attending an approved daycare centre must provide proof of immunization against the following diseases: diphtheria, tetanus, polio, pertussis, measles, rubella, mumps, chickenpox, meningococcal meningitis, *Haemophilus influenzae* type B and pneumococcal infection (Government of New Brunswick, 2018). In grade 7, the HPV vaccine and the vaccine against tetanus, diphtheria, and acellular pertussis (Tdap) are given. In grade 9, school-age children receive the quadrivalent meningococcal vaccine (Men-C-ACYW-135).
In New Brunswick, a network of vaccinators, including physicians, pharmacists, nurse practitioners, and midwives and nurses, administer publicly funded vaccines. The vaccines recommended in the routine

immunization schedule for school-age children are provided by Public Health and other health care providers. However, the responsibility for developing an immunization schedule rests with the Chief Medical Officer of Health.

Evaluation of the Effectiveness of School-Based Vaccination

A systematic review by Jacob et al. (2016) determined the economic impact of 12 school-based interventions recommended by the Community Preventive Services Task Force in the United States. The results showed that school-based vaccination had better reach and vaccination rates in school-aged children than strategies involving home visits and combined community strategies, which were both more costly and less effective.

Table 2 presents HPV and meningococcal vaccine uptake rates achieved in Canadian school-based immunization programs. The coverage rates presented in the table are below the public health goals of vaccinating 90% of target groups in multiple jurisdictions (Government of Canada, 2019b). There are substantial variations between and within Canadian P/Ts.

Table 2. School-Based Immunization Programs in Canada: HPV Vaccination Completion Rates and Meningococcal Vaccination Coverage Rates for Different Canadian Jurisdictions

Jurisdiction	HPV complete vaccine uptake (Females)	HPV complete vaccine uptake (Males)	Meningococcal vaccine coverage (Female/Male)	Source
Alberta	64.9% (2013-2014; 3 doses) 67.6% (2014-2015; 3 doses)	66.0% (2013-2014; 3 doses) 67.2% (2013-2014; 3 doses)	–	a
British Columbia	65.8% (2013-2014; 2 doses) 64.8% (2014-2015; 2 doses)	–	79.8% (2016-2017) 77.8% (2017-2018) 79.3% (2018-2019)	b
Manitoba	58.2% (2013-2014; 3 doses) 58.6% (2014-2015; 3 doses)	–	77.4% (2012; 11 y/o) 78.7% (2013; 11 y/o) 77.6% (2015; 13 y/o) 79,0% (2016; 13 y/o) 79.9% (2017; 13 y/o)	c
New Brunswick	75.1% (2012-2013; 3 doses) 73.1% (2013-2014; 3 doses) 73.5% (2014-2015; 3 doses) 75.4% (2015-2016; 3 doses) 74.8% (2017-2018; 3 doses) 74.9% (2018-2019; 3 doses)	70.2% (2017-2018; 3 doses) 72.8% (2018-2019; 3 doses)	72.4% (2012-2013) 73.2% (2013-2014) 77.3% (2014-2015) 71.4% (2015-2016) 73.7% (2016-2017) 78.0% (2017-2018) 77.6% (2018-2019)	d
Newfoundland and Labrador	94.3% (2012-2013; 3 doses) 88.7% (2013-2014; 3 doses) 89.2% (2014-2015; 3 doses)	–	96.8% (2013-2014) 96.6% (2014-2015)	e
Northwest Territories	39.3% (2013-2014; 3 doses) 48% (2014-2015; 2/3 doses) 55% (2015-2016; 2/3 doses)	–	–	f

Nova Scotia	77.2% (2012-2013; 3 doses) 75.0% (2013-2014; 3 doses) 75.6% (2014-2015; 3 doses) 80.8% (2015-2016; 2 doses) 79.0% (2016-2017; 2 doses)	81.0% (2015-2016; 2 doses) 84.9% (2016-2017; 2 doses)	91.0% (2012-2013) 93.7% (2013-2014) 93.9% (2014-2015) 94.5% (2015-2016) 93.9% (2016-2017)	g
Nunavut	61.9% (2013-2014; 3 doses) 61.5% (2014-2015; 3 doses)	–	–	h
Ontario	70.2% (2011-2012; 3 doses) 80.2% (2012-2013; 3 doses) 85.5% (2013-2014; 3 doses) 84.8% (2014-2015; 3 doses) 85.6% (2015-2016; 3 doses) 82.4% (2016-2017; 3 doses)	–	89.4% (2012-2013) 77.5% (2013-2014) 79.4% (2014-2015) 80.6% (2015-2016) 79.6% (2016-2017) 82.4% (2017-2018)	i
Prince Edward Island	87.3% (2012-2013; 3 doses) 84.9% (2013-2014; 3 doses) 82.7% (2014-2015; 3 doses)	79.0% (2013-2014; 3 doses) 81.4% (2014-2015; 3 doses) 85.0% (2015-2016; 2 doses)	94.6% (2014-2015) 94.5% (2015-2016)	j
Quebec	77% (2013-2014; 2 doses) 74.4% (2014-2015; 2 doses) 73% (2015-2016; 2 doses) 76% (2016-2017; 2 doses) 77% (2017-2018; 2 doses) 79% (2018-2019; 2 doses)	76% (2017-2018; 2 doses) 77% (2018-2019; 2 doses)	72% (2016-2017; 2 doses) 74% (2017-2018; 2 doses)	k
Saskatchewan	72.7% (2011-2012; 3 doses) 73.5% (2012-2013; 3 doses) 72.8% (2013-2014; 3 doses) 68.7% (2014-2015; 3 doses) 61.4% (2015-2016; 3 doses) 69.1% (2016-2017; 2 doses) 69.1% (2017-2018; 2 doses)	–	79.2% (2013-2014) 78.6% (2014-2015) 80.1% (2015-2016) 81.4% (2016-2017) 81.9% (2017-2018)	l
Yukon	Not Available	Not Available	Not Available	

Notes: HPV: Human Papillomavirus vaccine.
Men-C-C: Meningococcal conjugate (Strain C) vaccine
Men-C-ACYW-135: Meningococcal conjugate (Strains A, C, Y, W135) vaccine
Tdap: Tetanus, diphtheria (reduced toxoid), acellular pertussis (reduced toxoid) vaccine
–: Not found
a: (Alberta Health Services, 2018; Shapiro et al., 2017)
b: (BC Centre for Disease Control, 2019b, 2019a; Shapiro et al., 2017)
c: (Manitoba Health, Seniors and Active Living, n.d.; Shapiro et al., 2017)
d: (Government of New Brunswick, n.d.; Shapiro et al., 2017)
e: (Government of Newfoundland Labrador, 2015a, 2015b; Shapiro et al., 2017)
f: (Shapiro et al., 2017)
g: (Government of Nova Scotia, n.d.; Shapiro et al., 2017)
h: (Shapiro et al., 2017)
i: (Ontario Agency for Health Protection and Promotion (Public Health Ontario), 2017, 2018; Shapiro et al., 2017)
j: (Prince Edward Island Provincial Immunization Committee Chief Public Health Office, 2017; Shapiro et al., 2017)
k: (Ministère de la Santé et des Services sociaux, n.d.; Shapiro et al., 2017)
l: (Population Health Branch, Saskatchewan Ministry of Health, 2019a, 2019b; Shapiro et al., 2017)

In the case of HPV vaccination, studies have shown that school-based programs have higher vaccination rates in countries such as Canada, Spain, Scotland and Australia (Bird et al., 2017; Hopkins & Wood, 2013), and that Europe as a region had better vaccination coverage (Hopkins & Wood, 2013). Clearly, school-based immunization programs cover school-age children better than community-based immunization programs, but their cost-effectiveness may vary according to certain socio-demographic characteristics of the students. For example, Brotherton et al. (2013), after analyzing data from the Australian National HPV Vaccination Program Register, observed that vaccination coverage among Indigenous girls was lower at each dose compared to non-Indigenous girls. In fact, second doses are generally lower for HPV and there are a multitude of factors that impact this, like students missing clinic days, loss of consent forms, etc.

However, school-based immunization can also help reduce socio-economic inequalities in vaccine distribution (Bird et al., 2017), based on results from Australia, New Zealand and England on the socio-economic determinants of HPV vaccination (Blakely et al., 2014; Brotherton et al., 2013; Jean et al., 2018). For example, Jean, Elshafei, and Buttenheim (2018) evaluated the influence of the following variables on vaccination coverage in school curricula in the United Kingdom: family income, education level, race, residence status and occupation. In this study, the highest HPV vaccination rates were observed among whites, low-income families, non-migrant population, those with the lowest education level, and in local communities where the proportion of high-status jobs was low.

Of note, the United States only delivers the influenza vaccine in schools, and the delivery system is not uniform across the States. In addition, an analysis of two influenza programs in northern New York State in 2015–2016 showed how the cost-effectiveness of school-based influenza vaccination can vary according to primary or secondary school level (Yoo et al., 2019). Results showed that the overall effectiveness measure was 5.7 and 5.5 percentage points higher in the intervention primary (52.8%) and secondary schools (48.2%) respectively, than in the grade-matched control schools.

It is important to note that the effectiveness of vaccination strategies depends largely on the socio-cultural and organizational context in which they are implemented. This issue will be addressed by taking a closer look at two strategies for hepatitis B vaccination: in Canada and the United States.

While the American advisory group in 1980 chose universal neonatal vaccination as the main component of its national strategy to combat the hepatitis B virus, the Canadian advisory group opted for universal vaccination of school-age children and adolescents, although hepatitis B vaccine is offered at birth in the Northwest Territories and Nunavut, and at 18 months in Québec. Both strategies have generally worked well for the targeted cohort, although the trend for vaccination coverage rates is irregular. This is illustrated in the recent WHO data that showed that adolescent vaccination coverage against hepatitis B (HepB3) in Canada increased from 56% in 2010 to 70% in 2011 and 2012, decreased to 55% in 2013 and 2014, and increased again to 71% in 2017 and 2018 (World Health Organization, 2019a). In the United States, the hepatitis B vaccination rate for infants (HepB_BD) first increased from 64% in 2010 to 74% in 2013, then decreased to 64% in 2016 and 2017, and went up again to 66% in 2018 (see Table 3 in the Appendix). However, hepatitis B (HepB3) vaccination coverage rates for adolescents in the United States remained stable during the same period (World Health Organization, 2019a).

Finally, according to Elena Conis (2019), these programs must be seen in the context of the era when they were implemented. The author distinguishes the modern vaccination era from the previous era, which was marked by the approval of the first two measles vaccines in 1963. In exploring the successes and challenges of vaccination in the modern era in the United States, she concludes that this new era of vaccination differs from the previous one in several ways. For instance, it is characterized by the leadership of advocates who believed that mandatory vaccination of school-age children was the best way to ensure the health of the population. The era also saw an expansion of federally supported local vaccination initiatives to address “mild” and “moderate” childhood diseases.

Key Issues Related to School-Based Immunization Programs

School-based immunization programs are increasingly raising a variety of issues in Canada (Bettinger et al., 2013; MacDougall et al., 2014; Righolt et al., 2019; Tozzi et al., 2016) and in other developed countries (Feldstein et al., 2020; Vandelaer & Olaniran, 2015; Ward, Quinn, Bachelor, et al., 2013; Ward, Quinn, Menzies, et al., 2013). In a literature review, Perman and colleagues (2017) have identified the following factors that hinder school-based immunization programs. The first is national and regional policy issues. Studies have described the influence of two types of policies, those that have a direct impact and those that have an indirect impact. For example, in the UK, a social inclusion policy involving school nurses has had an indirect effect on reducing health inequalities and social exclusion, whereas a school empowerment policy had led to the refusal of some faith-based schools to participate in a school-based HPV program (Brabin et al., 2011; Stretch, 2008). The second factor concerns program management and direction. Many studies have focused on the influence of different types of management and leadership on the effectiveness of school-based programs. Organizational models and institutional relationships make up the third factor, and the fourth includes the facilities and systems required to operate the programs, such as data entry, distribution, and vaccine supply systems. Studies in different countries report that the lack of access to students’ medical records in school-based programs is a major organizational challenge. The labour force is also a factor that is often mentioned in studies from different countries, the recurring issues being staff capacity, workload, skill mix, experience and roles. The sixth factor is the financing, billing, reimbursement and sustainability issues of the program. This factor is prominent in the descriptive literature, but only in the United States, which does not have a publicly funded school-based vaccination program. In addition, communication with parents and students is addressed in most studies. Regardless of the country or type of vaccine, communicating to parents the purpose of vaccination and obtaining parental consent is reported to be one of the most important factors in the proper functioning of the program. The last factor identified in the literature by the authors is clinic organization and performance. This includes logistics and the physical configuration of clinics to facilitate the flow of students. Most of the studies that focused on this factor were American articles on pandemic and seasonal influenza (Perman et al., 2017).

Another issue is the attitude of the parents or the students themselves. To understand this, MacDougall and colleagues (2014) interviewed 55 parents in Ontario who had either already vaccinated at least one child against influenza or who had never done so between October 2012 and February 2013. The objective was to understand parents' views on the advantages and disadvantages of adding influenza vaccinations to existing school-based immunization programs in Ontario. Although the majority of participants found the program useful for school-age children, most felt that for a program to be acceptable, it should be well designed, with adequate parental control and transparent communication between the key parties involved, such as Public Health, schools and parents who consent voluntarily. In regards to information provided to parents, the main barrier identified by parents, nurses, teachers, and managers interviewed in an evaluation of school-based HPV vaccination programs was the negative impact of misinformation from the Internet and social networks, which creates doubts and concerns about the rationale, safety, and effectiveness of the vaccine (Dubé et al., 2019).

The challenge of obtaining consent is another issue in school-based vaccination. Health professionals are not always clear about how to best manage the consent process in a context where 14-year-olds can consent in some jurisdictions and cannot consent in other jurisdictions (Chantler et al., 2019). A more rigorous evaluation of interventions could improve the consent process in school-based immunization programs. This includes developing vaccinology training and education programs for medical and other health students, as well as teaching about vaccines in school or using motivational interviewing techniques as an educational intervention for parents of students (Dutilleul et al., 2019). In Canada, using the example of HPV, potential adverse events after immunization (AEFIs) associated with the HPV vaccine are generally communicated on paper along with informed consent forms to parents, legal guardians and students. If communication about these risks is not comprehensive and consistent across Canadian provinces and territories, inaccurate, incomplete and inconsistent information may negatively affect the consent process (Steenbeek et al., 2012). Braunack-Mayer and colleagues (2015) have identified these ethical challenges and divided them into three categories**.** The first is category is *informed consent*, which considers how student information is communicated, decision-making capacity, and voluntariness, especially since there are limits to how much accommodation can be offered for informed consent. The second is the *importance of privacy and confidentiality*, since students in the study indicated that they would prefer that information be shared by someone they trust. Perhaps if the immunization program was offered in association with a teacher, mistrust in the vaccination process could be reduced. The third category is the *negative effect of fear and anxiety*, which can be eliminated if health professionals adopted a humorous attitude and the use of distraction techniques. According to the authors of this study, some of the challenges can be overcome by adopting the same strategies used for vaccinations in a private setting (Braunack-Mayer et al., 2015). Public health authorities provide general information before clinic day and offer a contact number for questions or a website for parents who wish to obtain additional information on the vaccines their child will receive in school. However, public health authorities and school staff should work together to provide information on vaccinations on vaccination day as well to include clarification on privacy protection and vaccine safety.

Interventions and Tools for Optimizing Vaccination Coverage in School-Based Immunization Programs

Various interventions have been shown to be effective in increasing vaccination rates. These interventions include reminder and recall systems for vaccine recipients and service providers, educational interventions and informations for parents, students, legal guardians, etc., combined with strategies to improve access to vaccination services, and providing feedback of vaccination coverage results to vaccinators (Community Preventive Services Task Force, 2015). In this context, information systems are one of the most important factors in supporting the implementation of various interventions. Based on findings from a systematic review of 108 published articles and 132 conference abstracts, the evidence demonstrated the ability of immunization information systems to (Groom et al., 2015): 1) create or support effective interventions such as client and service provider reminder systems, as well as evaluation systems; 2) generate and evaluate public health interventions in the event of an outbreak; 3) facilitate management and accountability; 4) determine client immunization status; and 5) facilitate monitoring and surveys. Based on these conclusions, the U.S. Community Preventive Services Task Force recommended the use of immunization information systems and emphasized that these are effective in increasing vaccination rates and reducing vaccine-preventable diseases (Community Preventive Services Task Force, 2015). In Canada, several provinces have implemented an immunization information system. However, similar to vaccination programs, the information contained in these systems varies between jurisdictions (Bettinger et al., 2013). Such heterogeneity in vaccination information can make vaccine-preventable disease control more complex. The use and impact of these reminder systems however has yet to be evaluated in school settings.

Offering vaccination in school-based settings is recognized as an effective strategy to increase vaccination coverage rates (Community Preventive Services Task Force, 2016), but other interventions can also be implemented in schools to further enhance vaccine acceptance and uptake. For example, Tozzi and colleagues (2016) have emphasized the effectiveness of technological tools in improving immunization programs. They suggest that the use of technological tools can enhance immunization programs in several ways through the digitization of vaccination registries, as well as through the monitoring of vaccine-preventable diseases, adverse side effects following immunization, and client confidence in immunization programs. The use of technological tools can thus help increase vaccination coverage, and active parental involvement in vaccination strategies through informed decisions. A close comparison of such a technology in Canada is the Kids Boost Immunity (KBI) platform designed and maintained through a collaboration between ImmunizeBC, the British Columbia Ministry of Health and the Public Health Association of BC (Public Health Association of BC, 2019). The KBI has a website that offers online quizzes to increase users' vaccination knowledge. The KBI is coordinated through the BC Centre for Disease Control and is committed to posting accurate, up-to-date, and well-documented information for students and teachers. The team includes researchers, marketing specialists, teachers, and health professionals. Content is created and reviewed based on the credibility of the original sources and the objectivity of the findings. KBI is subject to meeting the needs of the provincial and territorial curriculum. All content on the site is read and signed off on by a minimum of three people: a staff member from the BC Centre for Disease Control or the Public Health Association of British Columbia, an experienced clinician with relevant expertise (registered nurse, physician, or professor) and an education professional. Quizzes allow students to learn about vaccines while having fun and doing a good deed – based on the number of correct answers, vaccines are donated to developing countries in collaboration with UNICEF. By informing and educating children about vaccines, it is possible to improve their vaccine acceptability in the present and when they become parents. The impact of KBI on vaccine acceptability, in particular, on school-based immunization programs has not yet been evaluated, but educational strategies, such as the promotion of exercise and environmental protection, have been shown to be effective in changing behaviours (Laine et al., 2014; Wysession et al., 2010).

Another Canadian intervention is the CARD™ tool (C-Comfort, A-Ask, R-Relax, D-Distract), a patient-centered coping framework for the delivery of school-based vaccinations that is feasible, cost-neutral and culturally acceptable for public health adoption (Taddio et al., 2010, 2015). CARD™ supports vaccine uptake, health equity, complements immunization competencies, and improves the quality of vaccine delivery practices. This practical tool is based on Canada's first clinical practice guidelines on pain management during vaccination (Taddio et al., 2015), and is evaluated in certain school vaccination programs in three (3) Canadian provinces where children are directly benefiting from the tool. A recent knowledge translation (KT) study in the Niagara Health Region found that students who used CARD™ experienced less fear, greater willingness to be vaccinated in school settings and had higher vaccination knowledge than students who did not use CARD™ for their school immunizations (Freedman et al., 2019).

In Australia, an intervention based on the use of text messaging has improved vaccination coverage in schools. A study conducted in the state of Victoria, Australia, confirmed the hypothesis that sending a reminder by text messaging (SMS) to parents who had consented to their child receiving the HPV vaccine resulted in a higher uptake of the vaccine in the school-based immunization program (Tull et al., 2019). Results showed that on the day of the last school visit, 85.71% of consenting students in the control group received the HPV vaccine, compared to 88.35% in the motivational message group and 89% in the self-regulatory message group. However, these strategies appear to be most effective in the context of well-established school vaccination programs. In fact, a study comparing two schools in the United States where influenza vaccination has been implemented showed that reminders and parental education alone are not sufficient to significantly increase vaccination rates (Szilagyi et al., 2019). According to Szilagyi and colleagues (2019), collaboration is needed with local health departments or other mass vaccination agencies that can set up school vaccination clinics and administer vaccines for these interventions to be optimal. In Canada, given that publicly funded school-based immunization programs are well-established and that many jurisdictions have immunization registries, there may be fewer barriers to the implementation of reminder and recall interventions.

Conclusion

Ultimately, the various improvements observed in the implementation of school-based immunization programs demonstrate that these approaches need to be encouraged and strengthened in Canada. In cases where all Canadian provinces and territories have implemented such programs, it is important to note that gains can still be made using different tools, means, and information. Finally, it should be noted that the success of these immunization programs depends on the collaboration between the health and education sectors to develop an acceptable policy that will ensure the availability of sufficient material and human resources, provide robust operational guidance, and ensure routine monitoring (Feldstein et al., 2020). This can lead to improved program management, alternative organizational models and institutional relationships, as well as increased capacity and roles for the workforce (particularly school nurses). It can also enhance communication with parents and students, methods of obtaining consent, and reorganization of service delivery in school settings. As new technologies are developing at a rapid pace, it is also important for Canada to take advantage of existing immunization information systems. Such technological advances can enable vaccine providers to implement interventions that have been shown to be effective, such as reminder and recall systems.

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Appendix

Table 3. Hepatitis B vaccination coverage rates in Canada and the US

Country	Vaccine	Year								
		2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Canada	HepB3	56%	70%	70%	55%	55%	69%	70%	71%	71%
US	HepB3	92%	91%	90%	91%	92%	92%	93%	93%	91%
US	HepB_BD	64%	69%	72%	74%	72%	72%	64%	64%	66%

Source: WHO, Data, Statistics and Graphics 2019
Official Country Reported Coverage Estimates Time Series
(https://www.who.int/immunization/monitoring_surveillance/data/en/)

Questions leading to the literature review

1. What initiatives regarding school-based immunization programs have already been taken in Canada?
2. What initiatives have other developed countries already taken with respect to school-based immunization programs?
3. Which of these initiatives have been successful or unsuccessful?
4. Which factors predict success or failure?

Research

The following databases were researched and referenced: Scopus, Embase, Web of Science, PubMed/Medline, and Cochrane Library.
The Google Scholar search engine was used for web searches.

Types of studies included

Inclusion criteria

- Original articles in English and French that include research on the following topics: school-based vaccination; school-based vaccination programs; school-based immunization programs; effectiveness, cost, benefit, gain; new information technologies (NITC); failure or success of school-based immunization programs;
- Books;
- Grey literature: review articles, government publications and agency reports, information from government and other institutional websites;
- Populations: school-age children;
- Developed countries.

Exclusion criteria

- Editorials, comments from letters to the editor;
- Non-school-based, experimental or currently unlicensed vaccines, animal vaccinations;
- Non-school-age populations;
- Underdeveloped countries.

Retrieval of articles and books

The selection and retrieval of articles and books was made by consulting the bibliographical databases selected above. All identified studies were screened in two stages: review of titles and abstracts and review of the full text. For title and abstract screening, study abstracts were first cross-referenced against the inclusion criteria described above. The full texts of all studies selected for inclusion were then reviewed.

The following references were selected for each of the themes in Table 4 below:

Table 4. Selected References

N°	Author(s) and Year of publication	Origin/ Country of origin	Aims/ Purpose	Study population and sample size	Key findings
School-Based Vaccination Effectiveness Evaluation					
1	https://doi.org/10.4103/ijpvm.IJPVM_49_17				
	Bird and coll., 2017	Canada	-Determine the levels of HPV vaccination programs in 2006 -Examine the various factors influencing vaccine uptake among the general Canadian population	A total of 718 peer-reviewed articles were initially identified, with 12 remaining after screening, and underwent methodological quality review	Individuals participating in school-based programs were 3.73 times more likely to be vaccinated against HPV compared to community-based programs. This is similar to the findings in previous studies showing that school-based programs have higher rates of vaccination uptake in countries such as Spain, Scotland, Australia, and the USA.
2	https://doi.org/10.1016/j.amepre.2015.11.003				
	Jacob, V. and coll., 2016	USA	A systematic review was conducted (search period, January 1980 through February 2012) to identify economic evaluations of 12 interventions recommended by the Task Force	Clients or providers Schools and MCOs	-The interventions recommended by the Task Force differed in reach, cost, and cost-effectiveness. -Present the economic information for 12 effective strategies to increase vaccination coverage that can guide implementers in their choice of interventions to fit their local needs, available resources, and budget.
3	https://doi.org/10.1016/j.vaccine.2013.01.028				
	Hopkins T. G. and coll., 2013	United Kingdom	Summarize the current trends in female HPV vaccination coverage throughout the world, and place it in the context of available research on attitudes towards vaccination amongst the public and health professionals		School-based opt-out programs consistently achieve highest coverage, whilst countries and regions without systematic vaccination schemes have low coverage. In all countries, the success of vaccination programmes is dependent on the support of the public and healthcare professionals. Worryingly, it appears that a proportion of clinicians still have significant reservations about promoting vaccination, particularly for younger age groups.
4	https://doi.org/10.1136/sextrans-2017-053357				
	Jean and coll., 2018	United Kingdom	Evaluate the association between vaccine uptake and socioeconomic status at the aggregate level	2013–2014 school year for 131 local authorities in England	Across all three doses, there are notable variations by socioeconomic status, with steep reverse gradients in three socioeconomic indicators.
5	https://doi.org/10.1186/s12913-019-4228-5				
	Yoo and coll., 2019	USA	Known about how the cost-effectiveness may vary by targeted age group (e.g.,	Two school-located influenza vaccination (SLIV) programs in upstate New	The overall effectiveness measure (proportion of children vaccinated) was 5.7 and 5.5

N°	Author(s) and Year of publication	Origin/ Country of origin	Aims/ Purpose	Study population and sample size	Key findings
			elementary or secondary school students)	York in 2015–2016: (a) elementary school SLIV (24 suburban and 18 urban schools) and (b) secondary school SLIV (16 suburban and 4 urban schools)	percentage points higher, respectively, in intervention elementary (52.8%) and secondary schools (48.2%) than grade-matched control schools.
6	https://doi.org/10.1016/j.vaccine.2014.02.071				
	Blakely and coll., 2014	New Zealand United Kingdom Australia	-Estimate the health gains, net-cost and cost-effectiveness of the currently implemented HPV national vaccination programme of vaccination dispersed across schools and primary care, and two alternatives -Generate estimates by social group (sex, ethnic and deprivation group)	New Zealand 12-year-old girls and boys in 2011	-The HPV vaccination program appears cost-effective and pro-equity. Our results suggest, however, that a more intensive school-only program may be a more optimal intervention in terms of health gain at reasonable cost-effectiveness, if the 73% vaccination coverage that we assumed is achieved (as it has been in Australia). -If price can be reduced, then a mandatory law may achieve cost-effectiveness and would maximize health gain.
7	https://www1.health.gov.au/internet/main/publishing.nsf/Content/cda-cdi3902-pdf-cnt.htm/$FILE/cdi3902b.pdf				
	Brotherton and coll., 2015	Australia	Present interim estimates of male HPV vaccination coverage achieved in the school-based program in 2013	Male and female	Male coverage for dose 1 was only slightly lower than for females (1%–6% lower) except for Tasmania.
8	https://doi.org/10.5694/mja13.10272				
	Brotherton, J. M. L. and coll., 2013	Australia	Notify vaccination coverage for girls aged 12–17	Girls aged 12–17 years as at 30 June 2007	The catch-up HPV vaccination program delivered over 1.9 million doses of HPV vaccine to girls aged 12–17 years, resulting in 70% of girls in this age group being fully vaccinated. The range in coverage achieved and the lower uptake documented among Indigenous girls suggest that HPV vaccination programs can be further improved.
Key Issues Related to School-Based Immunization Programs					
1	https://doi.org/10.1586/erv.13.30				
	Bettinger, J. A. and coll., 2013	Canada	Provide an overview of the Canadian epidemiology, serogroup B vaccine characteristics, potential strain coverage, immunization strategies and remaining pos-marketing research questions	Infants, children and adolescents	Inclusion of the new vaccines into public immunization programs will be decided at the provincial/territorial level, rather than nationally, and may result initially in different immunization schedules throughout the country, as have been seen with conjugate meningococcal vaccines. Such heterogeneous use and adoption of new vaccines complicates disease control but may assist in evaluation of effectiveness.
2	https://doi.org/10.2105/AJPH.2014.302280				
	Braunack-Mayer and	Australia	Investigate ethical issues in	9 secondary schools on	Identified ethical challenges for

N°	Author(s) and Year of publication	Origin/ Country of origin	Aims/ Purpose	Study population and sample size	Key findings
	coll., 2015		school-based immunization programs for adolescents and how they are addressed	immunization days in South Australia in 2011	the delivery of adolescent immunization in a school-based setting in 3 main areas: informed consent, restrictions on privacy, and harm to students in the form of fear and anxiety.
3	https://doi.org/10.1186/s12889-017-4168-0				
	Perman, S. and coll., 2017	United Kingdom	Understanding the facilitators and barriers is important for improving the delivery of future school-based vaccination programs	Systematic review: articles published in English between 2000 and 2015 using MEDLINE and HMIC electronic databases	Factors included programme leadership and governance, organizational models and institutional relationships, workforce capacity and roles particularly concerning the school nurse, communication with parents and students, including methods for obtaining consent, and clinic organization and delivery.
4	https://doi.org/10.1136/bmjopen-2014-005189				
	MacDougall, D. and coll., 2014	Canada	Understand the perspectives of Ontario parents regarding the advantages and disadvantages of adding influenza immunization to the currently existing Ontario school-based immunization programs	Parents of school-age children in Ontario	Participants who stated that a school-based influenza immunization program would be worthwhile for their child valued its convenience and its potential to reduce influenza transmission without interfering with the family routine. However, most thought that for a program to be acceptable, it would need to be well designed and voluntary, with adequate parental control and transparent communication between the key stakeholder groups of public health, schools and parents.
5	https://doi.org/10.1002/ijc.32135				
	Righolt, C. H. and coll., 2019	Canada	Estimate quadrivalent human papillomavirus (HPV) vaccine effectiveness (VE) against high-grade (HSILs) and low-grade squamous intraepithelial lesions (LSILs) and atypical squamous cells of undetermined significance (ASCUS)	Women at high risk of developing cervical cancer Females ≥9 years old who received the HPV vaccine in Manitoba (Canada) between September 1, 2006, and March 31, 2013 (N = 31,442)	The effectiveness of a vaccination program is influenced by its design and implementation details and by the target population characteristics. Further efforts should be targeted at achieving higher vaccine coverage among preadolescents, prior to the initiation of sexual activity.
6	https://doi.org/10.3389/fpubh.2016.00036				
	Tozzi, A. E. and coll., 2016	Italy Sweden	Characterize issues and challenges of immunization programs for which digital tools are a potential solution	Previously published research on the use of digital tools	Traditional surveillance systems have several limitations: - information is collected through health-care providers, not directly from individuals; therefore, traditional surveillance systems fail to catch signals from sick people who do not go to the doctor;

N°	Author(s) and Year of publication	Origin/ Country of origin	Aims/ Purpose	Study population and sample size	Key findings
					- traditional systems are based on case definitions, and therefore may miss emerging diseases with unexpected combinations of symptoms; - there is a consistent time lag between signals of disease and production and dissemination of aggregated incidence figures.
7	https://europepmc.org/abstract/med/24168090				
	Ward, K. and coll., 2013	Australia	Summarize the current operation of voluntary school-based vaccination programs in Australia	-Published literature -Those managing and implementing school-based vaccination programs in each state or territory -Review of program resources available in 2010	In Australia, school-based vaccination is now the primary method to deliver nationally recommended vaccines to adolescents. However, there is substantial variation between states and territories in how programs are funded, managed and implemented. This is largely due to differences in state and territory health systems, legislation, geography, and population size and characteristics.
8	https://europepmc.org/abstract/med/24168091				
	Ward, K. and coll., 2013	Australia	Compile a history of school-based vaccination in Australia, primarily focusing on adolescents	Adolescents	School-based delivery of vaccines has occurred in Australia for over 80 years and has demonstrated advantages over primary care delivery for this part of the population. In the last decade school-based vaccination programs have become routine practice across all Australian states and territories.
https://doi.org/10.1016/j.vaccine.2019.10.054					
9	Feldstein, L. R. and coll., 2019	USA	-Update and expand on previous global summaries of 2017 WHO-UNICEF JRF data -Describe adoption of school-based vaccination (SBV) by countries from 2008 to 2017	For analysis purposes, WHO member states were classified into two categories based on net proportion of children enrolled in primary school and proportion of children aged 12–23 months ever owning a home-based record (HBR); ≥80% and <80% for each.	-From 2008 to 2017, % countries with school-based vaccination (SBV) increased (58%–60%). -28 countries reporting no SBV (or no response) in 2008 reported SBV in 2017. -In 2017, 108 of 181 countries reported using SBV, delivering 18 different antigens. -High (>80%) home-based record availability and primary school enrollment in countries with SBV. -33 countries have high potential to implement checking of vaccination status at school.
10	https://doi.org/10.1016/j.vaccine.2014.11.037				
	Vandelaer and Olaniran, 2015	USA	Summarize the extent to which a school-based immunization approach is used around the	174 countries for which data on school-based immunization were	-In 2012, school-based immunization was used in 95 out of 174 countries.

N°	Author(s) and Year of publication	Origin/ Country of origin	Aims/ Purpose	Study population and sample size	Key findings
			world, and what antigens are most frequently being administered	available	-Tetanus and diphtheria toxoids are the most frequently administered antigens. -All school grades are targeted, but most countries give doses in first and sixth grade.
11	https://doi.org/10.1080/21645515.2018.1564440				
	Dubé and coll., 2019	Canada	Understand the determinants of low HPV vaccine uptake and identify strategies to enhance vaccine acceptance using the socioecological model	70 key informants including immunization managers, school nurses, school principals, teachers and parents of grade 4 students (9 years of age)	HPV vaccine uptake was dependent on many interrelated factors at the individual and interpersonal level, at the community level, at the organizational level, and at the policy level.
12	https://doi.org/10.1016/j.vaccine.2019.07.061				
	Chantler and coll., 2019	United Kingdom	Examine the practice of obtaining informed consent in adolescent immunization programs	39 interviews with immunization managers and providers collected as part of a 2017 service evaluation of the English adolescent girls' HPV vaccine program	-Parents and adolescents generally agreed on vaccine decisions although only 32% of parents discussed vaccination with their teenager. -Health professionals were not always clear about the best way to manage the consent process.
13	https://doi.org/10.1016/j.therap.2018.11.007				
	Dutilleul, A. and coll., 2019	France Canada	Identified a dozen concrete initiatives that could respond, at least in part, to the recommendations of the Steering Committee of the Citizens' Conference on Immunization		Develop information systems and data generation: -simplify the immunization journey and increase immunization opportunities; -develop training for health professionals; -learn vaccines in schools; use motivational interviewing in educational interventions; -undertake local initiatives; -improve supply and communicate the value of vaccines
14	https://doi.org/10.1111/j.1525-1446.2011.00974.x				
	Steenbeek et coll., 2012	Canada	Examine the accuracy, completeness, and consistency of human papilloma virus (HPV) vaccine-related physical risks disclosed in documents available to parents, legal guardians, and girls in Canadian jurisdictions with school-based HPV vaccine programs	13 Canadian jurisdictions between July 2008 and May 2009	Inaccurate, incomplete, and inconsistent information can threaten the validity of consent/authorization and potentially undermine trust in the vaccine program and the vaccine itself. Efforts are needed to improve the quality, clarity, and standardization of the content of written documents used in school-based HPV vaccine programs across Canada.
Interventions and Tools to Optimize Vaccine Coverage in School-Based Immunization Programs					
1	https://www.canimmunize.ca/en/home				
	CANImmunize, 2018	Canada	Dr. Kumanan Wilson and his team created CANImmunize as a way of empowering Canadians to easily track their	Canadians	This free and bilingual app provides several valuable tools to allow Canadians to self-manage their immunizations,

N°	Author(s) and Year of publication	Origin/ Country of origin	Aims/ Purpose	Study population and sample size	Key findings
			vaccination records		including the following: -Personalized immunization forecaster -Patient information -Information specific to children -Information for travellers -Pain management strategies
2	https://doi.org/10.1177/1715163517710959				
	Houle, S. and coll., 2017	Canada	Present CANImmunize Explain how pharmacists can get involved	Pharmacists	Pharmacists can refer patients with hesitancy or questions to download CANImmunize and access evidence-based information on vaccines and the diseases they prevent, as well as their safety and effectiveness
3	https://kidsboostimmunity.com/				
	Public Health Association of BC, 2019	Canada	Up-to-date and well-researched information for students and teachers	Students and teachers	Content on Kids Boost Immunity (KBI) should not be used as a replacement for medical advice from a healthcare professional.
4	https://doi.org/10.1016/j.jadohealth.2018.12.026				
	Tull, F. and coll., 2019	Australia	Test the hypothesis that sending a short message service (SMS) reminder to parents who had consented to their child's receiving the HPV vaccine would lead to greater uptake of the vaccine within the program	Parents of 4,386 consented adolescents	85.71% of consented students in the control condition received the HPV vaccine, compared with 88.35% (2.64% point increase) in the motivational message condition, and 89.00% in the self-regulatory message condition.
5	https://onlinelibrary.wiley.com/doi/abs/10.1111/josh.12840				
	Szilagyi, P and coll., 2019	USA	Compare 2 school-based programs designed to raise influenza vaccination rates	36 schools	Parent reminder/education combined with SLIV clinics raise vaccination rates, but parent reminder/education alone does not.
6	https://doi.org/10.4278/ajhp.131210-LIT-622				
	Laine, J. and coll., 2014	Finland	Systematic review synthesizes the evidence on the cost-effectiveness of population-level interventions to promote physical activity	A systematic literature search was conducted between May and August 2013 in four databases: PubMed, Scopus, Web of Science, and SPORTDiscus.	The most efficient interventions to increase physical activity were community rail-trails ($.006/MET-h), pedometers ($.014/MET-h), and school health education programs ($.056/MET-h).
7	http://www.earthscienceliteracy.org/es_literacy_6may10_.pdf.				
	Dutilleul, 2010				
8	https://doi.org/10.1097/PHH.0000000000000069				
	Groom, H. and coll., 2015	USA	Conducting systematic reviews for the Guide to Community Preventive Services to assess the effectiveness of Immunization Information Systems (IISs)	The literature search identified 108 published articles and 132 conference abstracts	Findings from 240 articles and abstracts demonstrate IIS capabilities and actions in increasing vaccination rates with the goal of reducing vaccine-preventable disease.
9	https://journals.lww.com/jphmp/Fulltext/2015/05000/Recommendation_for_Use_of_Immunization_Information.3.aspx				
	Community Preventive Services Task Force, 2015	USA	Recommend immunization information systems based on strong evidence of effectiveness	Findings from 108 published articles and 132 conference abstracts	Based on findings of a systematic review, the Community Preventive Services Task Force recommends immunization

N°	Author(s) and Year of publication	Origin/ Country of origin	Aims/ Purpose	Study population and sample size	Key findings
					information systems on the basis of strong evidence of effectiveness in increasing vaccination rates.
10	https://doi.org/10.1503/cmaj.092048				
	Taddio et al., 2010	Canada	Develop a clinical practice guideline, based on systematic reviews of the literature, as interpreted by experts, to assist clinicians in managing procedure-related pain and distress among children undergoing vaccine injections	Children	Key points Vaccine injections performed in childhood are a substantial source of distress. Untreated pain can have long-term consequences, including preprocedural anxiety, hyperalgesia, needle fears and avoidance of health care. Simple, cost-effective, evidence-based pain-relieving strategies are available. A “3-P” approach, combining pharmacologic, physical and psychological factors, improves pain relief.
11	https://doi.org/10.1503/cmaj.150391				
	Taddio et al., 2015	Canada	Develop a clinical practice guideline, based on systematic reviews of the literature, as interpreted by experts, to assist clinicians in managing procedure-related pain and distress among adults undergoing vaccine injections	Adults	Key points: -Pain at the time of vaccine injection is a common concern and contributes to vaccine hesitancy across the lifespan. -Evidence-based and feasible interventions are available to mitigate pain and are part of good vaccination clinical practice. -This guideline includes recommendations for pain mitigation based on five domains of pain management interventions (procedural, physical, pharmacologic, psychological and process): the “5P” approach.

Table 5. Official Documents, Institutional and Governmental Websites

N°	Author(s) and Year of publication	Origin/ Country of origin	Aims/ Purpose	Study population and sample size	Key findings
1	https://www.canada.ca/en/public-health/services/provincial-territorial-immunization-information/provincial-territorial-routine-vaccination-programs-infants-children.html				
	Government of Canada, 2019	Canada	Table summarizes the current routine vaccination schedule for infants and children in all provinces and territories across Canada	Infants and children Females/males	-Presentation of the vaccines used in each province -Target group catch-up period
2	https://www.ontario.ca/page/vaccines-children-school				
	Government of Ontario, 2015	Ontario/ Canada			
3	https://www.quebec.ca/sante/conseils-et-prevention/vaccination/programme-quebecois-d-immunisation/				
	Government of Québec, 2019	Québec/ Canada			
4	https://www.quebec.ca/sante/conseils-et-prevention/vaccination/vaccination-en-milieu-scolaire/				
	Government of Québec, 2019	Québec/ Canada			
5	https://publications.msss.gouv.qc.ca/msss/fichiers/2013/13-278-06W.pdf				
	Ministère de la santé et des services sociaux, 2013 (Ministry of Health and Social Services)	Québec/ Canada	To report on the progress of the operation which contributed to increasing the level of protection against measles in the school population and to updating our knowledge on this subject	Québec population	Summarizes the progress of the measles catch-up vaccination campaign held in Québec between November 15, 2011 and June 30, 2012
6	http://www.santecom.qc.ca/Bibliothequevirtuelle/santecom/35567000003613.pdf				
	Remis & Bédard, 1987	Québec/ Canada	Define the fundamental roles of the DSC (Community Health department) infectious disease control programs in Region 6A, and the minimum resources required to implement its activities	Eight DSCs in the Metropolitan Montréal area	Update of DSC situation since 1987
7	http://www.bccdc.ca/resource-gallery/Documents/Statistics%20and%20Research/Statistics%20and%20Reports/Immunization/Coverage/Measles_BC_2014.pdf				
	BC Centre for Disease Control, 2016	British Columbia/ Canada			
8	http://www.bccdc.ca/resource-gallery/Documents/Statistics and Research/Statistics and Reports/Epid/Annual Reports/2010CDAnnualReportFinal.pdf				
	BC Centre for Disease Control, 2012	British Columbia/ Canada			
9	https://immunizebc.ca/what-vaccines-do-school-age-children-need-and-when				
	ImmunizeBC, 2017	British Columbia/ Canada			
10	http://www.hpvregister.org.au/research/coverage-data/HPV-Vaccination-Coverage-2015				
	National HPV Vaccination Program Register, 2019a	Australia			National (Australia) HPV 3 dose vaccination coverage for females turning 15 years of age in 2017
11	http://www.hpvregister.org.au/research/coverage-data/HPV-Vaccination-Coverage-2015---Male				
	National HPV Vaccination Program Register, 2019b	Australia			National (Australia) HPV 3 dose vaccination coverage for males turning 15 years of age in 2017

N°	Author(s) and Year of publication	Origin/ Country of origin	Aims/ Purpose	Study population and sample size	Key findings
12	https://www.rivm.nl/en/en/measles/measles-in-the-netherlands				
	Netherlands National Institute for Public Health and the Environment and Ministry of Health, Welfare and Sport	Netherlands			-Measles epidemic occurred from May 2013 until March 2014 in municipalities with low vaccine coverage (below 90 percent) against measles. -For religious reasons, they do not have their children vaccinated. -2,700 patients with measles have been reported
13	https://www.cpha.ca/fr/chronologie-de-limmunisation				
	Canadian Public Health Association	Canada			Immunization timeline pre-1910 to 2008
14	https://www.cpha.ca/fr/cyberlivre-historique				
	Rutty and Sullivan, 2010	Canada			
15	https://www.historyofvaccines.org				
	The College of Physicians of Philadelphia	USA	Explore the role of immunization in the human experience and examine its continuing contributions to public health		
16	http://uis.unesco.org/fr/glossary-term/population-dage-scolaire				
	UNESCO	France			
17	https://www.thecommunityguide.org/sites/default/files/assets/Vaccination-Requirements-for-Attendance_1.pdf				
		USA			

Table 6. History of School-Based Immunization Programs, Sporadic Diseases and Outbreaks

N°	Author(s) and Year of publication	Origin/ Country of origin	Aims/ Purpose	Study population and sample size	Key findings
History of School-Based Immunization Programs in Canada					
1	http://www.jstor.org/stable/41983674				
	Canadian Public Health Association, 1965	Canada	Presented Policy Statement that was adopted as Association policy at a meeting of the Executive Council held on November 21, 1964.	Canadian population/school-age children/students	-History of the school-based immunization program in Canada -Morbidity and mortality due to smallpox, diphtheria, tetanus, pertussis, poliomyelitis, and tuberculosis 1936-1962
2	https://doi.org/10.1503/cmaj.109-3992				
	Walkinshaw, E., 2011	Canada	Present the Canadian picture of mandatory vaccinations	Provinces	-Three provinces have legislated vaccination policies, applying strictly to children about to enrol in school. -Ontario and New Brunswick require immunization for diphtheria, tetanus, polio, measles, mumps, and rubella. -Manitoba requires a measles vaccination.
Meningitis Outbreaks in Canada					
1	https://doi.org/10.1371/journal.pone.0050659				
	Gilca, R. and coll., 2012	Canada	To analyze the epidemiology of invasive meningococcal disease (IMD) in the province of Québec, Canada, 10 years before and 10 years after the introduction of serogroup C conjugate vaccination	IMD cases reported to the provincial notifiable disease registry in 1991–2011 and isolates submitted for laboratory surveillance in 1997–2011	-Important changes in the epidemiology of IMD have been observed in Québec during the last two decades. -Serogroup C has been virtually eliminated. -In recent years, most cases have been caused by the serogroup B ST-269 clonal complex.
2	https://doi.org/10.14745/ccdr.v40i09a01				
	YA, L. and coll., 2014	Canada	Describe the epidemiology of invasive meningococcal disease (IMD) in Canada from 2006 to 2011.	Data from the Enhanced Invasive Meningococcal Disease Surveillance System and national population estimates were selected for descriptive and inferential analyses	-IMD is still endemic in Canada. -Although individuals at any age can be affected, infants under 1 year of age are at the greatest risk, followed by children aged 1–4 years and individuals aged 15–19 years.
3	https://doi.org/10.3390/vaccines6010012				
	McCarthy, P. C. and coll., 2018	USA	Describes current meningococcal vaccines and	Vaccines	-Serogroups B and C (MenB, MenC) are

			discusses some recent research discoveries that may transform vaccine development against *N. meningitidis* in the future		responsible for most disease in Europe and North America. -Vaccination strategies against meningococcal meningitis include polysaccharide, glycoconjugate, combined conjugate and protein/OMV-based vaccines. -These vaccines have been proven to be safe and effective against *N. meningitidis* serogroups A, B, C, W and Y.
Measles Outbreaks in Canada					
1	https://doi.org/10.1177/0033354919826558				
	Conis E., 2019	USA	Follows the history of measles to explore immunization successes and challenges in this modern era		-The modern era of vaccination was heralded with the licensure of the first 2 measles vaccines in 1963. -This new era was distinct from the preceding era of vaccination for 4 main reasons.
2	https://doi.org/10.1093/infdis/jiv271				
	Gardy, J. L. and coll., 2015	USA	-Estimate the virus mutation rate -Determine that person-to-person transmission is typically associated with 0 mutations between isolates -Established that a single introduction of H1 virus led to the expansion of the outbreak beyond Vancouver	Whole-genome sequencing to investigate a dual-genotype outbreak of measles occurring after the XXI Olympic Winter Games in Vancouver, Canada	Of the 82 outbreak cases, 45 (54.9%) were PCR positive, containing MV nucleic acid for downstream genetic analyses.
3	https://doi.org/10.14745/ccdr.v41i07a02f				
	Naus, M. and coll., 2014	Canada	Count cases that are confirmed, probable and suspect	Local community of British Columbia, schools and religious leaders, local health care providers	-433 cases (325 confirmed cases and 108 probable cases) were detected -57% of cases occurred in students in a school
4	https://doi.org/10.14745/ccdr.v41i07a01				
	Sherrard, L. and coll., 2015	Canada	Describe measles activity in Canada for 2014 in order to support Canada's ongoing measles elimination status	All provinces and territories in Canada	During 2014, 418 measles cases were reported by five provinces and territories for an overall incidence rate of 11.8 cases per 1,000,000 population.